Five-Year Review Report

Fourth Five-Year Review Report
for the

Charles George Land Reclamation Trust Landfill Superfund Site

Town of Tyngsborough
Middlesex County, Massachusetts

June 2010

PREPARED BY:

United States Environmental Protection Agency
Region 1
Boston, Massachusetts

Approved by: Date:

for [signature] 6-24-10

James T. Owens, Director
Office of Site Remediation and Restoration
U.S. EPA, Region 1

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LIST OF ABBREVIATIONS AND ACRONYMS

AAL	Allowable Ambient Limit
ARAR	Applicable or Relevant and Appropriate Requirements
BOD	Biological oxygen demand
COD	Chemical oxygen demand
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
CH4	Methane
CO2	Carbon Dioxide
COC	Contaminant of Concern
cPAH	Carcinogenic Poly(cyclic) Aromatic Hydrocarbon (Compound)
CSF	Cancer Slope Factor
CWA	Clean Water Act
DEQE	(Massachusetts) Department of Environmental Quality Engineering
ECO	Ecological Benchmark Value
EPA	U.S. Environmental Protection Agency
ESD	Explanation of Significant Differences
FS	Feasibility Study
Gpd	Gallons per day
H2S	Hydrogen Sulfide
HDPE	High-Density Polyethylene
ISCO	Trademark - Teledyne Technologies Company
LEL	Lower Explosive Limit
IRIS	Integrated Risk Information System
LRWU	Lowell Regional Wastewater Utility
LTRA	Long Term Response Action
MassDEP	Massachusetts Department of Environmental Protection
MCL	Maximum Contaminant Level
MMCL	Massachusetts Maximum Contaminant Level
MO	Monitor Only
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NPL	National Priorities List
O2	Oxygen Gas
O&M	Operation & Maintenance
OU	Operable Unit
PAH	Poly(cyclic) Aromatic Hydrocarbon (Compound)
PAL	Project Action Limit
PCB	Polychlorinated Biphenyl
pH	Log 10 of the local hydrogen ion concentration using a standard electrode
PRP	Potentially Responsible Party
RAO	Remedial Action Objective
RI	Remedial Investigation
RCRA	Resource Conservation and Recovery Act

LIST OF ABBREVIATIONS AND ACRONYMS (continued)

RfD	Risk Reference Dose
ROD	Record of Decision
RSL	Regional Screening Level
SCADA	Supervisory Control and Data Acquisition
SDWA	Safe Drinking Water Act
SU	Standard Units (pH)
SVOC	Semi-volatile Organic Compound
THF	Tetrahydrofuran
TOC	Total Organic Carbon
TTO	Total Toxic Organics
TWD	Tyngsboro Water District
USACE	U.S. Army Corps of Engineers
VOC	Volatile Organic Compound

EXECUTIVE SUMMARY

This five-year review report was prepared for the Charles George Land Reclamation Trust Landfill Superfund Site located at the corner of Dunstable Road and Cummings Road in Tyngsborough, Middlesex County, Massachusetts. The Site is a 70-acre mixed industrial, municipal, and hazardous waste landfill located approximately one mile southwest of the town center of Tyngsborough, Massachusetts (Figure 1 in Attachment 1). From the late 1950s until 1967, it was operated as a small municipal dump. In 1967, the landfill was expanded to its present size and began accepting both household and industrial wastes, including drummed and bulk chemicals containing volatile organic compounds and metal sludges. The Commonwealth of Massachusetts ordered closure of the landfill in 1983 and the Site was listed on the National Priorities List that same year. Groundwater samples collected from private wells near the Site contained volatile organic compounds and metals. Benzene, tetrahydrofuran, arsenic, 1,4-dioxane, and 2-butanone are representative of the contaminants detected.

The Site is being addressed in five stages: initial actions and four long-term remedial phases or operable units. In response to the 1983 discovery of contaminated well water in nearby residential wells, the U.S. Environmental Protection Agency took the initial action of improving an above-ground pipeline that was supplying residents with a temporary alternative water supply. Other initial actions taken in 1983 and 1984 included the installation of a security fence and 12 gas vents at the landfill, and regrading of the landfill to cover exposed refuse.

The initial actions addressed the immediate threats posed by the Site. EPA then initiated long-term remedial phases and subdivided the effort into four operable units. Operable Unit 1 refers to the provision of a permanent alternative water supply for areas affected by the contaminated groundwater plume from the Site. Operable Unit 2 (Source Control) involves control of the contamination source to reduce off-site migration of contaminants (i.e., capping of the landfill and collection of the leachate and landfill gas with interim treatment). Operable Unit 3 addresses contaminated groundwater migration, permanent treatment of landfill gas and excavation of contaminated sediments in nearby Dunstable Brook (eliminated under Explanation of Significant Difference issued in September 1999) and Operable Unit 4 addresses leachate treatment. Construction complete status was attained for the entire Site in September 1998. The landfill cap, landfill gas collection/destruction system, and southwest groundwater collection trench (OU2 and OU3), and the groundwater/leachate collection system (OU3 and OU4) are in the operation and maintenance phase.

This is the fourth five-year review for the Site. The five-year review is required because hazardous substances, pollutants, or contaminants remain at the Site above levels that allow for unlimited use and unrestricted exposure. This five-year review concluded that the remedy is functioning as designed and provides continued protectiveness with respect to human health, but there are questions on its long-term protectiveness with respect to human health and ecological receptors. Examination of offsite groundwater, surface water, and sediment data collected in 2006 and 2009 indicated that additional monitoring should be re-established to understand with greater certainty contaminant distributions and trends both within and beyond the Site boundary. A similar monitoring program is recommended for sediment in surface water bodies adjacent to the Site.

In order for the remedy to remain protective in the long term, institutional controls to prevent installation and use of private drinking water wells near the Site are required. Institutional controls to prevent future disturbance of the landfill cap are also needed. The Settling Defendants under a Consent Decree entered in 2003 are required to implement these institutional controls.

FIVE-YEAR REVIEW SUMMARY FORM

Site name ***(from WasteLAN)***: Charles George Land Reclamation Trust Landfill		
EPA ID ***(from WasteLAN)***: MAD003809266		
Region: I	**State:** MA	**City/County:** Tyngsborough/Middlesex
NPL status: ■ Final □ Deleted □ Other (specify)		
Remediation status (choose all that apply): □ Under Construction ■ Operating □ Complete		
Multiple OUs?* ■ YES □ NO	**Construction completion date:** 09 / 25 / 1998	
Has site been put into reuse? □ YES ■ NO		
Lead agency: ■ EPA □ State □ Tribe □ Other Federal Agency ____		
Author name: Richard Fisher		
Author title: Remedial Project Manager	**Author affiliation:** EPA Region I	
Review period:** 09/30/2009 to 02/17/2010		
Date(s) of site inspection: 11/24/2009 and 12/07/2009		
Type of review: □ Post-SARA ■ Pre-SARA □ NPL-Removal only □ Non-NPL Remedial Action Site □ NPL State/Tribe-lead □ Regional Discretion		
Review number: □ 1 (first) □ 2 (second) □ 3 (third) ■ Other (specify) fourth		
Triggering action: □ Actual RA Onsite Construction at OU #____ □ Actual RA Start at OU#____ □ Construction Completion ■ Previous Five-Year Review Report □ Other (specify)		
Triggering action date ***(from WasteLAN)***: 06 / 28 / 2005		
Due date ***(five years after triggering action date)***: 06 / 28 / 2010		

* ["OU" refers to operable unit.]
** [Review period should correspond to the actual start and end dates of the Five-Year Review in WasteLAN.]

Five-Year Review Summary Form, cont'd.

Issues:

1) Limited groundwater data are available for the current five-year review period due to an intermittent groundwater monitoring program, which makes it difficult to assess long-term trends and confirm long-term protectiveness.
2) Potentially ecologically significant concentrations of PAHs were observed in sediment samples collected from Dunstable Brook during a recent sampling round.
3) Institutional controls have not been established to prevent future groundwater use and access to the landfill cap.
4) Potential impacts to human health associated with non-potable groundwater use (e.g., irrigation) have not been evaluated.
5) No documented program in place to ensure further sampling of stack emissions that are necessary to confirm remedy remains protective for the ambient air pathway.
6) No documented program in place to ensure continued monitoring of land use, groundwater quality, and soil gas monitoring that are necessary for continued evaluation of potential risk from vapor intrusion into occupied structures.

Recommendations and Follow-up Actions:

1) Maintain a regular groundwater monitoring program to evaluate extraction system effectiveness, as well as long-term trends and protectiveness. Target analytes should continue to include some that are not listed in the ROD, such as 1,4-dioxane and tetrahydrofuran.
2) Collect additional sediment data from nearby water bodies to determine sources and assess trends in PAH and metals concentrations potentially affecting ecological receptors.
3) Establish institutional controls to prevent use of potentially contaminated groundwater to maintain protectiveness over the long-term. Land-use restrictions should align with the owner/operator consent decree to prevent future disturbance of the landfill cap.
4) Though there have been no observations of such uses, risk from future non-potable groundwater uses should be evaluated to determine whether such uses should be restricted.
5) Update O&M Plan to include requirement for stack emissions monitoring a minimum of every five years.
6) Update O&M Plan to include requirement for continued evaluation of potential vapor intrusion risk.

Protectiveness Statement(s):

OU1 - OU1 refers to the provision of an alternate water supply for areas originally found to have been affected by the groundwater contaminant plume originating from the site. The remedy for OU1 currently protects human health and the environment because all areas known to have been impacted by contaminated groundwater have received an alternative water supply under OU1 (the original alternative supply) or OU3/OU4 (extensions to the original water supply lines). However, in order for this portion of the remedy to be protective in the long term, follow-up actions need to be taken. Specifically, institutional controls should be placed in the vicinity of the Site that would prevent both potable and non-potable uses if warranted, of the groundwater. The Town of Tyngsborough currently prevents potable use by not allowing installation of drinking water wells in areas that have access to public drinking water. However, additional institutional controls may be necessary to attain broader protectiveness in the long-term. These could include ordinances prohibiting, or advisories discouraging, installation of potable and non-potable water supply wells within the vicinity of the Site, regardless of the availability of a public water supply.

Five-Year Review Summary Form, cont'd.

OU2 - OU2 addresses source control to reduce off-site migration of contaminants (i.e., capping of the landfill and collection of leachate and landfill gas). This operable unit also includes the remedial action objective of "abating additional impact to surrounding surface waters and wetlands." This portion of the remedy is protective in the short-term; however, in order for this portion of the remedy to be protective in the long term, follow-up actions need to be taken. Although access to the landfill is currently strictly controlled by MassDEP, formal institutional controls are needed to prevent future disturbance of the cap. The Settling Defendant is required to implement these onsite controls under a Consent Decree with EPA. Also, there remains a need to continue air emissions monitoring, and surface water and sediment sampling in Dunstable Brook and Flint Pond Marsh to more fully evaluate possible long-term impacts of PAHs on both human health and ecological receptors.

OU3 and OU4 - OU3 focuses on contaminated groundwater migration and OU4 addresses leachate treatment. The protectiveness of these remedies are presented together since contaminated groundwater and leachate are considered together in ROD III, and are treated together in a combined groundwater/leachate collection system that discharges to the LRWU. The remedies for OU3 and OU4 are protective in the short-term; however, in order for this portion of the remedy to be protective in the long-term, follow-up actions need to be taken. The ROD specifies that long-term protectiveness will be achieved once groundwater and leachate contaminant concentrations drop below MCLs. In the interim, institutional controls are needed to prevent exposure to these contaminated media. The Town of Tyngsborough currently prevents installation of drinking water wells in areas that have access to public water. However, additional institutional controls may be necessary to attain broader protectiveness in the long-term. Specifically, this may require prohibiting installation of potable and non-potable water supply wells within the vicinity of the Site regardless of the availability of a public water supply. In addition, the Settling Defendant in the Consent Decree, entered in 2003 with EPA, is required to implement onsite controls to maintain protectiveness in the long-term for contaminated leachate.

Comprehensive Protectiveness Statement - Because the remedial actions of all operable units are protective in the short-term, the remedy is currently protective of human health and the environment. However, in order for the remedy to be protective in the long-term, the following follow-up actions are needed:

- Establish enforceable institutional controls to prevent future disturbance of the landfill cap.
- Establishment of enforceable institutional controls on the Site, and work with local officials on advisories/ordinances downgradient of the Site, to prevent potable water use from drinking water wells until MCLs are attained.
- Evaluate the risk of future non-potable groundwater uses (e.g., irrigation wells) to determine whether such uses should be restricted along with potable uses in the vicinity of Site
- Re-establish a formal groundwater monitoring program to allow continued evaluation of offsite contamination; the effectiveness of the groundwater extraction systems, and; potential impacts to human health.
- Re-establish a formal surface water and sediment monitoring program to allow continued evaluation of PAH and metal contamination in nearby surface water bodies, their potential sources, and/or the potential risk to ecological receptors.

- Update the O&M Plan such that it includes the establishment of mechanisms for evaluating the potential risk from vapor intrusion into occupied structures and continued stack emissions monitoring to evaluate potential risk through the ambient air pathway.

1.0 INTRODUCTION

The United States Environmental Protection Agency (EPA) is preparing this Five-Year Review report for the Charles George Land Reclamation Trust Landfill Site (Site) in Tyngsborough, Massachusetts, as required by the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and the National Oil and Hazardous Substances Pollution Contingency Plan (NCP).

CERCLA §121(c), as amended, states:

> *If the President selects a remedial action that results in any hazardous substances, pollutants, or contaminants remaining at the site, the President shall review such remedial action no less often than each five years after the initiation of such remedial action to assure that human health and the environment are being protected by the remedial action being implemented. In addition, if upon such review it is the judgment of the President that action is appropriate at such site in accordance with section [104] or [106], the President shall take or require such action. The President shall report to the Congress a list of facilities for which such review is required, the results of all such reviews, and any actions taken as a result of such reviews.*

The NCP part 300.430(f)(4)(ii) of the Code of Federal Regulations (CFR) states:

> *If a remedial action is selected that results in hazardous substances, pollutants, or contaminants remaining at the site above levels that allow for unlimited use and unrestricted exposure, the lead agency shall review such action no less often than every five years after the initiation of the selected remedial action.*

The purpose of this five-year review is to determine whether the remedy for the Site is protective of human health and the environment. Specifically, the report addresses the following three questions stated in OSWER Directive #9355.7-03B-P, "Comprehensive Five-Year Review Guidance":

Question A: *Is the remedy functioning as intended by the decision documents?*

Question B: *Are the exposure assumptions, toxicity data, cleanup levels, and remedial action objectives (RAOs) used at the time of remedy selection still valid?*

Question C: *Has any other information come to light that could call into question the protectiveness of the remedy?*

This fourth five-year review was performed by the U.S. Army Corps of Engineers (USACE) for EPA. The review was conducted for the entire site from October 2009 through February 2010. The results are documented herein. The content of this report also documents issues identified during the five-year review process and offers recommendations to address them.

The review is required because contaminants remain at the Charles George Land Reclamation Trust Landfill Superfund Site above levels that allow for unlimited use and unrestricted exposure. The triggering action for this statutory review is the completion of the last review in 2005.

2.0 SITE CHRONOLOGY

Table 2-1 provides a summary chronology of significant Site events dating from its origins as a municipal landfill through this fourth five-year review.

Table 2-1. Chronology of Site Events.

Event	Date
Site was operated as a Municipal dump	Late 1950s through 1967
New owner expanded landfill and accepted both household and industrial wastes	1967 to 1976
Hazardous wastes accepted, including drummed and bulk chemicals containing volatile organic compounds (VOCs) and metal sludges	1973 to 1975
EPA proposes site for listing on National Priorities List (NPL)	October 23, 1981
Bedrock wells serving Cannongate Condominium found to be contaminated and shut down by the State - State installs temporary water line and orders closure of landfill	July 1982
Four private bedrock wells serving homes adjacent to condominiums also found to be contaminated	May 1983
EPA issues Notice to Charles George Land Reclamation Trust requesting cooperation in cleanup	May 1983
Final listing date on the NPL	September 8, 1983
EPA undertakes emergency remedial actions including improvement to Cannongate temporary water line and landfill measures (fencing, soil cover, and gas vents)	August 1983 - March 1984
First Record of Decision (ROD) selecting extension of City of Lowell's water supply system to serve Cannongate area (OU1)	December 29, 1983
Second ROD selecting landfill cap, gas collection/venting, and leachate collection (OU2)	July 11, 1985
Explanation of Significant Differences (ESD) to include an additional 24 residential tie-ins to the OU1 water line	May 1988
OU1 water line is activated	Fall 1988
Third ROD selecting long-term groundwater monitoring, incineration of landfill gas, contaminated groundwater extraction, leachate treatment, and excavation of Dunstable Brook sediments (OU3 and OU4)	September 29, 1988
Construction of landfill cap (OU2) completed	October 1990
Fifty-four Potentially Responsible Parties (PRPs) enter into Consent Decrees with EPA	1992
Construction of interim gas treatment flare and portion of groundwater extraction remedy completed	1993 -1994
Extraction well portion of groundwater remedy completed	1995
Leachate and groundwater temporary treatment system in operation	1991 to 1997
Contamination first discovered in monitoring wells on Notre Dame Academy property	October 1995

Table 2-1 continued.

Contamination discovered in residential well water in Flint Pond neighborhood	August 1996
EPA evaluates alternatives for landfill gas treatment and selects enclosed flare to replace interim flare	1996
Existence of sanitary sewer connection near site is discovered, and evaluated as a replacement for on-site treatment of leachate and groundwater	1996 – 1997
Completion of water line extension to Notre Dame Academy	July 1997
Lowell Regional Wastewater Utility (LRWU) issues Industrial Discharge Permit allowing discharge of leachate and groundwater to sanitary sewer	January 1998
Construction for enclosed flare to replace interim flare is completed	April 1998
Completion of water line extension to Flint Pond neighborhood	June 1998
Dunstable Brook sediments sampled and risk re-calculated; results show sediment removal not necessary. Pump stations upgraded and Operations and Maintenance (O&M) building constructed on site to support long term O&M efforts	1998
Construction of sewer line from site to Flint Corner Municipal Pump Station including two pump stations	September 1998
Construction Complete status is attained for the Site	September 22, 1998
ESD issued to document changes to third ROD (additional water line extensions, selection of enclosed flare, elimination of Dunstable Brook sediment removal, and sanitary sewer extension for permanent leachate and groundwater disposal)	September 1999
Dorothy and Charles George settle all claims against them	March 2003
Long-Term Response Action (LTRA) period ends and O&M phase begins for OU4 – the Massachusetts Department of Environmental Protection (MassDEP) assumes responsibilities from EPA	September 2009
Completion of First Five-Year Review	August 31, 1995
Completion of Second Five-Year Review	March 22, 2000
Completion of Third Five-Year Review	June 28, 2005
EPA completed transfer of entire site O&M responsibilities to MassDEP	September 2009
Leachate and groundwater collection lagoon removed	October 2009
Completion of Fourth Five-Year Review (this report)	June 2010

3.0 BACKGROUND

3.1 Physical Characteristics/Land and Resource Use

The Charles George Land Reclamation Trust Landfill Superfund Site (Site) is a 70-acre mixed industrial, municipal, and hazardous waste landfill located approximately one mile southwest of the town center of Tyngsborough, Massachusetts (Figure 1). The Site is bordered to the east by U.S. Route 3, Flint Pond Marsh, and Flint Pond. A residential neighborhood is located on the Pond's northern peninsula approximately one-half mile east of the Site. The Academy of Notre Dame private school is on the eastern shore of Flint Pond. Dunstable Road and Dunstable Brook border the Site to the west and south, and the Cannongate Condominium complex is located approximately 800 feet to the southeast. Blodgett Street and Cummings Road form the northwestern border of the Site.

Dunstable Brook flows in a southerly direction beyond the Site before turning east, then northeasterly, discharging into Flint Pond Marsh which in turn supplies Flint Pond. Flint Pond ultimately discharges to the Merrimack River.

Land use in the vicinity of the site is predominantly rural residential but also includes some light industry and seasonal livestock grazing. This area of the Town of Tyngsborough has experienced heavy residential development in recent years. In addition, a large industrial park with a build-out capacity of 18 buildings has been constructed on the northern border of the site. Drinking water in the area is supplied by a water main installed as a result of the EPA's first ROD for the Site, water main extensions constructed by others, and private residential water supply wells. The public water supply is available to the area impacted by the Site, although some residents in the vicinity of the Site have chosen to retain their private water supply wells. The public water supply main is connected to the Lowell Regional Water Utility, which derives its water from the Merrimack River.

3.2 History of Contamination

Waste disposal activity at the Site was initiated in the mid 1950's. During the period between 1955 and when the land was purchased by Charles George Sr. in 1967, the Site was operated as a municipal dump. The Site continued to operate as a municipal landfill after acquisition by Charles George Sr. in 1967 and the Charles George Land Reclamation Trust (Charles George Sr. and Dorothy George, Trustees) in 1971. In 1973, the Trust was issued a permit by the Commonwealth of Massachusetts to handle hazardous wastes in addition to municipal and domestic refuse. Disposal of hazardous wastes and substances primarily in the form of drummed and bulk chemicals containing VOCs and toxic metal sludges continued from January 1973 to at least June 1976.

In 1982, the Tyngsborough Board of Health suspended the assignment of the Trust's land as a landfill. At approximately the same time, the Massachusetts Department of Environmental Quality Engineering (DEQE), now the MassDEP, ordered the closing of two wells serving the Cannongate Condominiums due to the presence of VOC contamination in the well water. The DEQE installed an above-ground water line from the North Chelmsford Water District to the condominiums to provide a temporary solution to the water shortage created by the loss of the wells.

3.3 Initial Response

EPA's involvement at the Site began with groundwater testing conducted in 1981 and 1982. The site was proposed for the NPL on October 23, 1981, and finalized on the NPL in September 1983. In that same year, EPA also allocated funds for a removal action at the Site to replace the DEQE's temporary water line with an insulated temporary water line. Other removal actions included construction of a security fence along the northwestern entrance to the landfill, re-grading and placement of soil cover over exposed refuse, and installation of twelve landfill gas vents. The basis for the removal action was documented in the first ROD issued on December 29, 1983. A remedial investigation (RI) and feasibility study (FS) were also begun in September 1983.

3.4 Summary of Basis for Taking Action

The initial action taken at the Site under the first ROD (USEPA, 1983) was based on the discovery of contamination in water from the wells that supplied the Cannongate Condominium complex to the south of the Site. The contaminants found included methyl ethyl ketone, acetone, toluene, benzene, methyl isobutyl ketone, trichloroethene, and 1,1-dichloroethane. Sampling of other private wells near the condominiums also began to show evidence of contamination. The first ROD extended a water line to affected residences to provide water from a neighboring town.

The basis for the second ROD (USEPA, 1985) was the poor condition of the abandoned landfill (lack of soil cover, exposed refuse, and leachate breakouts) that was allowing contaminants to migrate via surface runoff, groundwater passing through the waste, and gaseous emissions. Identified receptors included flora and fauna as well as humans coming into contact with surface waters and wetlands surrounding the Site. Landfill leachate and contaminated soil erosion were cited as having impacted the surrounding surface waters and wetlands. The potential migration of leachate into the bedrock aquifer was also cited as a concern. VOCs were detected in air samples from landfill vents and the surrounding environment, indicating that landfill gas control was also needed.

The third ROD (USEPA, 1988), addressing groundwater, leachate and sediment contamination, was based on a site-wide remedial investigation and risk assessment (Ebasco, 1988). The contaminants identified in Table 3-1 are those listed in the third ROD and are a representative subset of the contaminants identified at the Site that were selected for quantitative evaluation in the 1988 risk assessment.

Table 3-1. Contaminants Listed in ROD III.

Groundwater and Leachate	Air	Sediment
Acetone	Benzene	Polycyclic Aromatic Hydrocarbons (PAHs)
Benzene	Bromoform	
Benzoic Acid	Bromomethane	Arsenic
2-Butanone	Carbon Disulfide	Cadmium
1,1-Dichloroethenene	Carbon Tetrachloride	
Ethylbenzene	Chlorobenzene	
4-Methyl-2-pentanone	Chloroform	
4-Methylphenol	Chrysene	
2-Methylphenol	1,2-Dichloroethane	
Phenol	1,1-Dichloroethene	
Toluene	Methylene Chloride	
Trichloroethene	1,1,2,2-Tetrachloroethane	
Arsenic	Tetrachloroethene	
Cadmium	Toluene	
Chromium	1,1,2-Trichloroethane	
Copper	Trichloroethene	
Mercury	Vinyl Chloride	
	Xylenes	

The site-wide remedial investigation and risk assessment (Ebasco, 1988) estimated human health risks and hazards that exceed the EPA risk management criteria from the following:

- Exposure to groundwater via ingestion during domestic use.
- Exposure to airborne emissions from the venting system via inhalation of ambient air.
- Exposure to sediments in Dunstable Brook via dermal exposure to carcinogenic PAHs.

In 1998, sediments in Dunstable Brook were sampled and analyzed for PAHs and the human health risk associated with exposure to these sediments (residential scenario) was reassessed. This reassessment was done because of changes in toxicity information and risk assessment practices that had occurred since the 1988 risk assessment was performed. Also, the 1998 results had showed decreased concentrations relative to the data used to support the third ROD. The 1998 reassessment concluded that the risk and hazard from exposure to Dunstable Brook sediments met EPA's risk management criteria. This reassessment formed the basis for EPA's decision to eliminate removal of Dunstable Brook sediments from the OU3 remedy.

4.0 REMEDIAL ACTIONS

4.1 Remedy Selection

The Site was subdivided into four OUs for the purpose of investigation, remedy selection, and remediation. Three RODs for these OUs have been issued, as follows:

- ROD I: Provide an alternative water supply (OU1).
- ROD II: Control the contamination source (OU2) to reduce off-site migration of contaminants (i.e., cap the landfill and collect the leachate and landfill gas).
- ROD III: Provide treatment of groundwater, leachate and landfill gas and provide removal of Dunstable Brook sediments as the selected source removal remedy. ROD III covered both management of contaminated groundwater migration (OU3) and leachate treatment (OU4).

4.1.1 Operable Unit 1

ROD I, issued in December 1983, provided a permanent drinking water supply to local groundwater users by extending an existing water supply system (OU1). In early studies, local groundwater wells were found to contain VOCs associated with the site. The remedy minimized exposure and, therefore, provided a measure of protectiveness to human health. ROD I established as an objective a new water main to provide an uncontaminated alternative water service to the residents of the Cannongate Condominium complex and surrounding area specifically to:

- Mitigate and minimize danger to and provide adequate protection of public health and welfare from ingestion of contaminated drinking water.

To meet this objective, the 1983 ROD selected the extension of an existing (City of Lowell's) water supply system to Cannongate Condominiums. Residential well water users along Dunstable Road up to Cannongate Road and along Cannongate Road were also tied into the waterline extension. An ESD was issued during construction in 1988 to include these tie-ins, which totaled 24 in all.

4.1.2 Operable Unit 2

The final remedial action objectives selected in ROD II (1985) for addressing source control measures at the Site (OU2) are as follows:

- Abate additional impact to surrounding surface waters and wetlands.
- Minimize, to the extent possible, continued release to the groundwater.
- Control the emission of gases containing hazardous constituents to the surrounding residents.
- Minimize potential contamination of the water supplies and impacts on recreational uses around Flint Pond.

- Minimize potential exposure, via direct contact with leachate, to the surrounding public and wildlife.

- Secure the Site to eliminate unauthorized access.

- Comply with existing federal, state, and local laws.

- Ensure consistency with any off-site remedial alternatives, which may be selected in the third ROD as required by CERCLA sec. 101(24).

ROD II provided a cap for the Site consisting of a synthetic membrane and soil cover, a surface water management system, a passive landfill gas venting system, and a leachate collection system (OU2). These measures minimized the migration of contaminants through the air and groundwater and, therefore, provided a measure of protectiveness to human health. The landfill cover minimized storm water infiltration which reduces leachate generation. From 1991 to 1997, leachate and groundwater were collected and pumped into a 3.5 million-gallon storage lagoon and, at capacity, the wastewater was treated on-site in a temporary treatment facility. Treatment consisted of breakpoint chlorination, solids removal, and UV oxidation. The treated effluent was discharged to the eastern sedimentation pond with eventual discharge to Bridge Meadow Brook. Ambient Water Quality Criteria were met. Ten rounds of treatment were conducted, during which approximately 35 million gallons of wastewater were treated and discharged. The leachate collection system minimized impacts to off-site surface water and groundwater.

4.1.3 Operable Units 3 and 4

The remedial action objectives selected in ROD III (1988) to address management of contaminant migration at the Site (OU3 and OU4) to:

- Reduce potential future human health risks from ingesting benzene and arsenic in overburden groundwater southwest of the landfill.

- Reduce potential human health risks from benzene, arsenic, bis(2-ethylhexyl)phthalate, and trichloroethene in deep bedrock groundwater east of the landfill, with respect to use as a drinking water supply.

- Remediate shallow eastern groundwater to comply with Safe Drinking Water Act (SDWA) Maximum Contaminant Levels (MCLs).

- Reduce potential human health risks posed by bromoform and various carcinogenic contaminants in landfill vent emissions (primarily, 1,1-dichloroethene, 1,1,2,2-tetrachloroethane, vinyl chloride, methylene chloride, and carbon tetrachloride).

- Reduce potential human health risks from PAHs in sediments west of Dunstable Road, in the leachate drainageway to Dunstable Brook, as well as short reaches of Dunstable Brook itself.

ROD III completed the remedial actions via treatment of the media controlled during implementation of ROD II. Due to several investigations made subsequent to the issuance of ROD III, EPA modified four of the five remedies under the third ROD. These changes included extending the existing municipal water supply system, installation of an enclosed flare, determining that removal of sediments from

Dunstable Brook would not be necessary, and construction of a sanitary sewer extension, which provides an alternate remedy for leachate and groundwater treatment and discharge. An ESD was issued by EPA in 1999 to address these changes (USEPA, 1999).

The southwest groundwater collection trench has been operating since October 1993, and the eastern groundwater extraction system has been operating since 1995. Contaminated groundwater from these two extraction systems is collected at the West and East Pump Stations, respectively, where, starting in 1997, citric acid and a biocide are added to the wet wells for iron sequestration and microbial control. The collected water was originally pumped to the lagoon for temporary storage prior to transfer to the effluent monitoring station near the site entrance. The lagoon was retained for temporary storage of the contaminated groundwater to monitor the potential for dissolved iron precipitation while the efficacy of the treatment process (citric acid and biocide addition) was evaluated. From there, it is piped to the Cummings Road Pumping Station for discharge to the LRWU for treatment and disposal. This discharge is regulated by an LRWU industrial discharge permit. This system has continued to function without mishap or significant iron accumulation or deposition in the transfer piping or the temporary storage lagoon.

The residential well monitoring program started in 1989 was terminated in 1999 due partly to the now available municipal water supply near the landfill. In addition, certain residential wells in the Town of Dunstable near the Site were sampled in the past, but the historic absence of groundwater contaminants and in consideration of groundwater flow directions (Figures 2a, 2b, and 2c), sampling of these residential wells was deemed unnecessary.

The landfill gas collection and venting system is comprised of a passive, crushed stone, gas collection trench system under the cap liner, which directs the landfill gas through 28 vents along the top of the landfill. Three existing monitoring wells (acting as gas vents) are connected to an active horizontal header pipeline that lies atop the landfill. Twelve pre-existing vents were capped off. Landfill gas is being routed to an enclosed flare as part of ROD III. The landfill gas collection system originally delivered landfill gas to an interim open flare, but was later replaced by the enclosed flare. The enclosed flare, provided for under ROD III, thermally destroys contaminants carried in the gas and minimizes impacts to the air.

The need for excavation of sediments from Dunstable Brook was re-evaluated as part of the first five-year review (M&E, 1995). Sediments that were to be dredged and placed under the landfill cap during cover construction remain in the brook. The decision to dredge the brook had been based on a risk assessment of contaminant levels using toxicity assumptions valid at the time ROD III was issued in 1988. In 1989, EPA revised the relative absorption factors for PAHs, and in 1993, implemented the use of relative potency factors for carcinogenic PAHs (cPAHs). These changes were expected to result in decreased human health risk and hazard associated with exposure to sediments. Additional sediment data and a re-evaluation of relative absorption factors were presented in the First Five-Year Report (M&E, 1995). New risk calculations were not performed at that time, and EPA determined that more data was needed before dredging the brook. In 1998, EPA re-sampled brook sediments, re-evaluated the human health risks posed by cPAHs and determined that the concentrations of cPAHs are within the acceptable range of risk. This information was presented in the Second Five-Year Review Report (M&E, 2000) to support the decision not to dredge the brook.

ROD III called for on-site treatment of groundwater and leachate with onsite discharge into the aquifer or offsite surface water discharge. During pre-design activities in preparation for conceptual design of the permanent treatment plant for OU4, it was discovered that a sanitary sewer had been constructed during the summer of 1996 approximately one mile from the site. EPA determined that the Site wastewater would meet the LRWU's pretreatment requirements. Directing the discharge to the LRWU is more cost effective, more environmentally protective, and more reliable than the onsite treatment plant specified in the ROD (USEPA, 1999). In order to implement this approach, the dissolved iron in the extracted leachate and contaminated ground water had to be controlled to prevent deposition in the transfer piping and the lagoon. Since January 1998, citric acid and biocide have been added to the collected leachate and groundwater to prevent iron biofouling of the discharge pipelines. Chemical addition occurs at both the East and West Pump Stations, from which the water is pumped to the effluent monitoring station prior to discharge to the LRWU via the Cummings Road Pump Station. This process has continued to function without significant iron accumulation/deposition in either the transfer piping or the temporary storage lagoon (although it has been reported that there are occasionally some discolorations attributed to iron at the Cummings Road Pumping Station which does not affect its operation). The lagoon was subsequently bypassed, provisionally in 2000 and later, with approval by LRWU, in 2001 as a permanent measure. The lagoon was removed from the Site in October 2009.

4.2 Remedy Implementation

Additional details are presented in this section regarding the remedial actions conducted or being conducted at the site in accordance with the ROD objectives mentioned above. A site plan is provided in Figure 3.

4.2.1 OU1 Remedy Implementation

A water line, which provides an alternate water supply to serve the Cannongate area, was installed and activated in the fall of 1988. It was constructed under ROD I as OU1, and is now owned and operated by the Tyngsborough Water District (TWD). Since 1988, the line was extended (not by EPA as part of OU1) along Westford Road to the Westec Industrial Park. Under ROD III, EPA extended the line from the Westec Industrial Park location on Westford Road to Middlesex Road, to the Academy of Notre Dame school, up Middlesex Road to Kendall Road, and finally to Flint and Upton Roads. This extension is part of OU3 and was also turned over to the TWD in 1998. The waterline in Dunstable Road was extended by others from the Cannongate Road/Dunstable Road EPA terminus, up Redgate Road, and also extended up Dunstable Road to Blogett/Cummings Road to a commercial park constructed north of the Site. In 1998, EPA tied the Site into this system.

4.2.2 OU2, OU3, and OU4 Remedy Implementation: Source Control and Management of Migration

ROD II provided for source control by selecting a synthetic membrane cap with surface water diversion, off-gas collection and passive venting (now superseded by ROD III), and leachate seep collection. Construction of this cap and other remedial systems described above were completed in October of 1990. ROD III includes management of migration systems, control of groundwater and leachate, and groundwater/leachate disposal. MassDEP has O&M responsibilities for OU2, which constitutes the cap, surface water diversion system, the leachate collection system and the grounds within the fence (including the fence). MassDEP also has O&M responsibilities for the gas collection and the enclosed flare systems and the southwest groundwater extraction trench. MassDEP took over the financial responsibility for the southwest trench in September 2004 and fully funds these O&M responsibilities. EPA maintained O&M responsibilities for the eastern on-site leachate and groundwater collection and discharge systems for much of the 2005–2009 review period. In September 2009, this responsibility was transferred to MassDEP.

4.2.2.1 Landfill Cap, Leachate Collection, Groundwater Collection, and Treatment Systems

Construction of the synthetic landfill cap and appurtenant systems was initiated in early 1989 and completed in October 1990. Included in the construction of the cap were: a new shallow perimeter leachate toe-drain; two leachate pump stations with force mains flowing to a temporary leachate holding pond (lagoon); a passive gas collection and venting system; and a surface water diversion and sedimentation system. The old leachate collection systems on the east and west sides of the landfill, which were installed by the former landfill operator, were connected into pump stations.

The southwest groundwater extraction trench was completed and became operational in December 1993. It includes five wells that vary in depth from about 24 to 45 feet. The eastern groundwater extraction well field was completed in July 1995.

The eastern groundwater extraction system originally consisted of four extraction wells: CDM 1, CDM 2, CDM 3, and PW 1A (Figure 4). CDM 1 and CDM 2 had low yields and low concentrations of contaminants. CDM 2, which was open to both the overburden and shallow bedrock, was taken off line in 1996. CDM 1 was also taken off line the following year and currently is not pumped. In 1997, a new extraction well, WES 1, was constructed near CDM 2. WES 1 captures groundwater in overburden only and has a higher yield than CDM 2 when it was operating.

The First Five-Year Review (M&E, 1995) identified several significant problems with the leachate/groundwater collection systems. They included:

- Pump failure due to iron bacteria generating high dissolved iron loadings in the leachate and contaminated groundwater and subsequent oxidation and build up of precipitated iron in the pump station wet wells resulting in frequent pump motor burnout

- High line pressures from iron deposition and accumulation in transfer piping and tube failure in the original peristaltic pump system. Maximum line and pump tube pressures were limited by a diaphragm system which frequently "burst", requiring frequent replacement.

- Lack of pump station access due to limited space and a hazardous atmosphere within the manhole caused by landfill gas (e.g., hydrogen sulfide) infiltration.

- Equipment corrosion also due to hydrogen sulfide infiltration.

These problems were later addressed by modifying the leachate and groundwater collection and pumping systems. The process of groundwater extraction, leachate collection and transfer was analyzed and the over-arching problem was determined to be the infiltration of atmospheric oxygen into the mixed flow during transfer from the extraction wells to the lagoon. The lagoon was used as a temporary storage prior to periodic interim treatments of its contents once it reached a capacity of 3.5 million gallons, approximately every six months. A "pig" injection station was installed at each wet well station as a temporary measure to allow the transfer lines to be cleaned to maintain a moderate pressure rise in the transfer piping until a more permanent solution could be developed and implemented. In 1996, the site contractor, Weston Solutions Inc (formerly Roy F. Weston) evaluated treatment options and selected iron precipitation in a groundwater treatment plant they designed as described in the Final Report (Evaluation of Discharge Options). During the summer of 1997, a series of experiments was conducted by the New England USACE Division (now a District), which resulted in the recommendation of a continuous addition of sufficient chelant to sequester the dissolved iron in its reduced state and by the intermittent addition of a biodegradable biocide to limit bacterial activity in the wet wells where some exposure to atmospheric oxygen was inevitable.

Since December 1997/January 1998, citric acid and biocide have been added to the collected leachate and groundwater to prevent wet well biofouling and oxidized iron deposition in the discharge/transfer pipelines. Chemical addition occurs at both the East and West Pump Stations, from which the water is pumped to the effluent monitoring station prior to discharge to the LRWU via the Cummings Road Pump Station and its associated combined force main/gravity sewer located on Dunstable Road. EPA extended the Westford Road sewer line to the Site in 1998. The extension includes two off-site pump stations, two force main sections, and the remaining are gravity-fed sections. The EPA sewer line discharges to a pump station (built by others) located at the corner of Westford Road and Dunstable Road, locally known as Flint's Corner. At this time, EPA also constructed an O&M Building which houses equipment and vehicle storage, a wet laboratory, and an office. The extraction and discharge systems are monitored with a Supervisory Control and Data Acquisition (SCADA) system available in the building that provides for effluent monitoring and for remote access.

4.2.2.2 Landfill Gas Collection and Treatment System

The landfill gas collection and interim open flare gas destruction systems were constructed and became operational in 1994. During that year, landfill gas was characterized to determine the most appropriate destruction technology to meet the target cleanup levels established in ROD III. An enclosed flare system was determined to be the preferred alternative. Construction involved replacing the open flare stack with an enclosed flare stack. Some upgrading of the system was necessary, particularly the instrumentation and control panels, but most of the original system was utilized, including the flare building. This construction was completed in April 1998.

Landfill gas is collected via a system of 22 gas extraction vents and three existing groundwater monitoring wells (acting as gas vents) connected to an active horizontal header pipeline that lies atop the landfill. The pipeline is connected to a vacuum blower and enclosed flare for thermal treatment. There is no perimeter landfill gas collection system in place at the landfill.

The landfill vents are not typical, penetrating gas extraction wells. They are connected only to the gas venting layer located directly beneath the high-density polyethylene (HDPE) geomembrane. Not all of the passive vents were tied into the header pipe system; those passive vents that were not connected to the gas extraction system were capped off and are no longer functional.

4.2.2.3 Monitoring Systems

Monitoring of collected leachate/groundwater occurs at the effluent monitoring station located behind the O&M Building. By permit with the LRWU, continuous monitoring of pH, temperature and flow rate (in gallons per minute) occurs at the station along with collection of composite samples via a refrigerated ISCO® sampling unit and grab samples (additional details on effluent monitoring are presented in Section 4.3.3).

Monitoring of landfill gas occurs at both the individual gas vents on top of the landfill as well as the flare/blower station. Sample taps are in place at each gas vent for collection of samples using hand-held instruments. Each vent also includes a pressure gauge to measure small changes in static pressure (either positive or negative) to allow adjustment to extraction rates from each vent, but these were generally not operational and have not been found to be useful for this Site. Automated monitoring at the flare/blower station involves the following parameters: flare temperature, landfill gas flow rate, vacuum pressure of the extracted landfill gas, and oxygen concentration of the extracted gas.

Although there are no permanent perimeter monitoring wells for measuring methane or landfill gas in the vadose zone, the MassDEP has monitored the soil gas using multiple, temporary, surficial probes installed by EPA in 1997. In general, gas migration has not been an issue at the Site in the past due to the lack of sensitive receptors such as nearby structures or buildings, and due to concentrations below action levels or non-detection of monitored parameters in these wells.

4.3 Operation and Maintenance

This section discusses the operation and maintenance of the remedy at the Charles George Landfill.

4.3.1 Remedy Operation and Maintenance Program

During most of the 2005-2009 review period, O&M responsibilities were divided between MassDEP and the EPA (via the USACE). MassDEP oversaw the O&M of the landfill cap and grounds within the fence, surface water diversion system, site security, southwest groundwater extraction trench, gas collection system, and the enclosed flare system (i.e., OU2 and OU3). USACE was responsible for O&M of the east groundwater extraction system and discharge systems (i.e., OU4 east and west pump stations and effluent monitoring station) in compliance with the O&M manual for OU4 (Roy F. Weston, 1999). Since November 1999, the MassDEP has subcontracted Clean Harbors to perform O&M activities related to OU2, OU3 and the southwest groundwater extraction trench. H&S Environmental, Inc. conducted O&M of OU4 on behalf of USACE. On October 1, 2009, MassDEP took over O&M responsibilities for the OU 4 remedy components, which includes the East and West Pump Stations, the Eastern Groundwater Extraction System, the Effluent Monitoring Station, and the O&M Building. The formal transfer of responsibilities, which includes utility accounts and the sewer discharge permit, is documented in a letter dated September 30, 2009 from the MassDEP to the EPA (MassDEP, 2009).

4.3.2 MassDEP Responsibilities

Clean Harbors, as a contractor to MassDEP, conducts Semi-Annual (twice per year) landfill security and maintenance inspections, along with weekly inspections of the perimeter fence, southwest groundwater extraction trench, and enclosed flare system. Clean Harbors also performs semi-annual sampling of both the landfill gas collection system and 22 soil gas probes.

Semi-Annual landfill security and maintenance inspections consist of a complete walkover of the landfill cap inspecting for significant subsidence, bulging or evidence of deterioration. The inspections include observation of the roadways, perimeter fence, soil and gravel cover, drainage features, observation ports, and toe-drain clean outs. During these inspections, woody growth is removed from the cap and near cap drainage structures as necessary. A five-page "Landfill/Security/Site Maintenance" inspection checklist is used by Clean Harbors to document observations from the Semi-Annual inspection. Findings of the Semi-Annual inspection are reported to MassDEP in a Semi-Annual Status Report prepared by Clean Harbors. The Semi-Annual Status Report also summarizes observations and maintenance activities related to the quarterly sampling of soil gas probes and gas collection system sample ports, as well as weekly inspections of the flare and southwest groundwater extraction trench.

Monitoring of landfill gas is accomplished through the sampling of 22 gas extraction points (former gas vents), two new sample ports that were installed in the gas collection header pipes, and three monitoring wells (JLF1, JLF1A and JLF2) that were tied into the gas collection system (Figure 3). Monitoring at the gas extraction points is performed using Landtech Model GA-90 handheld instruments outfitted with hydrogen sulfide (H2S) pods. Parameters measured during the quarterly gas sampling consist of oxygen (O2), carbon dioxide (CO2), hydrogen sulfide (H2S), methane (CH4), temperature, and pressure (vent suction). Monitored parameters and details concerning gas system maintenance are recorded for each sample location on "Gas Collection System Inspection Checklists", which are included in Clean Harbors Semi-Annual Status Report to MassDEP.

Each vent also includes a pressure gauge to measure small changes in static pressure (either positive or negative) and valves to allow adjustment to extraction rates from each vent. However, MassDEP reported that in the past the valves were generally not operational and previous attempts to spatially "balance" different vent flow rates have not proven useful.

On a weekly basis, Clean Harbors performs routine monitoring and maintenance at the flare/blower station. Monitoring includes measuring gas quality and flow rate, blower speed, pressure set point, flare high temperature, landfill gas pressure, nitrogen pressure, and extracted gas oxygen concentration. Automated monitoring at the flare/blower station displays flare temperature, landfill gas flow rate, vacuum pressure of the extracted landfill gas and oxygen concentration of the extracted gas. Based on review of the O&M data, the oxygen sensor is a high maintenance item that frequently requires replacement. Observations from the weekly flare inspections are recorded on weekly "Flare Inspection Checklists", which are included in Clean Harbors Semi-Annual Status Reports to MassDEP.

Soil gas has been monitored since 1998 using multiple shallow probes that were installed near the perimeter of the Site in 1997 (55 temporary probes, total) as part of prior landfill gas migration studies. The current soil gas monitoring program consists of quarterly sampling of twenty (reduced to nineteen in 2004 due to destruction of one soil gas probe) select probes (locations described in Section 6.3 Data Review). Again, monitoring is accomplished with the use of a Landtech Model GA-90 handheld instrument that measures O2, CO2, H2S, and CH4. VOCs are also measured qualitatively at each probe using a Thermo 580B photoionization detector. Monitored parameters and details concerning probe maintenance are recorded on "Soil Gas Probe Monitoring Results" worksheets, which are included in Clean Harbors Semi-Annual Status Reports to MassDEP.

Weekly inspection activities performed by Clean Harbors at the Southwest groundwater extraction system include ambient air monitoring in pump manholes, inspection of pumps, floats, hoses, and support cables in each of the pump wells, and recording the number of pumps operating and operating amperages. Air quality parameters monitored in the pump manholes consist of percent lower explosive limit (LEL), O2, CO2, and H2S. Details concerning extraction pump and trench maintenance are recorded on weekly "Southwest Groundwater Collection Trench" worksheets, which are included in Clean Harbors Semi-Annual Status Report to MassDEP.

4.3.3 EPA/USACE Responsibilities

During the 2005-2009 review period, USACE, on behalf of the EPA, performed weekly site visits and monitoring of collected leachate and groundwater prior to discharge to the off-site sewer system. Weekly site visits included inspection and routine maintenance of the east extraction wells and East and West Pump Stations. Monitoring of collected leachate/groundwater occurs at the effluent monitoring station located behind the O&M Building. This station receives the discharge from the East and West Pump Stations and the leachate collection system prior to discharging to the LRWU. In accordance with the LRWU Industrial Sewer User Permit, continuous monitoring of pH, temperature and flow rate (gallons per minute) occurs at the station. The permit also requires the collection of quarterly composite samples (via a refrigerated "ISCO" sampling unit) and grab samples of discharge water at the Effluent Monitoring Station. Prior to 2004, weekly sampling was required as part of the permit but the frequency was dropped to quarterly in 2004. The composite samples are collected by the automated sampler on a flow-weighted basis. Prior to summer 2004, the sampler collected time-weighted composite samples (i.e., over a 24-hour period). As required by the permit (renewed for the period November 1, 2008 through October 31, 2013: LRWU, 2009), the water samples are analyzed for biochemical oxygen demand (BOD), chemical oxygen demand (COD), Total Toxic Organics (TTO), total cyanide, acidity, and metals (arsenic, antimony, beryllium, total chromium, copper, lead, nickel, selenium, thallium, and zinc). These responsibilities were formally transferred to MassDEP in September 2009 when the LTRA period ended for OU4 and the O&M phase began.

5.0 PROGRESS SINCE THE LAST FIVE-YEAR REVIEW

This section presents protectiveness statements and recommendations made in the Third Five-Year Review Report, as well as a summary of efforts made since 2005 to address recommendations.

5.1 Protectiveness Statements from Last Review

The following comprehensive protectiveness statement was developed for the 2000-2005 review period and was excerpted from the Third Five-Year Review Report:

Because the remedial actions at all OUs are protective in the short-term, the remedy is currently protective of human health and the environment. However, in order for the remedy to be protective in the long-term, the following follow-up actions are needed:

- *Establishment of enforceable institutional controls to prevent disturbance of the landfill cap*
- *Establishment of enforceable institutional controls on the Site, and work with local officials on institutional controls such as advisories or ordinances downgradient of the Site, to prevent potable water use from drinking water wells until MCLs are attained.*
- *Risk evaluation of non-potable groundwater uses (for example, irrigation wells), to determine whether such uses should be restricted along with potable uses*
- *Re-establishment of groundwater monitoring program to allow evaluation of extraction system effectiveness*
- *Performance of additional surface water and sediment sampling in water bodies in the Site vicinity to determine whether the Site may have impacted ecological receptors*

5.2 Status of Recommendations and Follow-Up Actions from the Third Five Year Review:

In response to the issues identified in the third five-year review period, follow-up actions were recommended. The status of each of these recommended actions is summarized in the following sections.

5.2.1 Institutional Controls

No institutional controls were established during the review period for the prevention of offsite groundwater use. Similarly, no enforceable institutional controls have been established for the long-term protection onsite; however, the Settling Defendants of the Site have entered into a Consent Decree with EPA to establish future land use restrictions to prevent disturbance of the landfill cap.

5.2.2 Non-Potable Groundwater Uses

An exposure scenario and associated evaluation of risk for non-potable groundwater use offsite was not included in the original risk assessment. No institutional controls for non-potable groundwater uses have been established to date.

5.2.3 Groundwater Monitoring Program

A formal groundwater monitoring program was not re-established during the review period; however, two sampling rounds were conducted, one in 2006 and the other in 2009. Fourteen monitoring wells and two extraction wells were sampled in 2006. Results from this round were documented in the Draft Evaluation Report of Groundwater Monitoring June 2006 Sampling Event (TRC, 2006a). In 2009, 18 monitoring wells and four extraction wells were sampled. Results from this event are documented in the

Groundwater Sampling Report (H&S Environmental, March 2010) and are discussed in Section 6.0 of this report.

5.2.4 Surface Water and Sediment Sampling

Two sampling events for surface water and sediment occurred since the last five-year review. The first was conducted in 2006 and included the collection of eight surface water and sediment sample pairs from Dunstable Brook, Flint Pond, and Flint Pond Marsh. Results from this round were documented in the Draft Ecological Evaluation Report June 2006 Sampling Event (TRC, 2006b). The report concluded that because certain ecological benchmarks for surface water and sediment were exceeded, future monitoring of these media was warranted. In 2009, 11 surface water and sediment pairs were collected and analyzed. Results from this event are documented in the Surface Water and Sediment Sampling Report (H&S Environmental, March 2010) and are discussed in Section 6.0 of this report.

6.0 FIVE YEAR REVIEW PROCESS

This section provides a summary of the five-year review process and the actions taken by EPA to complete this fourth five-year review.

6.1 Administrative Components

EPA is the lead agency for this five-year review. Support was provided by Richard Fisher, the EPA Remedial Project Manager for the Charles George Land Reclamation Trust Landfill Site. USACE personnel that contributed to this review included Ben Rice, Geologist; Ian Osgerby, Chemical Engineer; Jonathan Kullberg, Civil Engineer; and Larry Cain, Risk Assessor.

6.2 Community Notification and Involvement

A notice was published in *The Lowell Sun* on February 26, 2010 notifying the local community that a five-year review was being conducted for the Site. A similar notice will be published in this newspaper announcing that the five-year review report for the Site was completed, and that the results of the review and the report are available to the public at the local repository and EPA Region I office.

Community involvement was high leading up to the issuance of ROD III and thereafter during construction. Construction completion was attained in 1998. Since the last five-year review in 2005, no community concerns have been voiced to the EPA. EPA and MassDEP held informal informational meetings up until 1999.

6.3 Document Review

This five-year review included a review of relevant documentation including applicable decision documents and monitoring reports. Section 12.0 of this report contains a complete list of documents that were reviewed.

6.4 Data Review

6.4.1 Groundwater/Leachate

EPA contractor TRC reviewed groundwater analytical data collected during the third five-year review period and compared that data to historical data in order to evaluate whether the cleanup objectives of ROD III are being met. Groundwater samples collected from Site monitoring wells (Figure 4) in 1994, 1995, 1996, 1999, 2000, and 2001 and extraction wells WES-1, PW1-A, CDM-3, MH-2 and MH-4 in February 2002 were included in the review. Additional groundwater samples were collected in 2006 and 2009. Table 6-1 lists VOCs detected at concentrations that exceeded their respective MCLs in effect in 2001. Table 6-2 presents a similar summary for inorganic analytes. In general, the number of wells with VOC exceedances has been decreasing with time, while the number of wells with exceedances of inorganic compounds has remained relatively constant. Arsenic was the most commonly detected inorganic compound to exceed its MCL from year to year.

Table 6-1. Groundwater VOCs Exceeding MCLs.

Year	Sampling Event	Total Wells with Exceedences	Extraction Area	Number of Wells with Exceedences	List of Wells Sampled by Event	Analytes Exceeding Standards (see key)
1994	April	4	East	4	E&E FIT2	1
					GEI-F2	1
					JSB-1	1, 6
					MW-5	1
	November	8	East	5	E&E FIT2	1, 3, 4
					GEI-F2	1, 3
					GWC-2	4
					MW-5	1, 4
					MW-6	4
			Southwest	3	GWC-2	4
					MW-8	4
					MW-8A	4
1995	April	4	East	4	E&E FIT2	1, 3
					GEI-F2	1, 3
					JSB-1	3, 6
					MW-5	1
	October	4	East	4	CDM-4	3, 6
					E&E FIT2	1, 3
					GEI-F2	1, 3
					MW-5	1
1996	April	9	East	7	CDM-5B	4
					CDM-5S	1, 3, 4, 5
					E&E FIT2	1
					GEI-F2	1, 3
					JSB-1	4
					MW-5	1, 4
					MW-5A	4
			Southwest	2	BF-10	4
					SW-1	2
1999	April	2	East	2	CDM-5S	1
					GEI-F2	1, 3
	October	2	East	2	CDM-5S	1
					GEI-F2	1, 3
2000	April	3	East	3	CDM-5S	1
					GEI-F2	1,7
					GWC-1	1
	October	2	East	2	CDM-5S	1
					GEI-F2	3
2001	April	2	East	2	GEI-F2	1, 3, 7
					CDM-5S	1
2002	February	3	East	3	CDM-3	1
					PW-1A	1, 7
					WES-1	1
2006	June	1	East	1	CDM-3	1
2009	December	1	East	1	PW-1A	1

Key: 1. Benzene 2. Chlorobenzene 3. 1,2-Dichloroethane 4. Methylene Chloride 5. 1,1,2-Trichloroethane 6. Trichloroethene 7. Vinyl Chloride

Table 6-2 Groundwater Inorganic Analytes Exceeding MCLs.

Year	Sampling Event	Total Wells with Exceedences	Extraction Area	Number of wells with Exceedences	List of Wells Sampled by Event	Analytes Exceeding Standards (see key)
1994	April	8	East	4	E&E FIT2	8
					GEI-F2	8
					MW-5	8
					MW-5A	8, 15
			Southwest	3	GEI-11	14
					MW-9	15
					MW-9A	8
			Upgradient	1	MW-1A	14
	November	5	East	4	E&E FIT2	8
					GEI-F2	8, 11
					MW-5	8
					MW-5A	8
			Southwest	1	MW-9A	8
1995	April	5	East	4	E&E FIT2	8
					GEI-F2	8
					MW-5	8
					MW-5A	8
			Southwest	1	MW-9A	8
	October	8	East	6	CDM-4	8, 10, 12, 13, 15
					E&E FIT2	8
					GEI-F2	8
					MW-5	8
					MW-5A	8
					MW-6	9, 13, 14
			Southwest	2	MW-9	15
					MW-9A	8
1996	April	8	East	5	CDM-5S	8
					E&E FIT2	8
					GEI-F2	8
					MW-5	8
					MW-5A	8
			Southwest	2	MW-9	15
					MW-9A	8
			Upgradient	1	MW-1A	15
1999	April	6	East	5	CDM-5S	8
					E&E FIT2	8
					GEI-F2	8
					MW-5	8, 15
					MW-5A	8
			Southwest	1	MW-9A	8
	October	6	East	5	CDM-5S	8
					E&E FIT2	8, 14
					GEI-F2	8
					MW-5	8
					MW-5A	8
			Southwest	1	MW-9A	8
2000	April	11	East	7	CDM-5S	8
					E&E FIT2	8
					GEI-F2	8, 15
					GWC-1	8, 10, 13
					JSB-1	15
					MW-5	8
					MW-5A	8, 14

Year	Sampling Event	Total Wells with Exceedences	Extraction Area	Number of wells with Exceedences	List of Wells Sampled by Event	Analytes Exceeding Standards (see key)
			Southwest	2	MW-9	15
					MW-9A	8, 15
			Upgradient	2	MW-1	15
					MW-1A	15
	October	13	East	9	CDM-4	15
					CDM-5B	15
					CDM-5S	8, 15
					E&E FIT2	8, 15
					GEI-F2	8, 15
					GWC-1	8, 15
					JSB-1	15
					MW-5	8, 15
					MW-5A	8, 15
			Southwest	4	BF-11	15
					GEI-11	15
					MW-9	15
					MW-9A	8, 15
2001	April	7	East	5	MW-5	8, 15
					GEI-F2	8, 12
					MW-5A	8, 15
					E&E FIT2	8
					CDM-5S	8
			Southwest	2	MW-8A	8
					BF-10	11
2006	June	12	East	9	CDM-3	8
					CDM-5S	8
					E&E FIT2	8
					GEI-F2	8, 12
					MW-5	8
					MW-5A	8
					PW-1A	8
					WES-1	8
			Southwest	3	BF-10	8
					MW-8	8
					MW-8A	8
2009	December	13	East	9	CDM-3	8
					CDM-5S	8
					E&E FIT2	8
					GEI-F2	8, 13
					MW-5A	8
					MW-5	8
					PW-1A	8
					WES-1	8
			Southwest	4	BF-10	8
					MW-8	8
					MW-8A	8
					MW-9A	8

Key: 8. Arsenic 9. Cadmium 10. Chromium 11. Cyanide 12. Lead 13. Nickel 14. Silver 15. Thallium

A statistical analysis of groundwater data during the third five year review period was performed by EPA contractor TRC to evaluate concentration trends at selected monitoring wells and for select contaminants. Monitoring wells MW-5, GEI-F2, E&E FIT2, CDM-5S, JSB-1, MW-8, and MW-8A were used in the analysis because these locations are representative of key portions of the plume where MCLs exceedances have been observed historically. Benzene was selected for analysis because of its frequent occurrence at elevated concentrations. Despite not having established MCLs, both 1,4-dioxane and tetrahydrofuran (THF) were selected as representatives of landfill contamination due to their high frequency of detection and relatively high solubility and mobility in groundwater. In summary, the analyses showed statistically significant decreasing trends of these compounds in several wells. Details of the statistical analyses were provided in Attachment 3 of the Third Five-Year Review Report.

Contaminants that exceeded MCLs, as well as 1,4-dioxane and THF, in the 2006 and 2009 groundwater samples are listed in Table 6-3. Concentrations observed in selected wells were plotted along with earlier results in Figures 5 through 8 to compare past and present trends. Organic contaminants (benzene, 1-4-dioxane, and THF) appear to continue their overall decline, while arsenic concentrations exhibit either constant or possible increasing trends in the wells examined. With the exception of arsenic, no other groundwater contaminants exceeded their respective MCLs beyond the Site boundary (Figure 3). Observations with respect to the arsenic data are further discussed in Attachment 2.

Table 6-3. Selected Contaminants in Groundwater – 2006 and 2009 Sampling Rounds

Analyte	PAL	Overburden Wells										
		BF-10		CDM-5S		E&E-FIT2		MW-5A		MW-8A		MW-9A
		06/05/06	12/03/09	06/07/06	12/02/09	06/06/06	12/03/09	06/07/06	11/30/09	06/06/06	11/30/09	12/07/09
Arsenic	10 [1]	**<u>11.3J</u>**	**<u>10.9</u>**	**<u>289 J</u>**	**<u>370</u>**	**<u>89.1 J</u>**	**<u>33.4</u>**	**<u>129 J</u>**	**<u>109</u>**	**<u>170 J</u>**	**<u>203</u>**	**<u>10.4</u>**
Lead	15 [1]	1.0 U	1.8	0.79 J	4.0	4.2 J	0.42 U	1.0 U	0.26 J	0.40 J	1.6	0.65 J
Nickel	100 [2]	3.5	5.7 J	46.2	50.9	55.9	32.9	6.5	8.4	4.6	5.7	1.1 J
Benzene	5 [1]	0.50 U	0.50 U	3.5	0.85	4.0	1.5	1.2	0.50 U	0.40 J	0.50 U	0.50 U
THF	--	10 U	5.0 U	16	5.9	36	7.1	10 U	5.0U	10 U	5.0 U	5.0U
1,4-dioxane	--	1.6 J	8.7	440	210	540	180	4.5	2.4	160	120	1.4 J

Analyte	PAL	Bedrock Wells								Extraction Wells					
		GEI-F2		GEI-F2 (dup)	MW-5		MW-5 (dup)	MW-8		EW-CDM-3		EW-PW-1A		EW-WES-1	
		06/06/06	12/03/09	06/06/06	06/07/06	12/03/09	12/03/09	06/06/06	12/01/09	06/06/06	12/03/09	06/06/06	12/03/09	06/06/06	12/03/09
Arsenic	10 [1]	**<u>196 J</u>**	**<u>339</u>**	**<u>181 J</u>**	**<u>61.3 J</u>**	**<u>133</u>**	**<u>129</u>**	**<u>14.3 J</u>**	**<u>17.8</u>**	**<u>93.6 J</u>**	**<u>1120</u>**	**<u>241 J</u>**	**<u>227</u>**	**<u>26.0 J</u>**	**<u>159</u>**
Lead	15 [1]	**<u>60.2</u>**	**<u>135</u>**	**<u>45.3</u>**	1.0 U	0.49 U	0.22 U	1.0 U	0.22 U	1.0 U	0.81 J	1.0 U	0.65 J	1.0 U	0.18 U
Nickel	100 [2]	30.2	**<u>103</u>**	27.1	5.6	9.8 J	10.1 J	8.3	9.5	30.9	15.6 J	55.9	54.4 J	5.9	14.5 J
Benzene	5 [1]	2.2	0.98	2.2	1.4	0.46 J	0.46 J	0.73	0.50 U	**<u>5.4</u>**	0.88	**<u>43</u>**	**<u>6.7</u>**	0.5 UJ	0.39 J
THF	--	2.9 J	5.0 U	2.9 J	13	5.0 U	5.0 U	5.2 J	5.0 U	33	3.2 J	120	12	1.2 J	1.9 J
1,4-dioxane	--	140	66	140	28	27 J	14 J	370	200	410	98	750	240	44	83

Notes:
All units reported in micrograms per liter (ug/L)
PAL = Project Action Limit (TRC, 2006a)
1 - Maximum Contaminant Level
2 - Massachusetts Contingency Plan GW-1 Value
Values shown in **<u>bold and underlined</u>** equal or exceed PALs
J = estimated value below quantitation limit
U = analyte not detected at specified quantitation limit
dup = field duplicate sample
-- = no established PAL

6.4.2 Groundwater Elevations

Based on groundwater elevation data collected at the Site in 2006 and reported in the Draft Evaluation Report of Groundwater Monitoring June 2006 Sampling Event (TRC, 2006a), an overburden and shallow bedrock recharge area continues to exist north of the Site, with radial flow to the southwest, south, and east. The predominant flow in overburden and shallow bedrock continues to be to the southwest and east. Contours in overburden and shallow bedrock reflect a localized influence due to the operation of the southwest and eastern extraction systems.

6.4.3 Surface Water and Sediment

In 2006, surface water and sediment samples were collected from water bodies in the vicinity of the Site to assess potential adverse affects on ecological receptors. Samples were obtained from Flint Pond and Flint Pond Marsh east of the landfill, and from Dunstable Brook on the west (Figure 9). Previous surface water and sediment pairs were collected from these aquatic habitats in 1993 and 1999.

Surface water samples collected in 2006 were analyzed for VOCs and dissolved metals (field filtered samples). The results were reported in the Draft Ecological Evaluation Report June 2006 Sampling Event (TRC, 2006b). Trace concentrations of two VOCs, acetone and THF, were found in these samples; however, neither compound was reported at a concentration exceeding its ecological benchmark concentration. Several inorganic analytes, including aluminum, barium, iron, lead, and manganese, did exceed their respective ecological benchmark values (Table 6-4). Based on the concentrations and detection frequencies observed, continued surface water monitoring for both lead and manganese was recommended in the 2006 TRC report.

Collocated sediment samples were collected for VOCs, SVOCs, and metals analysis in 2006. Four VOCs, including 2-butanone, 2-hexanone, acetone, and benzene, were detected among the samples collected at concentrations exceeding their respective ecological benchmark values (Table 6-5), though none of these compounds was expected to present a significant risk to benthic biota. Among the SVOCs tested for, four PAHs (anthracene, pyrene, chrysene, and dibenzo(a,h)anthracene) were detected at concentrations exceeding benchmark values. All were found in samples collected from Dunstable Brook. Despite exceeding benchmark values (i.e., Threshold Effect Concentrations), sediment PAHs were well below Probable Effect Concentrations, and though impacts to benthic biota are possible at these concentrations, it was determined that adverse effects would be localized and only on sensitive benthic invertebrates.

Seven inorganic analytes were found in sediment samples at concentrations exceeding the benchmark screening values in one or more of the sediment samples collected in 2006 (Table 6-6). They included: arsenic, cadmium, iron, lead, manganese, nickel, and zinc. Cadmium, lead, and nickel were only detected in Dunstable Brook and the highest concentrations were reported in samples collected upgradient of the Site. Elevated manganese was detected in both Dunstable Brook and Flint Pond Marsh; however, the highest concentration was also reported in an upgradient sample. Iron and zinc concentrations were found at concentrations only moderately above the Low Effect Level, except for one iron concentration found at a Site stormwater discharge point (SED-5), which exceeded the Severe Effects Level benchmark for ecological receptors. Elevated arsenic concentrations were observed in seven of the eight samples collected – two reported values exceeded the Severe Effects Level benchmark.

Based on the 2006 results, it was determined that potential risk to aquatic and benthic biota exists in the habitats surrounding the Site and that surface water and sediment monitoring should continue. A subsequent surface water and sediment sampling round was performed in December 2009.

Analyte concentrations exceeding ecological benchmark values in the 2009 samples were compared to 2006 and 1999 results (Tables 6-4, 6-5, and 6-6). Important observations are summarized below.

- No VOCs were detected in any of the surface water samples collected in 2009 – THF and acetone, which were observed in 1999 and 2006, no longer appear to be present in surface water.

- Manganese and barium were reported in surface water samples at concentrations exceeding their respective ecological benchmark values in 2009 (Table 6-4). The manganese exceedances were limited to the Flint Pond Marsh. In the case of barium, the geographic distribution of the exceedances included upstream locations. These results are, by and large, consistent with past data. Other inorganic analytes (e.g. calcium, magnesium, potassium, and sodium) are also elevated in the Flint Pond Marsh samples. Due to the proximity of these sampling locations to U.S. Route 3 and the types of inorganic analytes detected there, a possible correlation with roadway runoff exists. Arsenic concentrations in the 2009 surface water samples are generally lower when compared to earlier results and all are less than the 150 ug/L benchmark (National Recommended Water Quality Criterion).

- Data from the 2009 sediment sampling round show two VOCs above ecological screening levels, however, both of these analytes were also detected in equipment blanks. These exceedances and equipment blank detections for acetone and 2-butanone were also present in the 2006 monitoring event. Additional data quality issues for the 2009 sampling event resulted in rejected data and the resulting incomplete data set prevented further evaluation of benzene, which was observed in the Flint Pond Marsh area, below both human health and ecological screening levels, during the 2006 sampling round (Table 6-5).

- Concentrations of PAHs continued to be observed above ecological screening levels in Dunstable Brook sediment in 2009, though a dissimilar suite of PAH compounds was found in this medium in earlier sampling rounds (Table 6-5). In addition, several of the PAHs were observed in upstream samples.

- Six inorganic analytes (arsenic, cadmium, iron, lead, manganese, and nickel) have historically been detected in sediments at concentrations greater than their respective ecological screening values. These same six appear in the 2009 data at similar concentrations (Table 6-6). Note that the only sample containing levels of lead that exceeded the ecological benchmark in the brook was collected from an upstream location.

Based on the above observations, the following general statements can be made: 1) VOCs do not appear to be a problem in either surface water or sediment; 2) PAHs continue to persist in Dunstable Brook sediments, albeit below concentrations associated with acceptable human health risk; 3) some metals (notably arsenic) continue to be present at elevated concentrations in both surface water and sediment; and 4) some contamination found in upstream surface water and sediment locations suggest the existence of other sources.

Table 6-4. Inorganic Analytes in Surface Water

		Dunstable Brook											
Analyte	PAL	SW-3	SW-3	SW-3A	SW-3B	SW-4	SW-5	SW-5	SW-5	SW-5 DUP	SW-6	SW-6	SW-6
		6/21/06	12/02/09	12/02/09	12/02/09	12/2/09	6/23/99	6/21/06	12/02/09	12/02/09	6/23/99	6/21/06	12/02/09
Aluminum	87[a]	82.6 J	114 U	105 U	108 U	121 U	70	200 UJ	120 U	120 U	**204**	**88.2 J**	189 U
Antimony	30[b]	2 U	0.25 U	0.21 U	0.23 U	0.20 U	NS	2 U	0.20 U	0.19 U	NS	2 U	0.22 U
Arsenic	150[c]	1.9	0.91 J	0.89 J	0.80 J	0.94 J	ND	6.2	0.93 J	0.80 J	ND	1.8	0.92 J
Barium	4[b]	**16.2**	**17.1 J**	**14.8 J**	**15.4 J**	**14.4 J**	**17.8**	**69.1**	**14.8 J**	**14.8 J**	**16.2**	**15.4**	**10.9 J**
Beryllium	0.66[b]	1 U	1.0 U	1.0 U	1.0 U	1.0 U	ND	1 U	1.0 U	1.0 U	ND	1 U	1.0 U
Cadmium	0.25[c]	1 U	1.0 UJ	0.010 J	1.0 UJ	1.0 UJ	ND	1 U	1.0 UJ	1.0 UJ	ND	1 U	0.0069 J
Calcium	--	9610	11600	10200	10600	8960	18800	62900	9120	9620	14700	8620	7390
Chromium	74[c]	0.36 J	0.28 J	0.19 J	0.34 J	0.33 J	ND	0.53 J	0.36 J	0.30 J	ND	0.48 J	0.60 J
Cobalt	23[b]	0.43 J	0.71 J	0.67 J	0.68 J	0.69 J	2.8	1 J	0.85 J	0.83 J	ND	0.59 J	1.3 J
Copper	9[c]	0.9 J	1.1 J	0.87 J	1.0 J	0.91 J	10.5	0.68 J	0.90 J	0.93 J	8.9	0.82 J	1.3 J
Iron	1000[a]	512	571	469	655	444	794	**3030**	451	440	555	494	742
Lead	2.5[c]	1 UJ	0.28 U	0.30 J	0.32 J	0.32 J	ND	3.9 J	0.45 J	0.28 U	ND	**7.4 J**	0.33 J
Magnesium	--	1910 J	2600	2360	2460	2240	4070	10200J	2280	2260	2990	1770 J	1740
Manganese	120[b]	72.6	7.4 J	3.8 J	19.3 J	9.4 J	**259**	**1010**	10.8 J	6.8 J	**638**	87.1	87.1 J
Mercury	0.77[c]	0.2 U	0.20 U	0.20 U	0.20 U	0.20 U	ND	0.2 U	0.20 U	0.20 U	ND	0.2 U	0.20 U
Nickel	52[c]	2.6	3.1	2.4	2.5	2.3	ND	5.6	2.3	2.2	ND	2.8	1.9
Potassium	--	2540 J	2830	2540	2640	2410	3740	13000	2470	2480	2690	2380 J	1690
Selenium	5[c]	5 U	5.0 U	5.0 U	5.0 U	5.0 U	ND	5 U	5.0 U	5.0 U	ND	5 U	5.0 U
Silver	0.36[b]	1 U	0.010 U	0.010 U	0.0085 U	0.0057 U	ND	1 U	0.0075 U	0.015 U	ND	1 U	0.035 J
Sodium	--	30000	34300	31500	32800	30600	43900	136000	31700	31100	38800	27800	21700
Thallium	12[b]	1 U	0.020 U	0.018 U	0.014 U	0.013 U	NS	1 U	0.011 U	0.015 U	NS	1 U	0.020 U
Vanadium	20[b]	0.52 J	0.38 J	0.56 J	0.40 J	0.42 J	ND	0.3 J	5.0 U	0.57 J	2.1	0.57 J	0.53 J
Zinc	120[c]	4.1 U	10.7 J	13.8 J	16.5 J	18.0 J	15.3	4.6 U	11.9 J	16.9 J	17:5	5.6 U	19.5 J

Notes:
All units reported in micrograms per liter (ug/L)
PAL = project action limit (TRC, 2006b)
Values shown in **bold and underlined** equal or exceed a PAL
J = estimated value, below quantitation limit
U = analyte not detected at specified quantitation limit
ND – not detected
NS = not analyzed during sampling event
-- = no established PAL
DUP = field duplicate sample
a = National Recommended Water Quality Criteria for Non-Priority Pollutants (Freshwater CCCs)
b = Toxicological Benchmarks for Screening Potential Contaminants of Concern for Effects on Aquatic Biota: 1997 Revision (Tier II Values: Secondary Chronic Value)
c = National Recommended Water Quality Criteria for Priority Pollutants (Freshwater CCCs)
1999 samples were unfiltered - results reported represent total recoverable concentrations
2006 and 2009 samples were filtered - results reported represent dissolved concentrations

Table 6-4. Inorganic Analytes in Surface Water (continued)

		Flint Pond				Flint Pond Marsh						
Analyte	PAL	SW-8 6/20/06	SW-8 12/01/09	SW-9 6/20/06	SW-9 12/01/09	SW-11 6/20/06	SW-11 DUP 6/20/06	SW-11 12/01/09	SW-14 6/20/06	SW-14 12/01/09	SW-15 6/20/06	SW-15 12/01/09
Aluminum	87^a	200 UJ	43.5 U	200 UJ	45.3 U	200 UJ	200 UJ	90.4 U	200 UJ	41.6 U	200 UJ	42.2 U
Antimony	30^b	2.0 U	0.23 U	2.0 U	0.25 U	2.0 U	2.0 U	0.22 U	2.0 U	0.30 U	2.0 U	0.38 U
Arsenic	150^c	3.6	0.65 J	2.0	0.92 J	3.8	3.4	1.0 UJ	3.8	0.52 J	11.1	0.77 J
Barium	4^b	**15.6**	**17.4 J**	**17.9**	**17.9 J**	**36.7**	**33.6**	**151 J**	**50.6**	**144 J**	**12.5**	**80.3 J**
Beryllium	0.66^b	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	0.093 J	1.0 U	1.0 U	1.0 U	1.0 U
Cadmium	0.25^c	1.0 U	1.0 UJ	1.0 U	0.12 J	1.0 U	1.0 U	1.0 UJ	1.0 U	0.043 J	1.0 U	1.0 UJ
Calcium	--	15200	12900	12800	12200	33500	32300	26000	34400	52400	27800	34000
Chromium	74^c	0.32 J	0.36 J	0.22 J	0.54 J	0.14 J	0.14 J	0.38 J	0.20 J	0.35 J	0.35 J	0.53 J
Cobalt	23^b	1.1	0.23 J	0.39 J	0.33 J	0.26 J	1.0 U	3.4 J	0.68 J	3.5 J	0.71 J	1.0 J
Copper	9^c	1.4 J	0.65 J	0.67 J	0.77 J	0.65 J	0.69 J	2.0 U	0.71 J	0.72 J	3.8	2.0 J
Iron	1000^a	**1450**	337	257	391	64.3 J	42.2 J	171 J	66.1 J	8.2 U	740	**1100**
Lead	2.5^c	**97.9 J**	0.23 U	1.0 UJ	0.29 U	1.0 UJ	1.0 UJ	0.15 U	1.0 UJ	0.24 U	1.0 UJ	1.1
Magnesium	--	2540 J	2430	1970 J	2230	4940 J	4780 J	4760	5190 J	9360	4110 J	5580
Manganese	120^b	**1530**	**171 J**	**324**	**199 J**	**344**	**344**	**5060 J**	**1430**	**8330 J**	**711**	**1690 J**
Mercury	0.77^c	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U
Nickel	52^c	2.2	1.1	1.8	1.2	4.1	4.3	3.0	4.8	6.2	4.9	3.3
Potassium	--	4170 J	2620	2760 J	2550	6450	6310	3450	6170	8470	7010	10200
Selenium	5^c	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	0.76 U	5.0 U	0.85 U
Silver	0.36^b	1.0 U	0.018 U	1.0 U	0.020 U	1.0 U	1.0 U	0.017 U	1.0 U	0.016 U	1.0 U	0.017 U
Sodium	--	48800	34900	38100	35300	122000	119000	132000	120000	526000	107000	571000
Thallium	12^b	1.0 U	0.018 U	1.0 U	0.014 U	1.0 U	1.0 U	0.069 U	1.0 U	0.047 U	1.0 U	0.016 U
Vanadium	20^b	0.13 J	5.0 U	0.15 J	5.0 U	0.17 J	1.0 U	5.0 U	0.31 J	5.0 U	0.38 J	5.0 U
Zinc	120^c	9.5 U	12.4 J	6.6 U	12.7 J	4.2 U	2.5 U	9.6 J	3.3 U	34.4 J	13.6	14.7 J

Notes:
All units reported in micrograms per liter (ug/L)
PAL = project action limit (TRC, 206b)
Values shown in **bold and underlined** equal or exceed a PAL
J = estimated value, below quantitation limit
U = analyte not detected at specified quantitation limit
NS = not analyzed during sampling event
ND – not detected
-- = no established PAL
DUP = field duplicate sample
a = National Recommended Water Quality Criteria for Non-Priority Pollutants (Freshwater CCCs)
b = Toxicological Benchmarks for Screening Potential Contaminants of Concern for Effects on Aquatic Biota: 1997 Revision (Tier II Values: Secondary Chronic Value)
c = National Recommended Water Quality Criteria for Priority Pollutants (Freshwater CCCs)
1999 samples were unfiltered - results reported represent total recoverable concentrations
2006 and 2009 samples were filtered - results reported represent dissolved concentrations

Table 6-5. Organic Analytes Exceeding Ecological Benchmark Values in Sediment

Analytes	ECO	Dunstable Brook										
		SED-3	SED-3	SED-3 DUP	SED-3A	SED-3B	SED-4	SED-5	SED-5 DUP	SED-5	SED-6	SED-6
		6/21/06	12/02/09	12/02/09	12/02/09	12/02/09	12/02/09	6/21/06	6/21/06	12/02/09	6/21/06	12/02/09
VOCs												
2-Butanone	270[a]	19 JEB	41 J	17 UJ	98	R	100	130 EB	NA	190	**1400 JEB**	17 J
2-Hexanone	22[a]	R	15 U	17 U	28 U	R	18 U	11 U	NA	22 U	R	28 U
Acetone	8.7[a]	**87 JEB**	**130 J**	**20 J**	**340 J**	R	**140 J**	**610 JEB**	NA	**250 J**	**1700 JEB**	**240 J**
Benzene	160[a]	R	15 U	17 U	28 U	R	18 U	11 U	NA	22 U	R	28 U
PAHs												
Anthracene	57[c]	**64**	**74 J**	25 J	62	**95 J**	6.8	46	17	8.7	3.3 U	19
Benzo(a)anthracene	110[a]	64	**150**	**130**	**130**	**170 J**	25	82	53	32	22 J	49
Benzo(a)pyrene	150[c]	3.3 U	110	110	69	110 J	24	66	90	24	3.3 U	69
Chrysene	166[c]	150	140	130	96	160 J	39	**350**	**240**	39	59	74
Dibenzo(a,h)anthracene	33[a]	3.3 U	26	26	17	31 J	7.0	**78**	**66**	9.8	3.3 U	23
Fluoranthene	423[c]	110	400 J	220 J	380	**520 J**	50	54	170	45	44	140
Fluorene	77[c]	11 J	**170 J**	27 J	**240**	**290 J**	11	14	13	8.3 U	19 J	12
Naphthalene	176[c]	3.3 U	**250 J**	9.3 J	**400**	**600 J**	6.6 U	3.3 U	4.2 J	8.3 U	3.3 U	9.6 U
Phenanthrene	204[c]	56	**510 J**	170 J	**640**	**870 J**	47	40	120	41	44	120
Pyrene	195[c]	150	**320**	**210**	**310**	**430 J**	67	**350**	**230**	68	110	150

Notes:
All units reported in micrograms per kilogram (ug/kg) - values shown in **bold and underlined** equal or exceed specified ecological benchmark values
ECO = ecological benchmark values (TRC, 2006b)
EB = detected in equipment blank
J = estimated value
R = rejected data point
U = analyte was not detected at the specified quantitation limit
UJ = estimated nondetect
NA = not applicable/not available
ND = not detected
DUP = field duplicate sample
a = Toxicological Benchmarks for Screening Contaminants of Potential Concern for Effects on Sediment-Associated Biota: 1997 Revision
b = USEPA, 2002. ECOTOX Users Guide: Ecotoxicology Database System, Version 3.0
c = MacDonald, D., C. Ingersoll, and T. Berger, 2000. Development and Evaluation of Consensus-Based Sediment Quality Guidelines for Freshwater Ecosystems.

Table 6-5. Organic Analytes Exceeding Ecological Benchmark Values in Sediment (continued)

Analytes	ECO	Flint Pond						Flint Pond Marsh									
		SED -8	SED - 8	SED -8	SED -9	SED -9	SED -9	SED -11	SED -11	SED -11 DUP	SED -11	SED -14	SED -14	SED -14	SED -15	SED -15	SED -15
		6/24/99	6/20/06	12/01/09	6/24/99	6/20/06	12/01/09	6/24/99	6/20/06	6/20/06	12/01/09	6/24/99	6/20/06	12/01/09	6/24/99	6/20/06	12/01/09
VOCs																	
2-Butanone	270[a]	NA	80 EB	13 U	NA	58 EB	16 U	58 J	250 JEB	310 JEB	R	ND	130 JEB	R	60	**<u>380 JEB</u>**	170 J
2-Hexanone	22[a]	NA	12 U	13 U	NA	6.5 U	16 U	ND	R	R	R	ND	**<u>100 J</u>**	R	ND	19 J	R
Acetone	8.7[a]	ND	**<u>420 EB</u>**	13 UJ	**<u>47</u>**	**<u>210 EB</u>**	16 UJ	**<u>230 J</u>**	**<u>930 JEB</u>**	**<u>1200 JEB</u>**	R	**<u>160</u>**	**<u>500 JEB</u>**	R	**<u>56</u>**	**<u>1400 JEB</u>**	**<u>470 J</u>**
Benzene	160[a]	ND	12 U	13 U	ND	6.5 U	16 U	39	14 J	27 J	R	**<u>350</u>**	8.6 J	R	**<u>330</u>**	**<u>230 J</u>**	R
PAHs																	
Anthracene	57[c]	NA	NA	4.9 U	NA	NA	13	NA	NA	NA	26 J	NA	NA	19 UJ	NA	NA	17 UJ
Benzo(a) anthracene	110[a]	ND	NA	4.9 U	ND	NA	14	ND	NA	NA	93 J	ND	NA	20 J	ND	NA	17 UJ
Benzo(a) Pyrene	150[c]	ND	NA	4.9 U	62 J	NA	6.3 U	120 J	NA	NA	100 J	39 J	NA	19 UJ	ND	NA	17 UJ
Chrysene	166[c]	ND	NA	4.9 U	ND	NA	15	ND	NA	NA	120 J	47 J	NA	30 J	ND	NA	25 J
Dibenzo(a,h) anthracene	33[a]	ND	NA	4.9 U	ND	NA	6.3 U	NA	NA	NA	26 J	NA	NA	19 UJ	NA	NA	17 UJ
Fluoranthene	423[a]	ND	NA	4.9 U	35 J	NA	42	64 J	NA	NA	210 J	80 J	NA	43	87 J	NA	29 J
Fluorene	77[a]	ND	NA	4.9 U	ND	NA	27	NA	NA	NA	25 UJ	NA	NA	19 UJ	NA	NA	17 UJ
Naphthalene	176[c]	ND	NA	4.9 U	88 J	NA	51	ND	NA	NA	25 UJ	160	NA	19 UJ	**<u>320</u>**	NA	17 UJ
Phenanthrene	204[c]	ND	NA	5.5	36 J	NA	86	65 J	NA	NA	160 J	89 J	NA	29 J	120 J	NA	26 J
Pyrene	195[c]	ND	NA	4.9 U	38 J	NA	39	75 J	NA	NA	**<u>220 J</u>**	60 J	NA	48 J	85 J	NA	39 J

Notes:
All units reported in micrograms per kilogram (ug/kg) - values shown in **<u>bold and underlined</u>** equal or exceed specified ecological benchmark values
ECO = ecological benchmark values (TRC, 2006b)
EB = detected in equipment blank
J = estimated value
R = rejected data point
U = analyte was not detected at the specified quantitation limit
UJ = estimated nondetect
NA = not applicable/not available
ND = not detected
DUP = field duplicate sample
a = Toxicological Benchmarks for Screening Contaminants of Potential Concern for Effects on Sediment-Associated Biota: 1997 Revision
b = USEPA. 2002. ECOTOX Users Guide: Ecotoxicology Database System, Version 3.0
c = MacDonald, D., C. Ingersoll, and T. Berger, 2000. Development and Evaluation of Consensus-Based Sediment Quality Guidelines for Freshwater Ecosystems.

Table 6-6. Inorganic Analytes Exceeding Ecological Benchmark Values in Sediment

		Dunstable Brook									
Analyte	ECO	SED-3	SED-3	SED-3 DUP	SED-3A	SED-3B	SED-4	SED-5	SED-5	SED-6	SED-6
		6/21/06	12/02/09	12/02/09	12/02/09	12/02/09	12/02/09	6/21/06	12/02/09	6/21/06	12/02/09
Arsenic	9.79[a]	**26**	**42.1**	**33.1**	**23.7**	**31.5 J**	9.1	**64**	9.2	**25**	9.0
Cadmium	0.99[a]	.46 J	0.17 J	0.19 J	0.47 J	0.31 J	0.15 J	0.4 J	0.24 J	**1.2 J**	0.72 UJ
Iron	20000[b]	**24000**	**37100 EB**	**31800**	**23100 EB**	**25100 JEB**	7440 EB	**54000**	9830 EB	**28000**	14200 EB
Lead	35.8[a]	23	17.1 J	14.2 J	30.0 J	27.1 J	19.4 J	22	22.0 J	**61**	**61.9 J**
Manganese	460[b]	**1500**	**509 J**	377 J	**1040 J**	**2360 J**	273 J	440	248 J	**3600**	81.6 J
Nickel	22.7[a]	21	**29.4**	**27.1**	**32.8**	**31.7 J**	15.9	**37**	22.3	**38**	15.6

		Flint Pond					
Analyte	ECO	SED-8	SED-8	SED-8	SED-9	SED-9	SED-9
		6/24/99	6/20/06	12/01/09	6/24/99	6/20/06	12/01/09
Arsenic	9.79[a]	2.6	17	1.9	**48.6**	**46**	1.9
Cadmium	0.99[a]	ND	0.14 J	0.26 UJ	0.24	0.19 J	0.44 UJ
Iron	20000[b]	2190	5500	3310 EB	7020	11000	1650 EB
Lead	35.8[a]	2.7	23	5.2 J	21.2	17	7.6 J
Manganese	460[b]	19.4	47	42.4 J	428	**480**	19.3 J
Nickel	22.7[a]	1.4	5.1 J	5.7	15.9	19	5.3

		Flint Pond Marsh									
Analyte	ECO	SED-11	SED-11	SED-11 DUP	SED-11	SED-14	SED-14	SED-14	SED-15	SED-15	SED-15
		6/24/99	6/20/06	6/20/06	12/01/09	6/24/99	6/20/06	12/01/09	6/24/99	6/20/06	12/01/09
Arsenic	9.79[a]	**10.6 J**	**21**	**25 J**	**9.8 J**	**27.6**	8.1 J	**17.9 J**	**25**	**25**	**18.6 J**
Cadmium	0.99[a]	0.34	0.48 J	0.53 J	0.93 J	0.48	0.49	1.8 R	0.25	0.25	1.5 R
Iron	20000[b]	9360	13000	15000 J	2780 JEB	17600	6900	12800 JEB	10000	10000	16000 JEB
Lead	35.8[a]	20.9	14	15 J	**126 J**	11.3	18	**45.6 J**	6.3	6.3	26.2 J
Manganese	460[b]	296	**580**	**660 J**	**1320 J**	**676**	150	**766 J**	**540**	**540**	278 J
Nickel	22.7[a]	10.8	12	13 J	**26.9 J**	11.3	11	**28.7 J**	9.0	9.0	**30.9 J**

Notes:
All units reported in milligrams per kilogram (mg/kg) - values shown in **bold and underlined** equal or exceed specified ecological benchmark values
ECO = ecological benchmark values (TRC, 2006b)
EB = detected in equipment blank
ND = not detected
J = estimated value, below quantitation limit
U = analyte not detected at specific quantitation limit
UJ = estimated nondetect
DUP = field duplicate sample
a = MacDonald, D., C. Ingersoll, and T. Berger, 2000. Development and Evaluation of Consensus-Based Sediment Quality Guidelines for Freshwater Ecosystems.
b = Guidelines for the Protection and Management of Aquatic Sediment Quality in Ontario, June 1992.

6.4.4 Landfill Gas Collection and Flare System

6.4.4.1 Flare System Operation Records

The October 2005 to December 2009 monthly inspection logs prepared by Clean Harbors were reviewed to evaluate flare O&M activities. The percentage of Site visits for which the flare was found to be operational during each semiannual or quarterly reporting period appears to be not unlike the prior 5 year review period. Weekly flare inspection logs indicate that overall, the flare has had no major operational or maintenance problems, no more down time than operating time since the last Five Year Review, but has had some typical replacements in the flare monitoring system. The exception was for the period January through September, 2005 where the flare was essentially down for most of the second and third quarters for parts replacement including an oxygen sensor and a louver drive motor/control unit. Overall, the unit was operating for only about seven percent in this semi-annual period, primarily attributed to low flare temperature. Intermittent operation is not unusual for an aged landfill as indicated by the sporadic methane production and reduced concentration. In addition, the system collected landfill gas from the upper portions just below the cap and not from the depths of the interior and is subject to atmospheric pressure fluctuations which can be positive or negative on a temporal basis. This causes air and hence oxygen to enter the upper landfill below the cap when the ambient pressure is greater than the local landfill cap pressure. The vacuum pumping system at the flare provides a negative pressure when operating to collect the gas and transfer to the flare. As described in the Third Five-Year Review Report, the percentage of time the flare was operational appears to have decreased steadily over the past years, from approximately 35 percent during the first quarter of 2000, to approximately 21 percent for the last quarter of 2004. This has continued through this reporting period except for 2005 when an extended shutdown for two quarters was incurred reducing it to approximately 7 to 8 percent. Clean Harbors technicians reported that the flare typically runs between eight (8) and 24 hours per week. The oxygen sensors are frequently replaced. The air compressor and VFD were replaced in the third and fourth quarters of 2006. Clean Harbors' weekly observations have indicated that most of the time, the flare is off as a result of an automatic shutdown due to a low temperature alarm in the stack. This information indicates that the flare temperature decreases after several hours or days of burning, regularly causing the flare to be extinguished. This likely occurs at a point when the levels of collected methane gas become too low to fuel the flare, and/or the levels of oxygen in the system are too high. However, the flare control system does not measure methane, so there is no real-time verification of low methane levels triggering the flare shutdowns. Clean Harbors technicians responsible for O&M of the flare indicated that intrusion of air/oxygen into the gas collection system has been an ongoing problem since the start up of the enclosed flare in April 1998. This apparent intrusion was also a problem during operation of the open flare system. Methane concentrations at the flare are monitored and recorded at the flare sample port on a semiannual basis. Methane concentrations are also measured within the gas collection system at several landfill gas header sample ports on a semiannual basis. However, it should be noted that the flare was not operating immediately prior to the majority of the semiannual flare sample port and landfill header port sampling events. Therefore, methane measurements are not likely representative of full-scale operating conditions and possibly biased high due to build-up of gas in the system while the flare is not burning. Flare sample port methane concentrations were, on average, around 50 percent. Based on the above information, the frequent shutdown of the flare indicates that the landfill may not be generating enough methane to keep the flare running as currently configured and/or that there may likely be air/O2 infiltration into the header system at the toe drain connection. However, as discussed below, based on landfill gas monitoring performed in soil gas probes located around the perimeter of the landfill, it appears that landfill gas is being contained within the gas collection system and is not migrating beyond the landfill cap.

The flare does not operate more than three to five days continuously and frequently less than this. This intermittent operation can cause operating challenges with the current flare system. Alternative systems may be considered in the future depending on operations status, as well as on risk evaluations.

6.4.4.2 Soil Gas Probe Data

Soil gas measurements of oxygen, carbon dioxide, hydrogen sulfide, methane, and VOCs are recorded on a semi-annual basis at twenty soil gas probes located near the perimeter of the Site and at the boundary of a downgradient development (i.e., "Cannongate"). Probe locations are shown in Figure 10. The monitored probes are located as follows: (a) seven probes at the fence line to the north of the leachate collection pond and landfill; (b) six probes at the fence line northwest of the landfill, across from a residence at the corner of Cummings and Dunstable Roads; (c) two probes south of the landfill along the fence line near the southwest sedimentation basin; and (d) five probes southeast of the landfill along the northern edge of the Cannongate development. One of the probes near the Cannongate development (SG-CG-31) was previously destroyed during prior five year review periods plus SG-CG-2 vent is also destroyed (first noted in the semi-annual report, January through June, 2007, dated December 15, 2007). Occasionally, vents have water in the sample tube and cannot be sampled (almost routinely for SG-CG-4 and 5 vents in the 2nd quarter of 2005). Measurements were taken using a Landtech GA-90 hand held instrument.

Soil gas probe data sheets are used by Clean Harbors to record quarterly soil gas results. Clean Harbors noted in the checklists used for the flare system that the flare should be started manually one day prior to the soil gas probe measurements to ensure the flare was operating during soil gas measurement events. Water in the sample tube occasionally prevents measuring the probe gas composition.

Methane concentrations were non-detect for all probes in the probe data recorded in quarterly and semi-annual soil gas probe monitoring events. Hydrogen sulfide concentrations and VOCs were non-detect except for one event reported in the 2005 semi-annual report where VOC was 9.4 ppm. Oxygen levels were essentially 21 percent but occasionally a few percent below this but with less than a few ppm of CO_2. Problems were occasionally noted by Clean Harbors with some of the probes during sampling, namely due to water intrusion (e.g., SG-CG-4), and the probes near Cannongate, or low gas flows in the wells near the west detention/sedimentation basin. The temporary probes will be replaced with permanent probes.

The landfill gas monitoring data from the last monitoring period up to September 30, 2009 does not appear to indicate any issues with migration of landfill gas beyond the limits of the cap. No explosive concentrations of methane have been detected over the last five years. Therefore, the landfill cap and gas collection system appear to be functioning properly to limit the migration of landfill gas. As noted in the previous subsection above, the gas collection system and the vents should be monitored as the flare operations become ever more intermittent due to inadequate flammability/flow of landfill gas.

6.4.5 Gas Vent/Landfill Gas Collection System Monitoring Data

Landfill gas is sampled quarterly by Clean Harbors in a network of 22 gas collection system header ports or former gas vents, and three former monitoring wells that were tied into the gas collection system. During the period from March 2005 to June 2009, methane concentrations measured in the gas collection system have been generally within the range from 36 to 76.1 percent. The lowest overall methane concentrations were detected at a converted monitoring well during the third and fourth quarter of 2006 sample event, where methane levels dropped to 0.3 percent. O&M records did not indicate a reason for this drop in methane levels. Clean Harbors carried out pressure testing and video testing of the gas collection system in the second half of 2003. Methane levels measured subsequent to the pressure testing have been consistent with historic levels measured in the gas collection system.

Comparison of flare inspection dates with gas vent sampling dates indicates that the flare was not running at the start of any of the gas vent sampling events. A Clean Harbors technician noted that the flare was down upon arrival on each date, and then was manually started at the onset of gas vent sampling activities. Therefore, landfill gas concentrations at the time of sampling are not representative of full-scale operating conditions, and are likely artificially high due to build up of methane in the gas collection system while the flare is not running. Sampling at the flare sample port when the unit had been restarted ranged between 36 and 56 percent methane with oxygen ranging 3.6 to 0.6 percent. Lack of continuous operations of the flare blower/landfill gas extraction accounts for a wide range of variability in gas composition and flow conditions in the gas collection system.

Clean Harbors technicians noted that air/oxygen intrusion into the gas collection system has been an ongoing problem and may be attributed to the configuration of the landfill gas vents, which are seated within the cover layer but do not fully penetrate the wastes. Pressure testing and video inspection of the system completed in 2003 did not identify any large leaks in the system that would account for the high levels of oxygen.

6.4.6 Southwest Groundwater Extraction Trench Data

The five extraction pumps and associated instrumentation of the southwest extraction trench system are inspected weekly by Clean Harbors. Clean Harbors reported that the southwest extraction trench has operated without major issues although the pumps have been shut down frequently for high water levels in the wet well. The pumps generally restart without trouble once reset. Each week, one pump is removed for inspection and cleaning if necessary. Fouling of the pumps, especially Pump No 3, was the most frequent maintenance problem noted. Fouled pumps are soaked overnight (or longer if needed) in a cleaning solution (e.g., acetic acid) to remove build up. Other occasional maintenance issues include normal wear on the pumps and level sensors, and freezing of the pump discharge lines, often rendering one or more pumps out of service through the winter months. Based on review of southwest extraction system inspection checklists, it appears that the system operated with an average of two out of five pumps running at most times. Inspection shows that the average number of operating pumps has been around four at most times, indicating that maintenance activities have become more successful in maintaining efficient operation of the system. Over the past five years, no major problems have been reported with operation and maintenance of the southwest extraction system. Infrequent mechanical and electrical issues with the pumps and vaults are addressed in a timely manner. Weekly maintenance activities appear adequate to keep the systems operating. The primary issue related to the fouling may be the lack of continuous operations due to low water flows, leading to prolonged exposure to atmospheric air/oxygen in the wet well sump.

6.4.7 Landfill Maintenance Inspections

A landfill security and maintenance inspection is performed twice per year, usually in June and December. According to MassDEP maintenance records, the landfill cap is mowed twice per year (spring and fall). A commercial herbicide (i.e., "Roundup" or similar weed control product) is applied to the rock cover portions of the cap and detention basins once per year. MassDEP and Clean Harbors reported that the herbicide program has been successful in limiting woody vegetative growth in the stone, rip rap and drainage areas, which was a recurring issue in the past, as noted in the previous five-year review. Occasional repairs are made to the fence and gates surrounding the landfill as a result of fallen trees or vandalism, and missing warning signs are regularly replaced. Overall, Clean Harbors reported few problems with the Site security fence or the warning signs posted along it in their weekly inspections from 2000 to 2005. Potholes and ruts are regularly observed and repaired on the perimeter roadway around the landfill. Some areas of potholes and possible wash-outs are noted and may require repair each spring after the snow melts.

Other current maintenance issues include potential settlement of the overflow pipe in the West Detention and Sedimentation basin. The intake of this 18" diameter vertical standpipe is less than one foot from the bottom of the basin, and was currently covered by ice on the northern half of the pipe. Clean Harbors planned to review as-built drawings for this drain pipe to determine the amount of settlement, if any, and identify repair options. Another issue with the West Detention and Sedimentation basin is an apparent loss of grade at Dunstable Road that causes sedimentation in the vicinity of the basin outfall and flooding of the basin out onto Dunstable Road. MassDEP has had a berm constructed alongside the fence line in an attempt to keep the street stormwater flow separate from site stormwater. MassDEP personnel have previously reported that sediments in the ditch need to be cleaned out from the sedimentation basin outfall to the berm at Dunstable Road.

6.4.8 East and West Pump Stations (Army Corps of Engineers)

USACE personnel reported that the East Pump Station has been functioning as intended with no major maintenance issues over the past five years. However, historically, one of the three pumps has been inoperable for an extended period of time. To prevent iron biofouling in the discharge lines, a biocide (Redux B-T20®) and a 50 percent citric acid solution are added to the pump station discharge using an automated chemical feed system. The citric acid is added continuously at approximately 200 ppm based on USACE onsite laboratory testing, which indicated that four times the dissolved iron concentration would be a reasonable estimate of the chelant concentration and would account for most variations experienced at the site. Tolcide (biocide) is added at approximately 300 ppm for an hour, twice each day to control the potential for bacterial fouling in the wet wells where some exposure to air is inevitable.

According to USACE personnel, the West Pump Station has generally been without major maintenance issues over the past five years. In 2004, a repair was made to a leaking section of HDPE pipe coming from the West Pump Station wet well where it daylights into the pump station building. The leaking section was removed and spliced with a new piece of HDPE pipe. However, USACE personnel reported that the new section of pipe was leaking and that a more permanent repair would need to be made.

Occasional leachate odor is reported at the West Pump Station. USACE personnel also reported that the pipes connecting the pump stations to the Effluent Monitoring Station are occasionally cleaned to remove iron buildup if the pressure in the force mains is high.

6.4.9 Effluent Monitoring

Effluent flow and pH are monitored continuously and other parameters are monitored on a monthly or quarterly basis as shown in the Table 6-7. Reported results are provided to the LRWU on a quarterly basis using prescribed forms by the site contractor Nobis Engineering, Inc. between 2005 and May 2008, and by the new site contractor H&S Environmental thereafter. The permit allows discharge of the effluent from the site to the sanitary sewer which allows its contents to be transferred to the TWD and ultimately to the LRWU. Effluent limitations are regulated for the combined discharges of Process 001 and Process 002 (East and West Pump Stations) at Site 001 (Effluent Monitoring Station) under the classification LRWU's Industrial Wastewater Pretreatment Program. The LRWU has determined that the landfill does not have any discharges prescribed under the Categorical Discharger Rule.

Table 6-7. Effluent Limitations

o Parameter	o Limit (unit)	o Frequency	o Sample Type
Flow	86,400 (gpd)	o Continuous	o Meter
pH	5.0 – 9.5 (SU)	o Continuous	o Meter
Acidity	MO	o Quarterly	o Grab
Arsenic	0.556 (mg/L)	o Quarterly	o 24-hour Composite
Chemical Oxidant Demand (COD)	MO	o Quarterly	o 24-hour Composite
Chromim (Total)	8.108 (mg/L)	o Quarterly	o 24-hour Composite
Copper	3.124 (mg/L)	o Quarterly	o 24-hour Composite
Lead	0.857 (mg/L)	o Quarterly	o 24-hour Composite
Nickel	1.541 (mg/L)	o Quarterly	o 24-hour Composite
Total Suspended Solids (TSS)	MO	o Quarterly	o 24-hour Composite
Total Toxic organics (TTO)	MO	o Quarterly	o Grab

Flow is typically between 600,000 and 1,000,000 gallons/month thus less than 12,000,000 million gallons/year as shown in Table 6-8 and the permit would allow up to 2,500,000 gallons per month. Monthly quantities are thus typically well below the permit level which provided for additional discharge capacity for the lagoon contents prior to its demolition in October, 2009. Prior to 2000, the extraction and leachate flows were temporarily stored in the lagoon thus precipitation added to the total while the performance under sequestration and biocide treatment were evaluated by LRWU. In 2001 the lagoon bypass was approved by LRWU with discharge directly through the effluent monitoring station.

Additional requirements described as monitoring only (MO) and to be reported in the quarterly report included summarizing the flow and pH and the concentration of acetone, 1,4 dioxane, and THF. Concentrations of 1,4-dioxane and THF provide a useful indicator of the extent of the plume as they are generally stable, highly soluble compounds. There have been no exceedances in any of these parameters in the current five year period. All additional parameters monitored on a regular (monthly) basis are also to be reported, which typically include biological oxidant demand (BOD), RCRA metals not otherwise specified above, VOCs, SVOCs, PCBs, Pesticides by EPA Methods (624, 625 and 608 respectively).

Table 6-8. Flow Measurements

Year	Month Read	Cumulative Volume (gallons)
1998	December 31	10,161,915
1999	December 31	17,557,626
2000	September 29	27,738,187
2001	September 30	38,263,950
2002	December 31	51,132,788
2003	January 5 (2004)	60,386,755
2004	January 3 (2005)	68,978,117
2005	January 3 (2006)	79,914,411
2006	January 2 (2007)	89,148,619
2007	December 31	95,662,738
2008	December 31	103,868,922*
2009	June 30	108,419,000**

* Computer totalized after June due to meter tripping until reset to zero at 100,000,000 gallons
** Final report submitted by USACE prior to transfer from EPA to MassDEP.

6.4.10 Lagoon Demolition/Well Rehabilitation

6.4.10.1 Lagoon Demolition

The lagoon had provided temporary storage for the untreated extraction and leachate collection flows until December 1997, and also during the period from December 1997 through May 2001 for the treated flows. Temporary storage was provided for up to 3.5 million gallons at which point a temporary treatment facility was erected to treat the lagoon contents to very stringent compliance requirements prior to release into a drainage swale as surface water. In 1998, extracted groundwater and leachate collection flows still continued to be transferred to the lagoon for temporary storage prior to pumping to an effluent monitoring tank and release into the sanitary sewer connection at the Cummings Road Pumping Station. A period of monitoring was undertaken after a letter for a change of operation was transmitted from the USACE to the LRWU (February 25, 2000) to determine if the iron sequestration and biocide addition was effective in preventing iron/bacterial fouling of the sewer line and the transfer lines of the TWD and LRWU.

As required by LRWU Permit No. 085, a letter was submitted in 2000 to explain the change in the effluent discharge from the Site, detailing the intent to bypass the lagoon and directly transfer the extraction and leachate collection flows to the effluent monitoring tank prior to release into the sanitary sewer. A letter of acceptance was issued by LRWU in May making this change permanent. No compliance issues have been reported since this operating change was made active.

The lagoon demolition began in October and was completed on November 24, 2009 under contract to H&S Environmental and their subcontractor Maximillian.

6.4.10.2 Well Rehabilitation

As part of preparations for the transfer of facilities from EPA/USACE to the MassDEP on September 30, 2009, extraction wells, wet wells at the East and West Pump Stations, and the Effluent Monitoring Tank were shut down for cleaning. This was the first scheduled cleanout since the sequestration project was initiated in 1998. An Extraction Well and Wet Well Cleaning/Preventive Maintenance Report on these activities was prepared and released by H&S Environmental on November 23rd, 2009 (H&S, 2009e). Geosearch Inc. was the cleanout subcontractor; pre- and post-development well performance data are presented in Table 6-9 below.

Table 6-9. Summary of Extraction Well Performance

			Pre-Redevelopment		Post Development		
Extraction Well	Pump Condition	Well Condition	Flow Rate (gpm)	Drawdown (ft)	Flow Rate (gpm)	Drawdown (ft)	Final Flow Rate (gpm)
WES-1	Good	Good	4.5	10	9	13	6
CDM-3	Good	Good	1.5	10	1.5-2	*	1
PWI-A**	Good	Good	> 12	4	N/A	N/A	4.5

* Not recorded

** Re-development not required due to high flow potential

It was noted that no significant quantity of sediment was observed in any of the wet wells even after many years of lagoon operations. The Effluent Monitoring Tank did have a significant quantity of sediment, but is likely related to the closure of the lagoon and pumping of disturbed sediments. It was noted that the sediments looked to be more of an organic nature (possibly through airborne deposition) than oxidized iron or other inorganic precipitate.

6.4.11 Site Operating Expenditures:

Tables 6-10 and 6-11 summarize operating expenditures and costs during the current review period.

Table 6-10. Site Operating Expenditures

Year	EPA Costs ($)	MassDEP Costs ($)	Total ($)
2005	181,329	35,247	216,576
2006	201,870	77,407	279,277
2007	198,522	55,330	253,852
2008	335,816	59,291	395,107
2009	183,341	85,023	268,364
Non-Routine Maintenance*	613,422		613,422
Miscellaneous Items	110,979		110,979

*Special Items (non-routine): plan documents, increased non-routine activities, SCADA upgrade, demolition and removal of the lagoon, well/tank rehabilitation, and hazardous waste disposal.

Note: Rehabilitation of the extraction wells, east and west wet wells, equilibration tank was not implemented until EPA to MassDEP site management transition (work was carried out by H&S Environmental)

Table 6-11. Chemical Treatment (Sequestration) versus Estimated GWTP (Precipitation) Costs

Item	Capital	Annual O&M	Year	Annual Cost	Annual Savings
Proposed GWTP *	$4,265,500	$405,000	1997-1998	$ 4,670,500	
Sequestration**	$10,000	$17,000	1998	$27,000	$4,643,500
Sequestration		$17,000	1999	$17,000	$388,000
Sequestration			2000-2009	$170,000	$3,880,000
Total To Date			1998-2009	$204,000	$8,911,500***
Total Projected			1998 – 2028	$527,000	$16,283,500

*Evaluation of Discharge Options, 7 June, 1996, Roy F. Weston, Inc. (Weston Solutions, Concord, NH)
**Value Engineering Proposal, 1 February, 1998; Actual Incurred O&M Chemical Costs
***Actual savings to date

6.5 Site Inspection

Inspections of the site were performed on November 24, 2009 and December 7, 2009. Trip reports and photographs detailing field observations are provided in Attachment 3. The following personnel were in attendance during the November 24, 2009 inspection:

Richard Fisher	RPM, EPA Region 1
David Buckley	Project Manager, MassDEP
David O'Connor	Project Engineer, USACE (EPA Contractor Representative)
Douglas Murphy	O&M Technician, Clean Harbors (MassDEP O&M Contractor Rep)
Peter Hugh	Five-Year Review Technical Lead, USACE
Larry Cain	Five-Year Review Inspection Team, USACE
Ian Osgerby	Five-Year Review Inspection Team, USACE
Ben Rice	Five-Year Review Inspection Team, USACE

The following personnel were in attendance during the December 2009 Site inspection:

David O'Connor	Project Engineer, USACE (EPA Contractor Representative)
Jonathan Kullberg	Five-Year Review Inspection Team, USACE

6.5.1 November 2009 Site Inspection

The November inspection consisted of visits to the landfill perimeter road, leachate and groundwater collection systems, former leachate collection pond, landfill cap and gas vent piping, and landfill gas blower building and flare facility.

6.5.1.1 Perimeter Road

An inspection of the gravel perimeter road was conducted via vehicle beginning at the southwestern gate entrance on Dunstable Road, moving eastward along the southern limits of the landfill and circling north and then westward along the periphery of the landfill and ending at the main entrance on Cummings Road on the northern side of the site. In general, the road appeared to be in good condition at the time of the inspection, showing minimal signs of surface water erosion, rutting, or standing water. The security fence, which flanks the perimeter road along much of its course, appeared to be in good condition and devoid of any observable breaches.

6.5.1.2 East Pump Station

The eastern pump station groundwater and leachate collection and treatment facility was visited and inspected. The system is largely automated, requiring periodic checking by the O&M contractor. Pumped groundwater and collected leachate are blended in an underground mixing tank, pumped up to a building where it is treated with citric acid and a biocide to reduce iron precipitation before it is pumped westward to an effluent monitoring station. In general, the above ground components appeared to be in good condition and working properly. The west pump station was not visited during the inspection, but, according to site O&M personnel, the system is essentially identical in design to the east pump station and operated and maintained in a similar manner.

6.5.1.3 Inactive Leachate Collection Pond

At the time of the inspection, removal of the inactive leachate collection lagoon was underway. The lagoon, which has not been in operation for approximately ten years, was originally designed to collect landfill leachate and groundwater. According to site personnel, sediment excavated from the former lagoon was being disposed of offsite as F001 code hazardous waste though the contaminant concentrations were expected to be relatively low. Sediment and liner material removal was nearly complete at the time of the inspection, and the surface was re-graded and recently seeded. In-situ sub-bottom soil samples were not available at the time of this review.

6.5.1.4 Landfill Cap and Gas Vents

The surface of the landfill appeared to be in good condition, with some differential settlement noted on the easternmost limit near the crest. No significant indications of erosion, standing water, cracks, bulges, or slumps were noted. The former depression repair site, centrally-located near the crest of the landfill, appeared to be in good condition. Numerous survey monuments were noted on the northern flank of the landfill along the cap access road. According to site personnel, these monuments were left over from a cap differential settlement study conducted several years ago and are no longer in use. Vegetation at the top of the landfill appeared to be properly established, healthy (no obvious evidence of stress), and well maintained. The steeper flanks of the cap, which are capped with crushed aggregate, appeared to be in good condition as well, devoid of significant woody vegetation.

One gas vent pipe well located at the top of the landfill was arbitrarily selected as a representative for inspection. The access lid was not locked. Vent piping appeared to be in good condition and, according to site personnel, the riser pipe is welded to the cap liner. There was no visible or olfactory evidence of landfill gas leakage at the penetration point. The gas vent located at the highest point of the crest of the landfill is equipped with a pressure relief value to prevent excessive pressures from building beneath the cap in the event of a gas extraction system failure; it was not visited during the inspection.

6.5.1.5 Landfill Gas Collection and Flare Facility

Piping from the numerous landfill vents are manifolded and piped to the blower building where gas is extracted from beneath the cap. From there, the gas is pumped to the flare house where it is thermally destroyed in an enclosed flare tower. According to site personnel, the gas is comprised of predominantly methane and carbon dioxide. The flare uses the methane as fuel – there are currently no fuel supplements to enhance combustion. Oxygen concentrations within the gas mixture have continued to rise in recent years, presumably through leakage at the vent cap penetrations and/or the toe of the landfill slope. Due to the potential explosive mixture when oxygen concentrations in the gas exceed five percent, the flare automatically shuts down. According to site personnel, this occurs as frequently as 2 to 3 times per week. The flare does not appear to automatically relight once it shuts off, requiring a technician to check the status and reset/ignition conditions.

6.5.2 December 2009 Site Inspection

The December inspection focused specifically on the landfill cap and appurtenant structures. See attached inspection checklist in the appendices.

6.5.2.1 Landfill Cap

The landfill inspection began by travelling the access road at the top of the landfill from west to east. The perimeter access road was then travelled in a clockwise direction starting at the project office building. The landfill had a light coating of snow from the day before; however, this did not significantly impede the inspection. Features of the landfill inspected included the cap, the drainage swales, and access roads. Observations were made regarding the vegetative cover, gravel cover, erosion, settlement, and general condition of the various features.

- The landfill surface is in good condition and all slopes appear stable. The areas with vegetated surfaces appeared healthy and dense with full coverage. The areas covered with crushed stone appeared stable without any signs of distress, other than some observed vehicle tracks on the side slopes (most likely produced by off-road vehicles).

- A depression was noted at the eastern end of the top of the landfill, at the end of the upper most access road. This depression was noted in previous inspections, and is about a foot deep and roughly 50 feet across, which matches previous descriptions. It was noted by past project personnel that this area was a truck turnaround during construction of the landfill. There does not appear to be any damage or malfunctioning of the cap in this area.

6.5.2.2 Appurtenant Structures

- Minor ponding and associated vegetative growth was noted in the perimeter drainage swale on the northeast and the south-central sides of the landfill. The vegetative growth should be controlled with an herbicide.

- The east, southwest and west detention and sedimentation basins all have woody growth, in some areas near the riprap. The woody growth could be controlled by removal and/or regular application of an herbicide if appropriate.

- The access roads were in generally good condition.

- The gas header connection on the south-central perimeter of the landfill cap was observed to be disconnected at the time of this inspection. This vent, along with the other two vents at the toe of the landfill, has been taken off line in an attempt to limit oxygen infiltration. Removal of the three toe drain vents did not have a noticeable impact on flare operations, however, they will remain off line in order to mitigate the potential of oxygen infiltration.

6.6 Interviews

6.6.1 Onsite Interviews

Following the completion of the November 24, 2009 site visit, a collective interview was conducted onsite at the O&M Building with members of the USACE five-year review team (Peter Hugh, Larry Cain, Ian Osgerby, and Ben Rice) and site personnel representing USEPA (Rich Fisher, Dave O'Connor, Bob Santonsuosso, and Patrick Schauble) and MassDEP (Dave Buckley and Doug Murphy). An interview log is provided in Attachment 4. Significant observations include:

- Initial capacity problems occurred shortly after construction of the permanent alternative water supply line. These problems were corrected shortly thereafter by the Lowell Regional Water Utility and there are no current problems with the supply system and its associated extensions at this time.

- The landowner has entered into a consent decree with USEPA to established institutional controls to prevent future site access and establish future use limitations to prevent exposure to site contaminants.

- The only major alteration, modification, or repair made to the leachate and ground water recovery and associated treatment systems is the removal of sediments and the liner from the former leachate collection lagoon. The lagoon has been inactive since the permanent leachate and groundwater recovery systems were installed. No major changes have been made to the landfill cap or gas collection and treatment system in the past five years, though the existing landfill gas remote monitoring system (SCADA) was upgraded recently

- The Town of Tyngsborough has instituted a policy against installation of water supply wells on parcels having access to the municipal water supply (Interview with Joan Ferarri, Health Administrator for the Tyngsborough Board of Health on March 10, 2005 in *Third Five-Year Review for the Charles George Land Reclamation Trust Landfill Superfund Site*; USEPA, 2005). No enforceable institutional controls have been established to restrict access to groundwater for potable and non-potable (e.g., drinking water, livestock, and irrigation). These concerns were discussed with the local municipalities some time ago for nearby residential properties, but there has been little interest. All nearby potential groundwater users are currently on the LRWU water supply line except for one residential property. This particular property is located up-gradient of the site and not likely to be impacted by groundwater contaminated originating at the site.

- Environmental monitoring during the 2005-2009 review period included: semi-annual sampling of landfill gas, primarily for methane; groundwater; and surface water and sediment (at Flint Pond, Flint Pond Marsh, and Dunstable Brook) in June 2006 and December 2009. No formal monitoring programs for groundwater or surface water and sediment have been established during the review period. Groundwater samples were collected for analysis of VOCs, including 1,4-dioxane and tetrahydrofuran, and total metals. Surface water samples were analyzed for VOCs, including 1,4-dioxane and tetrahydrofuran, and dissolved metals. Sediment samples were analyzed for VOCs, including 1,4-dioxane and tetrahydrofuran, PAHs, TOC, and metals.

- MassDEP is considering replacing some of the temporary perimeter soil gas probes that are used for the semi-annual soil gas surveys sometime in 2010.

- Past sediment accumulation in the drainage swales located along Dunstable Road bordering the western side of the site was determined to be caused by winter road sanding by the local municipalities. The condition has been corrected by construction of an earthen berm, which diverts street runoff away from the site.

- Conversations with the superintendent of the Tyngsborough Sewer Commission regarding the iron build-up downstream of the sanitary sewer revealed that the precipitation was essentially a film or sheen and not a significant accumulation of iron floc. No associated mechanical problems have been reported by the superintendent.

6.6.2 Telephone Interviews

Telephone interviews were conducted in January 2010 with representatives of the Town of Tyngsborough (local municipality). Interview logs are provided in Attachment 4 and summaries are provided below.

<u>Mr. Kevin O'Conner – 14 Jan 2010:</u>

Mr. O'Conner is a former member of the Tyngsborough Board of Selectmen, serving for nine years between 2000 and 2009. He is also a former residential abutter to the Site, living on Brookview Circle for 27 years prior to 2007, and is currently the Town's Veterans Agent. Notable discussions topics follow.

- Regarding his overall impression of the site, Mr. O'Conner could think of no significant issues or negative events associated with the Site that affected him as a residential abutter, or that he was alerted to as a member of the Board of Selectmen. He has been impressed and reassured by the managing regulatory agencies' regular and frequent presence onsite personnel and their attention to detail including cap maintenance (grass mowing) and prompt repairs of the security fence.

- Mr. O'Conner stated that the Tyngsborough Board of Selectmen received many information letters and notices (submitted by MassDEP primarily) over the course of his tenure on the board. He believes this regular correspondence kept them well informed on site activities, project progress, and upcoming events.

- As an abutting resident and municipal representative, Mr. O'Conner could think no problems or issues with the site that the five-year review should focus on. He could not recall and site visits, inspections, reporting activities, conducted by Tyngsborough Board of Selectmen during the past five years.

- There has been some industrial development abutting the landfill property to the northeast of the Site, but Mr. O'Conner was not aware of any nearby residential build-out or use changes in the vicinity in the past five years.

- As a former member of the Board of Selectmen, he would have been aware of any events or situations that would have required a response by Town officials. Mr. O'Conner could not recall any complaints, violations, or incidents related to the site or site operations during the past five years.

- Mr. O'Conner recognized the current level attention being given to the remedy by the regulatory agencies, and suggested and hoped they continue their commitment to the Site in the future.

Mr. Matt Marro – 19 Jan 2010:

Mr. Marro is the current Director of Conservation for the Town of Tyngsborough Conservation Commission, and has served as the Town's full-time environmental affairs investigator for the past three years.

- Mr. Marro is familiar with the Charles George Landfill and routinely (3 to 4 times per week) passes by the site as part of his job. Overall, he has no issues with the site, though his knowledge of specific onsite activities and conditions is limited.

- The Conservation Commission has not received any informational letters and notices during the past five years. However, Mr. Marro is interested in being kept apprised of site activities and upcoming events that are typically communicated to the Town. He requested that he be included on the appropriate distribution lists.

- Part of Mr. Marro's job is to observe and evaluate environmental conditions such as stressed vegetation, odors, and surface water quality within the Town of Tyngsborough. He is not aware of any problems associated with the site at this time and is does not have any specific issues that the five-year review should focus on and he could not recall reporting activities, site visits, or inspections conducted by the Conservation Commission during the past five years.

- Regarding existing or planned changes to the site and surrounding properties in the last five years, Mr. Marro indicated that beaver damming along Dunstable Brook in the vicinity of the site has become problematic in recent years. He stated that continued dam construction in that area will ultimately pose a problem for storm water runoff and the potential for flooding for the site and nearby residential properties will increase. He also speculated that flooding could adversely impact groundwater recovery on the southwestern side of the landfill.

- To his knowledge, neither Mr. Marro nor the Conservation Commission has received complaints, observed violations, or been notified of other incidents related to the site requiring a response. The Conservation Commission office has received no calls or complaints associated with the site.

- Mr. Marro asked that he be included on the distribution list for any regular correspondence between site management and the municipality. In addition, he recommended that beaver damming along Dunstable Brook be monitored periodically throughout the year by site management to evaluate possible current and future impacts on site operations.

7.0 TECHNICAL ASSESSMENT

This section addresses the following three technical assessment questions identified in EPA's guidance document for conducting Five-Year Reviews:

7.1 Question A: Is the remedy functioning as intended by the decision documents?

Yes. This five year review has evaluated monitoring data, documentation, ARARs, site visit information, and risk information generated during the review period. This information indicates that the remedy is functioning as intended by the decision documents. Future groundwater and land use institutional controls have not been established to prevent groundwater use and access to the landfill cap in the future. Institutional controls to prevent use of potentially contaminated groundwater and to prevent future disturbance of the landfill cap should be established to maintain protectiveness over the long-term. Recent sampling data indicate the need for continued monitoring, since the concentrations of some constituents may not be stable or decreasing. This is further discussed below in the context of Question C.

7.2 Question B: Are the exposure assumptions, toxicity data, cleanup levels, and remedial action objectives (RAOs) used at the time of remedy selection still valid?

Yes. Table 7-1 presents the differences in toxicity values that have occurred since the remedy was selected. Although minor changes have occurred since the 3rd five year review (in 2005), none of these changes appear to affect the protectiveness of the selected remedy because groundwater is not being used for drinking purposes. The noted changes are highlighted in Table 7-1. Shaded cells indicate a change to a toxicity value. An underlined value means that the change is toward a more stringent toxicity value.

In February 2010, USEPA released for review a final draft version of the Toxicological Review of Inorganic Arsenic, In Support of Summary Information on the Integrated Risk Information System (IRIS). That document is a precursor to a change that may be made in the IRIS database resulting in a more stringent oral cancer toxicity value for inorganic arsenic. The change is not reflected in the IRIS database at the time of this five year review. The anticipated toxicity value is 17 times more stringent than the current value, so the cleanup goal for the Site may need to be revisited at some time in the future.

1,4-dioxane is an industrial chemical that has lately been identified as an emerging contaminant that may be appropriate for regulation. There is no federal drinking water standard for 1,4-dioxane, but a recently developed standard is available from the Commonwealth of Massachusetts. Although a cleanup goal for 1,4-dioxane was not identified at the time of the ROD, one may be appropriate since it is a common industrial chemical that is consistently detected in the groundwater at the landfill.

Table 7-1. Comparison of 1988 and 2010 Oral Reference Doses and Oral Cancer Slope Factors for Compounds of Concern

Contaminant of Potential Concern	Oral Reference Dose (RfD) (mg/kg-day)		Oral Slope Factor (SF) $(mg/kg\text{-}day)^{-1}$	
	1988	2010	1988	2010
2-Butanone	0.05	0.6	N/A	N/A
Benzoic Acid	N/A	4	N/A	N/A
Di-n-butylphthalate	0.1	0.1	N/A	N/A
4-Methylphenol (p-Cresol)	N/A	0.005	N/A	N/A
trans-1,2-Dichloroethene	N/A	0.02	N/A	N/A
Toluene	0.29	0.08	N/A	N/A
Arsenic (a)	N/A	0.0003	1.5	1.5
Benzene	N/A	0.004	0.052	0.055
Cadmium (food)	0.00029	0.001	N/A	N/A
Cadmium (water)	0.00029	0.0005	N/A	N/A
Chromium (as VI)	0.005	0.003	N/A	N/A
Mercury (as salts)	0.002	0.0003	N/A	N/A
Benzo(a)anthracene (b)	N/A	N/A	11.5	0.73
Chrysene (b)	N/A	N/A	11.5	0.0073
Benzo(b)fluoranthene (b)	N/A	N/A	11.5	0.73
Benzo(a)pyrene (b)	N/A	N/A	11.5	7.3
Indeno(1,2,3-cd)pyrene (b)	N/A	N/A	11.5	0.73
Dibenz(a,h)anthracene (b)	N/A	N/A	11.5	7.3
Trichloroethene	N/A	N/A	0.011	0.0059
bis(2-Ethylhexyl)phthalate	0.02	0.02	0.00068	0.014
Methylene chloride	N/A	0.06	0.0143	0.0075
1,2-Dichloroethane	N/A	0.02	0.035	0.091
Chloroform	N/A	0.01	0.081	0.031
1,1-Dichloroethene	N/A	0.05	1.16	N/A
1,1,2,2-Tetrachloroethane	N/A	0.004	0.2	0.2
Vinyl chloride	N/A	0.003	0.025	0.72
Carbon tetrachloride	N/A	0.0007	0.13	0.13
1,1,2-Trichloroethane	N/A	0.004	0.0573	0.057
Tetrachloroethene	N/A	0.01	0.0017	0.54
Chlorobenzene	0.0057	0.02	N/A	N/A
Xylenes	0.2	0.2	N/A	N/A
Bromomethane	0.0004	0.0014	N/A	N/A
Bromoform	0.02	0.02	N/A	0.0079
Carbon disulfide	0.1	0.1	N/A	N/A

N/A = Not Applicable or Not Available
Changed values are indicated with shading, new values or changes that are more stringent are underlined.
(a) Arsenic oral slope factor used in 1998 sediment re-assessment was 1.75 (mg/kg-day)-1.
(b) Oral slope factor (2005) for this compound is the same as that used for the 1998 re-sediment assessment.

7.2.1 Review of ARARs

The 1983 ROD preceded the revised National Contingency Plan (40 CFR Part 300, March 1990) and CERCLA Compliance with Other Laws Manual: Parts I and II, (OSWER Directives 9234.1-01 and 9234.1-02, respectively). The 1983 ROD set forth the Safe Drinking Water Act as an ARAR for the selected remedy. The second ROD in 1985, also developed prior to the revised National Contingency Plan (40 CFR Part 300, March 1990) set forth the ARARs. At the time, key guidance documents for conducting analysis of ARARs were not yet in existence, so detailed analysis of the applicability or relevance and appropriateness of each regulation were not provided in the ROD. ARARs for the Site identified in the 1988 ROD include the following:

Chemical-specific ARARs for groundwater cleanup and leaching targets
SDWA MCLs

Location-specific ARARs
Federal Executive Order 11990 (Protection of Wetlands)
Clean Water Act (CWA) (including dredge and fill regulations)
Clean Air Act
Although it was not specified, the ROD presumably also includes Federal Executive Order 11988 (Floodplain Management)

Action-specific ARARs
Although it was not specific, the ROD specified compliance with "RCRA corrective action," which presumably includes:
RCRA General Facility Standards
RCRA Preparedness and Prevention Requirements
RCRA Groundwater Monitoring Requirements
RCRA Surface Impoundment Closure Requirements
Other RCRA Requirements for training, inspections and design for treatment and monitoring

"To Be Considered" policies, criteria, and guidance:
Massachusetts State AALs (Allowable Ambient Limits) for stack emissions.
Although it was not specific, the ROD specified risk-based cleanup goals and noted the groundwater classification, which presumably includes:
EPA Risk Reference Doses (RfDs)
EPA Human Health Assessment Cancer Slope Factors (CSFs)
EPA Health Advisories, Human Health and Ecological Risk Assessment Guidance
EPA Final Groundwater Use and Value Determination Guidance

Although changes have occurred over time, the changes that have occurred in the federal MCLs and "to be considered" criteria do not call into question the effectiveness of the remedy because groundwater is not being used for drinking purposes. The SDWA was last amended in 1996, and only one change has been promulgated since 1997 for any of the contaminants of concern (COCs) in groundwater.

The action-specific ARARs are directed at the remedial response activities that are now complete, so they are not considered in this review. Some initial ARARs addressing groundwater treatment and discharge to surface water are no longer applicable because the remedy changed and groundwater and leachate are discharged to the LRWU. Over the years, several rules have been amended and re-designated for operators of hazardous waste treatment, storage, and disposal facilities. However, any such activity at the Site is now minimal. No changes have occurred since the time of the ROD that would call into question the protectiveness of the remedy.

The selected Applicable or Relevant and Appropriate Requirements supporting the remedy were checked for newly promulgated standards and TBC (to be considered) for chemicals of potential concern identified in the remedy. No such changes that might affect the protectiveness of the remedy were identified during the current review period.

Tables provided in the previous five-year review are carried forth to this five year review in Attachment 5.

7.2.1.1 Chemical-Specific ARARs and TBCs

The chemical-specific ARARs for groundwater in Table 2 of Attachment 5 consist of SDWA MCLs and Massachusetts MCLs (MMCLs), along with federal MCL Goals (MCLGs) and Massachusetts Office of Research and Standards Guidelines (ORSGs). These latter guidelines are not enforceable and are to be considered, whereas the SDWA MCLs and MMCLs are promulgated standards and thus are relevant and appropriate criteria.

The MCL for arsenic was changed in 2001 from 50 µg/L to a more stringent 10 µg/L and became enforceable on January 23, 2006. The updated MCL may therefore be a more appropriate cleanup goal than is specified in the ROD, although the interim goal remains protective since the water currently is not used as a source of drinking water. The cleanup goal may be subject to further more stringent revision based on anticipated changes to toxicity values for arsenic, as noted in Section 7.2 (Question B). This change does not affect remedy protectiveness because public water is available in the area. Upcoming evaluations of arsenic will likely require careful consideration of naturally occurring background concentrations as determined from samples collected from upgradient monitoring wells. Additionally, the MassDEP Office of Research and Standards guideline for 1,4-dioxane in drinking water of 3 ug/L is to be considered as a non-enforceable guideline that did not exist at the time of RODs. The MassDEP's Groundwater Use and Value determination should be examined, and, if necessary, revised. Consideration could be given to updating the groundwater cleanup levels based on any revisions to the use and value determination.

7.2.1.2 Location-Specific ARARs

The wetland requirements identified in the 1988 ROD for Flint Pond, Dunstable Brook, and wetlands bordering the Site remain in effect. The 1985 ROD compensated for an anticipated loss of wetlands on the north side of the landfill by establishing a larger wetland south of the Site. Wetlands affected by remedial actions were assessed in 1990 in the *Wetland Damage Assessment Report* (HMM, 1990). Approximately 1.5 acres of wetlands were filled during capping activities and an additional 5 acres were altered or damaged. The noted report outlined general mitigation requirements and procedures. A wetlands inspection in 1993 found that the wetland mitigation proposed in the Wetland Damage Assessment Report had not been addressed. No replicated wetlands were observed, although the damages were found. No wetlands remain onsite and their replacement is impractical (USEPA, 2000). As part of the cap remedy, three acres of sedimentation basins constructed to collect surface water runoff are providing an environment that resembles a wetland.

7.2.1.3 Action-Specific ARARs

Treatment of landfill gas is with an enclosed gas flare that meets requirements for Best Available Control Technology (BACT). With no treatment total VOCs emitted would be less than 0.368 ton per year, which is less than the 1 ton per year limit that would require additional air quality controls.

7.3 Question C: Has any other information come to light that could call into question the protectiveness of the remedy?

No. As noted under *Question A*, however, certain constituents warrant focused monitoring during the upcoming review period. This is discussed further in the following subsections.

7.3.1 Groundwater

As discussed in 6.4.2, the concentration of arsenic in groundwater at GEI-2 (BR) has recently increased, and more monitoring data is needed to determine if the increase is outside the range of expected variability.

Table 7-2 shows the most recent sample results for groundwater containing tetrahydrofuran and 1,4-dioxane. Although these substances are being observed, they are not included in the RODs or ESD.

Table 7-2. Tetrahydrofuran and 1, 4-Dioxane in Groundwater

Target Analyte	Location	Sample Date	Conc (µg/L)	RSL (µg/L)	Is Conc>RSL?
Tetrahydrofuran	CDM-5S	12/2/2009	5.9	NA	NA
	E&E-FIT2	12/3/2009	7.1	NA	NA
	EW-CDM-3	12/3/2009	3.2	NA	NA
	EW-PW-1A	12/3/2009	12	NA	NA
	EW-WES-1	12/3/2009	1.9	NA	NA
	SW-TRENCH	12/3/2009	2.9	NA	NA
1,4-Dioxane	BF-10	12/3/2009	8.7	6.1	**Yes**
	CDM-5B	12/2/2009	34	6.1	**Yes**
	CDM-5S	12/2/2009	210	6.1	**Yes**
	DS-1	12/4/2009	270	6.1	**Yes**
	DS-2	12/4/2009	280	6.1	**Yes**
	E&E-FIT2	12/3/2009	180	6.1	**Yes**
	EW-CDM-3	12/3/2009	98	6.1	**Yes**
	EW-PW-1A	12/3/2009	240	6.1	**Yes**
	EW-WES-1	12/3/2009	83	6.1	**Yes**
	GEI-10	12/2/2009	1	6.1	No
	GEI-F2	12/3/2009	66	6.1	**Yes**
	JSB-1	12/1/2009	37	6.1	**Yes**
	MW-12	12/7/2009	1.1	6.1	No
	MW-5	12/3/2009	27	6.1	**Yes**
	MW-5 (dup)	12/3/2009	14	6.1	**Yes**
	MW-5A	11/30/2009	2.4	6.1	No
	MW-8	12/1/2009	200	6.1	**Yes**
	MW-8A	11/30/2009	120	6.1	**Yes**
	MW-9	12/4/2009	12	6.1	**Yes**
	MW-9A	12/7/2009	1.4	6.1	No
	SW-TRENCH	12/3/2009	71	6.1	**Yes**

Conc – Concentration
NA – Toxicity value or RSL not available
RSL – Most recent USEPA Regional Screening Level

There are numerous exceedances of the 6.1 µg/L RSL for 1,4-dioxane, which is a carcinogen. The RSL corresponds to a target cancer risk of 1×10^{-6}. Note that fewer exceedances occur at a concentration of 61 µg/L (cancer risk of 1×10^{-5}), and none exceed 610 µg/L (cancer risk of 1×10^{-4}). Also note that several of the samples were taken from groundwater treatment extraction and discharge points, although several (e.g., MW-8 and MW-8A) are from monitoring wells. Although they are not listed in the ROD, the results indicate that these substances should continue to be included as target analytes for upcoming monitoring efforts.

Further evaluation of the cleanup goals should be considered based not only on the aforementioned revision to the MCL for arsenic and the updated risk evaluation criteria for 1,4-dioxane, but for anticipated future groundwater use which may be studied by the State. In the meantime, continued observations in the area and dialogue with local officials are necessary to monitor the current use, or lack thereof, of groundwater for drinking water and/or irrigation purposes.

7.3.2 Sediments

The ROD dated 1988 called for dredging Dunstable Brook to achieve a risk-based concentration of 1 mg/kg PAHs in the residual sediment. The goal to protect human health was stated as follows:

> *To reduce to acceptable levels the existing incremental cancer risks above 1x10(-6) for a most probable exposure scenario.*

The cleanup goal of 1 mg/kg total PAH was in 1988 expected to achieve a residual cancer risk of 4×10^{-6}. None of the recently reported concentrations for PAHs exceed this limit. A brief evaluation of risk to human health using more up-to-date methods is provided below and in Attachment 6. This evaluation demonstrates that the human health risks associated with PAH levels observed in sediment of Flint Pond, Flint Pond Marsh, and Dunstable Brook are below EPA acceptable risk criteria of 1×10^{-4} cancer risk and Hazard Quotient of 1.

Recently reported concentrations of target analytes (VOCs and PAHs) in sediment at Flint Pond and Flint Pond Marsh are shown in Table 7-3. Table 7-3 shows PAH concentrations in recent sediment samples that exceed current USEPA Regional Screening Levels (RSLs) for residential soil. Since there are no human health risk screening values for sediment, the RSLs for residential soil were used as a conservative screening level for sediment. The use of RSLs for residential soil as a screen for sediment is very conservative because likely sediment exposure is much lower than residential soils due to much lower exposure intensity/frequency and because there is a tendency for sediments to be washed off in overlying surface water. The risk evaluation given in Attachment 6 was conducted because of these RSL exceedances.

Table 7-3. Recently Detected Target Analytes in Sediment.

Maximum Reported Concentration in Sediment in December 2009						USEPA Regional Screening Level (RSL) for Residential Soil	Exceeds Residential Soil RSL? (Yes/No)			Ratio of Exceedance (Concentration/RSL)		
Target Analyte	Dunstable Brook	Flint Pond	Flint Pond Marsh	Max of Any	Max Location		Dunstable Brook	Flint Pond	Flint Pond Marsh	Dunstable Brook	Flint Pond	Flint Pond Marsh
	mg/kg	mg/kg	mg/kg	mg/kg		mg/kg						
2-Butanone	0.19	<0.013	0.17	NA	Dunstable Brook	28,000	No	No	No	--	--	--
2-Hexanone	<0.028	<0.013	NA	NA	NA	210	No	No	No	--	--	--
Acetone	0.34	<0.013	0.47	NA	NA	61,000	No	No	No	--	--	--
Anthracene	0.095	0.013	0.026	0.095	Dunstable Brook	17,000	No	No	No	--	--	--
Benzene	<0.028	<0.013	NA	NA	NA	1.1	No	No	No	--	--	--
Benzo(a)anthracene	0.17	0.014	0.093	0.17	Dunstable Brook	0.15	Yes	No	No	1	--	--
Benzo(a)pyrene	0.11	<0.0063	0.10	0.11	Dunstable Brook	0.015	Yes	No	Yes	7	--	7
Chrysene	0.16	0.015	0.12	0.16	Dunstable Brook	15	No	No	No	--	--	--
Dibenzo(a,h)anthracene	0.031	<0.0063	0.026	0.031	Dunstable Brook	0.015	Yes	No	Yes	2	--	2
Fluoranthene	0.52	0.042	0.21	0.52	Dunstable Brook	2,300	No	No	No	--	--	--
Fluorene	0.29	0.027	<0.025	0.29	Dunstable Brook	2,300	No	No	No	--	--	--
Naphthalene	0.60	0.051	<0.025	0.60	Dunstable Brook	3.6	No	No	No	--	--	--
Phenanthrene	0.87	0.086	0.16	0.87	Dunstable Brook	NA	No	No	No	--	--	--
Pyrene	0.43	0.039	0.22	0.43	Dunstable Brook	1,700	No	No	No	--	--	--

The RSL is the lower of the concentrations associated with either a target hazard quotient of 1 or a cancer risk of 1:1,000,000.
Max - Maximum Concentration.
NA- Not available.

Three carcinogenic PAHs in Dunstable Brook, and two PAHs in Flint Marsh Pond exceed their respective RSLs. In order to assess the cumulative effects of multiple carcinogens and mutagens for the purpose of this review, risks were calculated using the following exposure parameters:

- Resident.
- Chronic exposures.
- Ingestion rate of 100 mg/day (child), and 50 mg/day (adult).
- Exposed skin surface area of 2,500 cm^2 per day.
- Adhesion factor of 0.2 mg/cm^2.
- Particulate (airborne dust) emission factor of 1.36 m^3/kg.
- Inhalation exposure time of 24 hours per day.
- 350 days per year exposed.
- Body weights of 15 kg (child) and 70 kg (adult).
- Duration of noncancer exposure of 6 years (child) and 24 year (adult).
- Duration of carcinogenic/mutagenic exposure of 14 years (child) and 14 years (adult).
- Lifetime of 70 years.

As mentioned previously, the exposures evaluated are for soil in a residential setting. The risk estimates offered simply as an interim check of the observations made during the five year review, since screening levels are exceeded. The risk results are presented in Tables 7-5 and 7-7.

Table 7-5 indicates that the greatest noncancer hazard quotient is for the child, at 0.00007. This estimate is far below the limit of 1 that is used under CERCLA to determine the need for remediation. Table 7-7 indicates that the total cancer risk estimate for the resident is 1×10^{-6}. This estimate is within EPA's acceptable risk range of 1×10^{-6} to 1×10^{-4}. The conclusion is that although there are exceedances of residential soil RSLs, none of the risk estimates approach levels of concern. As noted previously, using soil exposures to represent sediment exposures produces uncertainty, but in this case tends toward overestimation of actual risks, as corroborated by the risk evaluation in Attachment 6.

Table 7-4. Chemical-Specific Parameters Used in Noncancer Risk Estimates for This Five-Year Review

Analyte	GIABS	Dermal ABS	RfDo (mg/kg/day)	RfDd (mg/kg/day)	RFC (mg/m^3)
ANTHRACENE	0.76	0.13	3.00E-01	3.00E-01	NA
BENZ[A]ANTHRACENE	0.31	0.13	NA	NA	NA
BENZO[A]PYRENE	0.31	0.13	NA	NA	NA
CHRYSENE	0.31	0.13	NA	NA	NA
DIBENZ[A,H]ANTHRACENE	0.31	0.13	NA	NA	NA
FLUORANTHENE	0.31	0.13	4.00E-02	1.24E-02	NA
FLUORENE	0.31	0.13	4.00E-02	1.24E-02	NA
PHENANTHRENE	0.73	0.01	NA	NA	NA
PYRENE	0.31	0.13	3.00E-02	9.30E-03	NA

GIABS – Gastrointestinal Absorption Factor
ABS – Absorption Factor
RfDo – Oral Reference Dose
RfDd – Dermal Reference Dose
RFD – Reference Concentrations

Table 7-5. Noncancer Hazard Estimates for Sediment Exposures Evaluated in This Five-Year Review

Analyte	EPC	Oral				Dermal				Inhalation		Sum			
		Child		Adult		Child		Adult		Resident		Child		Adult	
	(mg/kg)	Intake	HQ	Intake	HQ	Intake	HQ	Intake	HQ	Intake	HQ	HQ	% of Total	HQ	% of Total
ANTHRACENE	1.9E-02	5.2E-08	1.7E-07	5.6E-09	1.9E-08	3.4E-08	1.1E-07	5.1E-09	1.7E-08	5.7E-12	NA	2.9E-07	3.8E-03	3.6E-08	0%
BENZ[A]ANTHRACENE	4.9E-02	1.3E-07	NA	1.4E-08	NA	8.7E-08	NA	1.3E-08	NA	1.5E-11	NA	0	0	0	0%
BENZO[A]PYRENE	6.9E-02	1.9E-07	NA	2.0E-08	NA	1.2E-07	NA	1.8E-08	NA	2.1E-11	NA	0	0	0	0%
CHRYSENE	7.4E-02	2.0E-07	NA	2.2E-08	NA	1.3E-07	NA	2.0E-08	NA	2.2E-11	NA	0	0	0	0%
DIBENZ[A,H]ANTHRACENE	2.3E-02	6.3E-08	NA	6.8E-09	NA	4.1E-08	NA	6.1E-09	NA	7.0E-12	NA	0	0	0	0%
FLUORANTHENE	1.4E-01	3.8E-07	9.6E-06	4.1E-08	1.0E-06	2.5E-07	2.0E-05	3.7E-08	3.0E-06	4.2E-11	NA	3.0E-05	4.0E-01	4.0E-06	40%
FLUORENE	1.2E-02	3.3E-08	8.2E-07	3.5E-09	8.8E-08	2.1E-08	1.7E-06	3.2E-09	2.6E-07	3.6E-12	NA	2.5E-06	3.4E-02	3.5E-07	3%
PHENANTHRENE	1.2E-01	3.3E-07	NA	3.5E-08	NA	1.6E-08	NA	2.5E-09	NA	3.6E-11	NA	0	0	0	0%
PYRENE	1.5E-01	4.1E-07	1.4E-05	4.4E-08	1.5E-06	2.7E-07	2.9E-05	4.0E-08	4.3E-06	4.5E-11	NA	4.2E-05	5.7E-01	5.8E-06	57%
	Sum		2E-05		3E-06		5E-05		8E-06		0	7E-05	100%	1E-05	100%

EPC - Exposure Point Concentration
HQ – Hazard Quotient

Table 7-6. Chemical-Specific Parameters Used in Cancer Risk Estimates for This Five-Year Review

Analyte	Evaluated as a Mutagen?		Dermal ABS	CSFo $(mg/kg*d)^{-1}$	CSFd $(mg/kg*d)^{-1}$	URi $(mg/m^3)^{-1}$
	Yes/No	ADAF				
ANTHRACENE	No	--	0.13	NA	NA	NA
BENZ[A]ANTHRACENE	Yes	3	0.13	7.3E-01	2.3E-01	1.1E-01
BENZO[A]PYRENE	Yes	3	0.13	7.3E+00	2.3E+00	1.1E+00
CHRYSENE	No	--	0.13	7.3E-03	2.3E-03	1.1E-02
DIBENZ[A,H]ANTHRACENE	Yes	3	0.13	7.3E+00	2.3E+00	1.2E+00
FLUORANTHENE	No	--	0.13	NA	NA	NA
FLUORENE	No	--	0.13	NA	NA	NA
PHENANTHRENE	No	--	0.01	NA	NA	NA
PYRENE	No	--	0.13	NA	NA	NA

ADAF – Age-Dependent Adjustment Factor
ABS – Absorption Factor
CSFo – Oral Cancer Slope Factor
CSFd – Dermal Cancer Slope Factor
URi – Inhalation Unit Risk

Table 7-7. Cancer Risk Estimates for Sediment Exposures Evaluated in This Five-Year Review

Analyte	EPC (mg/kg)	Oral			Dermal			Inhalation			Sum	
		Child's Intake	Adult's Intake	ELCR	Child's Intake	Adult's Intake	ELCR	Child's Intake	Adult's Intake	ELCR	ELCR	% of Total
ANTHRACENE	1.9E-02	1.0E-08	1.1E-09	NA	6.8E-09	1.0E-09	NA	1.1E-12	1.1E-12	NA	0	0%
BENZ[A]ANTHRACENE	4.9E-02	8.1E-08	2.9E-09	6.1E-08	5.2E-08	2.6E-09	1.2E-08	8.9E-12	3.0E-12	1.3E-12	7.3E-08	5%
BENZO[A]PYRENE	6.9E-02	1.1E-07	4.1E-09	8.6E-07	7.4E-08	3.7E-09	1.8E-07	1.3E-11	4.2E-12	1.8E-11	1.0E-06	71%
CHRYSENE	7.4E-02	4.1E-08	4.3E-09	3.3E-10	2.6E-08	4.0E-09	6.9E-11	4.5E-12	4.5E-12	9.8E-14	4.0E-10	0%
DIBENZ[A,H]ANTHRACENE	2.3E-02	3.8E-08	1.4E-09	2.9E-07	2.5E-08	1.2E-09	5.8E-08	4.2E-12	1.4E-12	6.7E-12	3.4E-07	24%
FLUORANTHENE	1.4E-01	7.7E-08	8.2E-09	NA	5.0E-08	7.5E-09	NA	8.5E-12	8.5E-12	NA	0	0%
FLUORENE	1.2E-02	6.6E-09	7.0E-10	NA	4.3E-09	6.4E-10	NA	7.3E-13	7.3E-13	NA	0	0%
PHENANTHRENE	1.2E-01	6.6E-08	7.0E-09	NA	3.3E-09	4.9E-10	NA	7.3E-12	7.3E-12	NA	0	0%
PYRENE	1.5E-01	8.2E-08	8.8E-09	NA	5.3E-08	8.0E-09	NA	9.1E-12	9.1E-12	NA	0	0%
	Sum			1E-06			2E-07			3E-11	1E-06	100%

EPC – Exposure Point Concentration
ELCR – Excess Lifetime Cancer Risk

As noted, the ROD focused on human health effects related to exposures to sediment. Ecological risks were considered subsequent to the RODs and ESD. The prior five year review reported that the findings of that effort (ESAT, 2000) were as follows:

> *The surface water of Flint Pond, Flint Pond Marsh, and Dunstable Brook had benchmark exceedances only for metals in 1999. These exceedances included overlaps in barium, copper, and manganese at all three sites, and individual exceedances for aluminum and iron at Flint Pond Marsh and Dunstable Brook. However, many of these exceedances also occurred in the upgradient background sample of Dunstable Brook, including aluminum, manganese, copper, and barium.*
>
> *Sediment samples from Flint Pond and Flint Pond Marsh showed a few less benchmark exceedances in 1999 compared to 1993, but as of 1999, 10 and 8 COPCs were still evident in these water bodies. Dunstable Brook showed less sediment contamination with only 3 COPCs, but it was not sampled in 1999 for recent comparison. The upgradient site on Dunstable Brook revealed extremely high levels of acetone in 1993 sediment samples, but no other organics were found above benchmarks. This site also showed the highest sediment concentrations of manganese, suggesting a source above the landfill for this and other metals. Bridge Meadow Brook showed only one COPC in sediments, but it was the farthest water body from the landfill and is diluted by the waters of Dunstable Brook.*
>
> *Toxicity tests run with 1993 sediment samples on Hyallela azteca and Chironomus tentans showed significant decreases in the survival rates of both species (but not growth) when tested from Dunstable Brook and an unnamed tributary compared with the upstream background sample.*

Tables 6-4 (inorganic chemicals in surface water), 6-5 (organic chemicals in sediment), and 6-6 (inorganic chemicals in sediment) presented previously in Section 6 indicate that there are continued exceedances of ecological benchmarks at this time. Potential adverse effects, if any, are probably limited to localized areas, suggesting that continued monitoring to observe trends in contaminant concentrations is adequate at this time. Additional toxicity testing may be considered in the future based on these trend evaluations.

7.3.3 Indoor Air

The vapor intrusion pathway was not evaluated in the 1988 risk assessment, and was not addressed in the ROD. This pathway was evaluated during the prior five year review due to concerns about shallow groundwater containing VOCs potentially affecting the air in structures used onsite for operation and maintenance, and at several residences downgradient of the Site. Although exceedances of screening levels for indoor air occurred at that time, it was determined that exposures to volatile contaminants in shallow groundwater migrating from the Site were not affecting indoor air quality in nearby buildings, as follows:

> *There are no occupied structures within 100 feet of this well. Therefore, the vapor intrusion pathway is considered incomplete and exposures to residents and Site workers via indoor air are likely to be negligible.*

Table 7-8 presents a comparison of the most recent monitoring data for VOCs in groundwater to a target concentration in groundwater that is associated with non-cancer hazard quotient of 1 and a cancer risk of 1×10^{-6}. The concentration in groundwater is calculated from the USEPA Regional Screening Levels for indoor air, using the dimensionless Henry's Law constant for the given constituent.

The values used for the comparison are derived from USEPA's Regional Screening Levels (USEPA, 2010a) since they are up-to-date, and provide risk-based concentrations rather than drinking water standards[1].

Table 7-8. Comparison of Most Recent VOC Detections in Groundwater to Screening Values for the Vapor Intrusion Pathway

Target Analyte	Well Location	Date Sampled	Meas. Max Conc in GW (µg/L)	Henry's Law Constant (unitless)	Est. Vapor Conc at GWI (µg/m³)	GWI Vapor to Indoor Vapor AF (unitless)	Comparison: Est. Indoor Air Conc (µg/m³)	Comparison: Indoor Vapor RSL (µg/m³)	Comparison: Exceeds? (Yes/No)
Acetone	MW-12	12/7/2009	8.7	0.00143	6,084	0.001	0.012	32,000	No
Benzene	EW-PW-1A	12/3/2009	6.7	0.23	29	0.001	1.541	0.31	**Yes**
Chlorobenzene	EW-PW-1A	12/3/2009	5.3	0.127	42	0.001	0.673	52	No
Cyclohexane	E&E-FIT2	12/3/2009	0.44	6.13	0.07	0.001	2.697	6,300	No
1,1-Dichloroethane	GEI-F2	12/3/2009	2.3	0.24	10	0.001	0.552	1.5	No
1,2-Dichlorobenzene	EW-PW-1A	12/3/2009	1.9	0.079	24	0.001	0.149	210	No
1,2-Dichloroethane	GEI-F2	12/3/2009	1.2	0.04	30	0.001	0.048	0.094	No
1,4-Dichlorobenzene	EW-PW-1A	12/3/2009	2.5	0.079	32	0.001	0.196	0.22	No
Methyl tert-butyl ether	CDM-5S	12/2/2009	0.22	0.024	9	0.001	0.005	9.4	No
Trichlorofluoromethane	GEI-F2	12/3/2009	0.95	3.97	0.2	0.001	3.772	730	No

Est. – Estimated
Meas. – Measured
Max – Maximum Detected Concentration in December of 2009.
RSLv – USEPA Regional Screening Level for indoor air
RSLw – RSLv converted to a concentration in groundwater
Conc – Concentration
GWI - Groundwater Interface
H – Dimensionless Henry's Law Constant
AF – Attenuation Factor
Indoor air concentration = $C_{gw}*AF*H*10^3 L/m^3$

During the current five year review period, VOCs continue to be detected in the groundwater being influenced by the Site. The modeled indoor air concentration of benzene associated with its concentration in groundwater at one sample location exceeds the RSL for residential air. However, no buildings exist in the vicinity of the contamination and the exposure pathway remains incomplete at this time. The upcoming five year review should confirm that no such changes occur during the upcoming review period.

7.3.4 Ambient Air

The previous five year review stated the following with respect to the ambient air pathway (i.e., outdoor vapors):

> *Evaluation methods and exposure assumptions applicable to the ambient air pathway have changed significantly since 1988. This pathway is currently evaluated using inhalation toxicity values rather than oral toxicity values, as done in 1988. A qualitative comparison of ambient air levels estimated in the 1988 risk assessment to risk-based ambient air preliminary remediation goals (PRGs) established by EPA Region 9 confirms the conclusions of the 1988 risk assessment (i.e., the ambient air pathway was associated with risks and hazards above EPA risk management*

[1] As was the case for the screening values provided in the older *Draft Guidance for Evaluating the Vapor Intrusion to Indoor Air Pathway from Groundwater and Soils (Subsurface Vapor Intrusion Guidance)* published by USEPA in 2001.

guidelines). However, it is anticipated that current ambient air levels are less than those estimated in 1988 based on the installation, operation, and maintenance of the landfill gas collection system. Enclosed flare stack testing is scheduled by MassDEP in 2005. The analytical results obtained during this testing should be evaluated to confirm that the remedy remains protective relative to the ambient air pathway.

Table 7-9. Comparison of Flare Outlet Emissions to Cleanup Levels per ROD and Screening Levels for Human Health.

Target Analyte	Average Flare Outlet Concentration (ppbv)	MW	Cleanup Levels per ROD			RSL for Residential Air		
			($\mu g/m^3$)	Converted Units (ppbv)	Exceeds? (Yes/No)	($\mu g/m^3$)	Converted Units (ppbv)	Exceeds? (Yes/No)
Benzene	2.8	78.11	568	178	No	0.31	0.10	Yes
Bromomethane	0.55	94.95	NA	NA	No	5.2	1.34	No
2-Butanone	3.47	72.11	NA	NA	No	5,200	1,764	No
Carbon Disulfide	4.23	76.14	NA	NA	No	730	235	No
Chlorobenzene	0.2	112.56	NA	NA	No	52	11.3	No
Chloromethane	1.71	50.49	NA	NA	No	94	45.5	No
Dichloromethane	0.77	84.93	1,030	297	No	5.2	1.5	No
Tetrachloroethylene	0.3	165.83	8,690	1,282	No	0.41	0.06	Yes
Xylenes	0.4	106.2	NA	NA	No	100	23.05	No

MW - Molecular Weight (g/mol)
RSL - USEPA Regional Screening Level for indoor air
ROD - Cleanup level is established in ROD
ppbv = C (μg/m3) x 109 (ppb/atm) x 10^{-3} (m^3/L) x R x T/(MW x 10^6 [μg/g])
Where:
R = gas constant (0.0821 L-atm/mole-K)
T = absolute temperature (298K)

Table 7-9 indicates that no substances emitted from the flare exceed cleanup levels established in the ROD. For recently reported chemicals that were not included in the cleanup levels, USEPA RSLs are applied. Note that the RSLs do not consider site-specific characteristics such as dispersion from the point source at the stack. In this respect, the RSLs are generally more stringent than are the goals specified in the ROD. Two of the constituents, benzene and tetrachloroethylene, were detected at concentrations that exceed the RSLs. Therefore, further analytical sampling of stack emissions should be conducted as appropriate during the upcoming review period. Those results should be evaluated to compare to prior results, and to confirm that the remedy remains protective for the ambient air pathway.

7.4 Technical Assessment Summary

The five year review concludes that the remedy is functioning as intended by the decision documents. This finding is based on evaluation of current and anticipated land uses, monitoring data, documentation, ARARs, site visit information, and risk information collected during the most recent review period. Future groundwater and land use institutional controls have not been established to prevent groundwater use and access to the landfill cap in the future. Institutional controls to prevent use of potentially contaminated groundwater and to prevent future disturbance of the landfill cap should be established to maintain protectiveness over the long-term. The findings also indicate the need for continued monitoring of the concentrations of some constituents that still exceed MCLs, may not be stable (i.e., arsenic in groundwater and PAHs in sediment in Dunstable Brook and Flint Pond Marsh), or may not be included in the ROD (e.g., 1,4-dioxane and other constituents in flare outlet vapors). With respect to the PAHs in sediment, concern is focused on exceedances of ecological screening values rather than human health risks. Further discussion is provided above in *Questions A, B and C*, and in Sections 8 (*Issues*), and 9 (*Recommendations*).

8.0 ISSUES

Issues that have been identified during this five-year review are listed by operable unit in Table 8-1. Also identified is whether each issue may affect protectiveness now or at some time in the future. In general, the issues do not call into question the current protectiveness of the remedy, rather they relate to maintaining protectiveness over time.

Table 8-1. Issues at the Charles George Land Reclamation Trust Landfill Superfund Site, Tyngsborough, Massachusetts.

Issues	Affects Current Protectiveness	Affects Future Protectiveness
Issues That May Affect Future Protectiveness		
Intermittent groundwater monitoring program. Limited groundwater data (only two sampling rounds) are available for the current five-year review period, including for arsenic contamination, which has been detected in offsite groundwater monitoring wells at concentrations exceeding the MCL. The limited groundwater data makes it difficult to conduct long-term trend evaluations and confirm long-term protectiveness, however, no known drinking water wells are currently affected.	No	Yes
Potential impacts to ecological receptors due to PAHs and metals in sediment. Potentially significant concentrations of these compounds were observed in samples collected from Dunstable Brook and Flint Pond Marsh during the 2009 sampling round.	No	Yes
Future groundwater and land use institutional controls have not been established to prevent groundwater use and access to the landfill cap in the future.	No	Yes
Future non-potable groundwater use. Potential risks to human health associated with non-potable groundwater use (e.g., irrigation) have not been evaluated.	No	Yes
O&M Issues		
Stack emissions monitoring. Further sampling of stack emissions is necessary to confirm that the remedy remains protective for the ambient air pathway.	No	Yes
Vapor intrusion into occupied structures. There are no occupied structures that may be affected by soil vapors. Continued land use, groundwater quality, and soil gas monitoring are necessary to monitor changes in concentrations and land use during the upcoming review period.	No	Yes

9.0 RECOMMENDATIONS AND FOLLOW-UP ACTIONS

Recommendations and follow-up actions for each issue identified in Section 8 are listed by operable unit in Table 9-1. Also listed is the agency responsible for implementing and overseeing implementation of the recommendation. As noted in Section 8, the recommendations for the issues do not call into question the current protectiveness of the remedy, rather they relate to maintaining protectiveness over time.

Table 9-1. Recommendations and Follow-up Actions for the Charles George Land Reclamation Trust Landfill Superfund Site, Tyngsborough, Massachusetts.

Issue	Recommendations and Follow-up Actions	Party Responsible	Oversight Agency	Milestone Date	Affects Protectiveness	
					Current	Future
Issues that May Affect Future Protectiveness						
Intermittent groundwater monitoring program. Limited groundwater data (only two sampling rounds) are available for the current five-year review period, including for arsenic contamination, which has been detected in offsite groundwater monitoring wells at concentrations exceeding the MCL. The limited groundwater data makes it difficult to conduct long-term trend evaluations and confirm long-term protectiveness, however, no known drinking water wells are currently affected.	Update the O&M Plan to include maintaining a groundwater monitoring program to evaluate extraction system effectiveness and assess onsite and offsite concentration trends. Target analytes may continue to include 1,4-dioxane and tetrahydrofuran which are not listed in the ROD. In addition, the state's Groundwater Use and Value determination should be examined, and, if necessary, revised. The groundwater cleanup levels should then be adjusted to reflect any revision to the use and value determination.	MassDEP	MassDEP	2012	No	Yes

Issue	Recommendations and Follow-up Actions	Party Responsible	Oversight Agency	Milestone Date	Affects Protectiveness	
					Current	Future
Potential impacts to ecological receptors due to PAHs and metals in sediment. Potentially significant concentrations of these compounds were observed in samples collected from Dunstable Brook and Flint Pond Marsh during the 2009 sampling round.	Collect additional sediment data from nearby water bodies to assess trends in PAH and metals concentrations potentially affecting ecological receptors.	EPA	EPA	2012	No	Yes
Future groundwater and land use institutional controls have not been established to prevent groundwater use and access to the landfill cap in the future.	Institutional controls to prevent use of potentially contaminated groundwater should be established to maintain protectiveness over the long-term. Land-use restrictions should align with the Consent Decree to prevent future disturbance of the landfill cap.	MassDEP & EPA	EPA	2012	No	Yes
Future non-potable groundwater use. Potential risks to human health associated with non-potable groundwater use (e.g., irrigation) have not been evaluated.	Future non-potable groundwater use should be evaluated to assess risk to human receptors, and to determine whether such uses should be restricted.	EPA	EPA	2015	No	Yes

Issue	Recommendations and Follow-up Actions	Party Responsible	Oversight Agency	Milestone Date	Affects Protectiveness	
					Current	Future
O&M Issues						
Stack emissions monitoring. Further sampling of stack emissions is necessary to confirm that the remedy remains protective for the ambient air pathway.	Update the O&M Plan to ensure that stack emissions continue to be monitored every five years. Results should be evaluated and compared to prior results to confirm that the remedy remains protective for the ambient air pathway. Further evaluation of the dispersion of stack emissions to points of exposure is recommended if analytical results exceed ROD criteria.	MassDEP	MassDEP	2012	No	Yes
Vapor intrusion into occupied structures. There are no occupied structures that may be affected by soil vapors. Continued land use, groundwater quality, and soil gas monitoring are necessary to monitor changes in concentrations and land use during the upcoming review period.	During the current five year review period, VOCs continue to be detected in the groundwater being influenced by the Site. The concentration exceeded screening values for indoor vapor intrusion at one location. However, no changes to the incomplete exposure pathway for indoor air have occurred during that time. Update the O&M Plan to ensure that inspections and monitoring are done as necessary to confirm the continued incomplete exposure pathway to indoor air is maintained.	MassDEP	MassDEP	2012	No	Yes

10.0 PROTECTIVENESS STATEMENTS

OU1

OU1 refers to the provision of an alternate water supply for areas originally found to have been affected by the groundwater contaminant plume originating from the site. The remedy for OU1 currently protects human health and the environment because all areas known to have been impacted by contaminated groundwater have received an alternative water supply under OU1 (the original alternative supply) or OU3/OU4 (extensions to the original water supply lines). However, in order for this portion of the remedy to be protective in the long term, follow-up actions need to be taken. Specifically, institutional controls should be placed in the vicinity of the Site that would prevent both potable and non-potable uses if warranted, of the groundwater. The Town of Tyngsborough currently prevents potable use by not allowing installation of drinking water wells in areas that have access to public drinking water. However, additional institutional controls may be necessary to attain broader protectiveness in the long-term. These could include ordinances prohibiting, or advisories discouraging, installation of potable and non-potable water supply wells within the vicinity of the Site, regardless of the availability of a public water supply.

OU2

OU2 addresses source control to reduce off-site migration of contaminants (i.e., capping of the landfill and collection of leachate and landfill gas). This operable unit also includes the remedial action objective of "abating additional impact to surrounding surface waters and wetlands." This portion of the remedy is protective in the short-term; however, in order for this portion of the remedy to be protective in the long term, follow-up actions need to be taken. Although access to the landfill is currently strictly controlled by MassDEP, formal institutional controls are needed to prevent future disturbance of the cap. The Settling Defendant is required to implement these onsite controls under a Consent Decree with EPA. Also, there remains a need to continue air emissions monitoring, and surface water and sediment sampling in Dunstable Brook and Flint Pond Marsh to more fully evaluate possible long-term impacts of PAHs on both human health and ecological receptors.

OU3 and OU4

OU3 focuses on contaminated groundwater migration and OU4 addresses leachate treatment. The protectiveness of these remedies are presented together since contaminated groundwater and leachate are considered together in ROD III, and are treated together in a combined groundwater/leachate collection system that discharges to the LRWU. The remedies for OU3 and OU4 are protective in the short-term; however, in order for this portion of the remedy to be protective in the long-term, follow-up actions need to be taken. The ROD specifies that long-term protectiveness will be achieved once groundwater and leachate contaminant concentrations drop below MCLs. In the interim, institutional controls are needed to prevent exposure to these contaminated media. The Town of Tyngsborough currently prevents installation of drinking water wells in areas that have access to public water. However, additional institutional controls may be necessary to attain broader protectiveness in the long-term. Specifically, this may require prohibiting installation of potable and non-potable water supply wells within the vicinity of the Site regardless of the availability of a public water supply. In addition, the Settling Defendant in the Consent Decree, entered in 2003 with EPA, is required to implement onsite controls to maintain protectiveness in the long-term for contaminated leachate.

Comprehensive Protectiveness Statement

Because the remedial actions of all operable units are protective in the short-term, the remedy is currently protective of human health and the environment. However, in order for the remedy to be protective in the long-term, the following follow-up actions are needed:

- Establish enforceable institutional controls to prevent future disturbance of the landfill cap.
- Establishment of enforceable institutional controls on the Site, and work with local officials on advisories/ordinances downgradient of the Site, to prevent potable water use from drinking water wells until MCLs are attained.
- Evaluate the risk of future non-potable groundwater uses (e.g., irrigation wells) to determine whether such uses should be restricted along with potable uses in the vicinity of Site
- Re-establish a formal groundwater monitoring program to allow continued evaluation of offsite contamination; the effectiveness of the groundwater extraction systems, and; potential impacts to human health.
- Re-establish a formal surface water and sediment monitoring program to allow continued evaluation of PAH and metal contamination in nearby surface water bodies, their potential sources, and/or the potential risk to ecological receptors.
- Update the O&M Plan such that it includes the establishment of mechanisms for evaluating the potential risk from vapor intrusion into occupied structures and continued stack emissions monitoring to evaluate potential risk through the ambient air pathway.

11.0 NEXT REVIEW

Five year reviews are done every five years at sites where contaminant levels remain at concentrations that prevent unlimited, unrestricted use of the Site. Since the remedy does not allow for unrestricted use of the Site at this time, a follow-up five-year review will be required. The next five-year review for the Charles George Land Reclamation Trust Superfund Site should be conducted in 2015.

12.0 DOCUMENTS REVIEWED AND REFERENCES CITED

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ATTACHMENT 1

REPORT FIGURES

Figure 1. Site Location Map

BASE MAP IS A PORTION OF THE FOLLOWING 7.5' USGS TOPOGRAPHIC QUADRANGLE: LOWELL, MA-NH 1987

0 1000 2000 3000

scale in feet

02136/CGL/TOPO

SITE LOCATION MAP

CHARLES GEORGE LANDFILL
TYNGSBORO, MASSACHUSETTS

M&E Metcalf & Eddy

TRC

Boott Mills South
Foot of John Street
Lowell, MA 01852
978-970-5600

QUADRANGLE LOCATION

MASS

TRC PROJ. NO.: 02136-0200-01166

EPA CONTRACT NO.: 68-W6-0042

RAC SUBCONTRACTOR NO.: 107061

Figure 2a. Overburden Groundwater Contours – May 2006

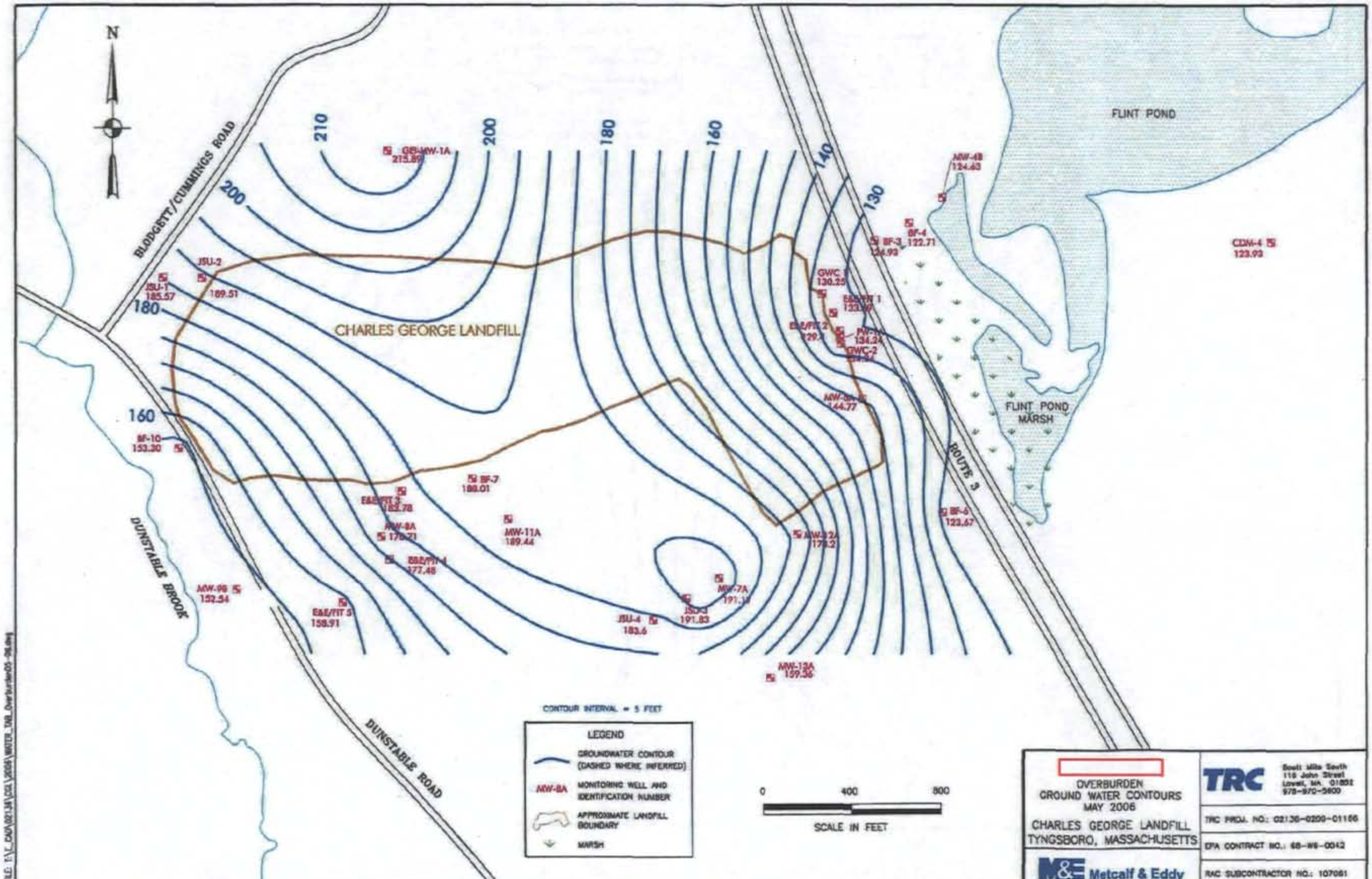


Figure 2b. Shallow Bedrock Groundwater Contours – May 2006

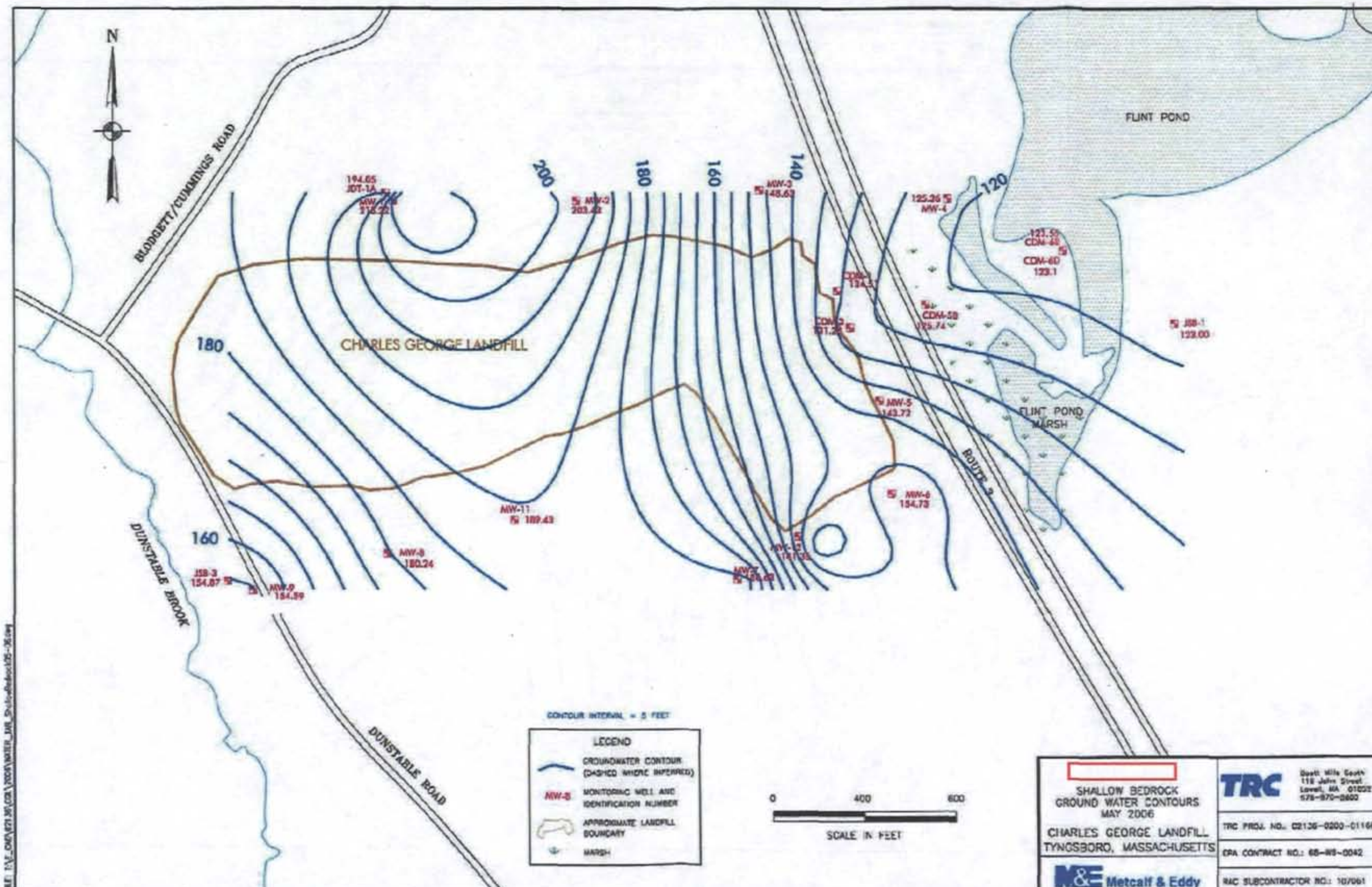


Figure 2c. Deep Bedrock Groundwater Contours – May 2006

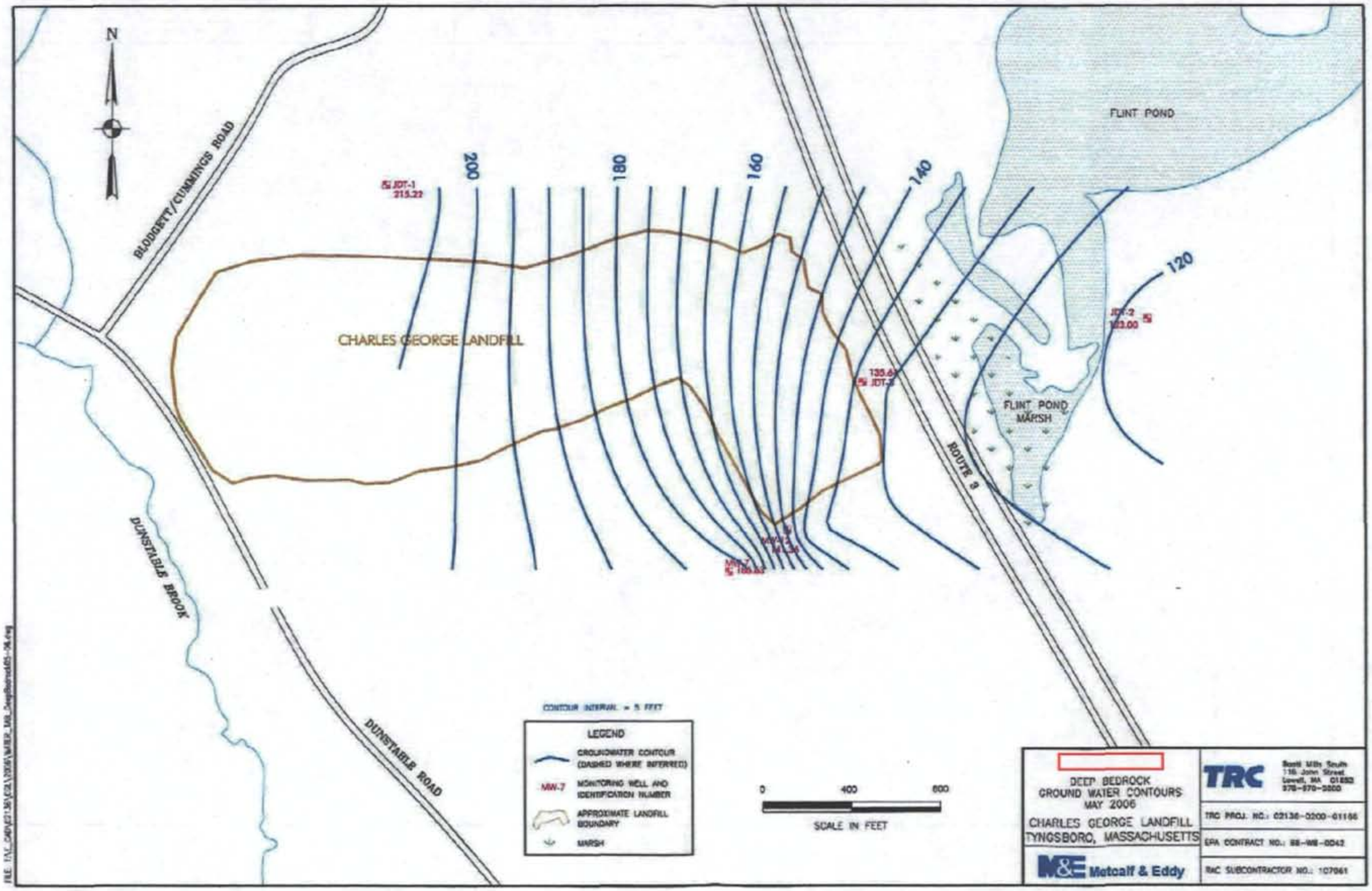


Figure 3. Site Plan

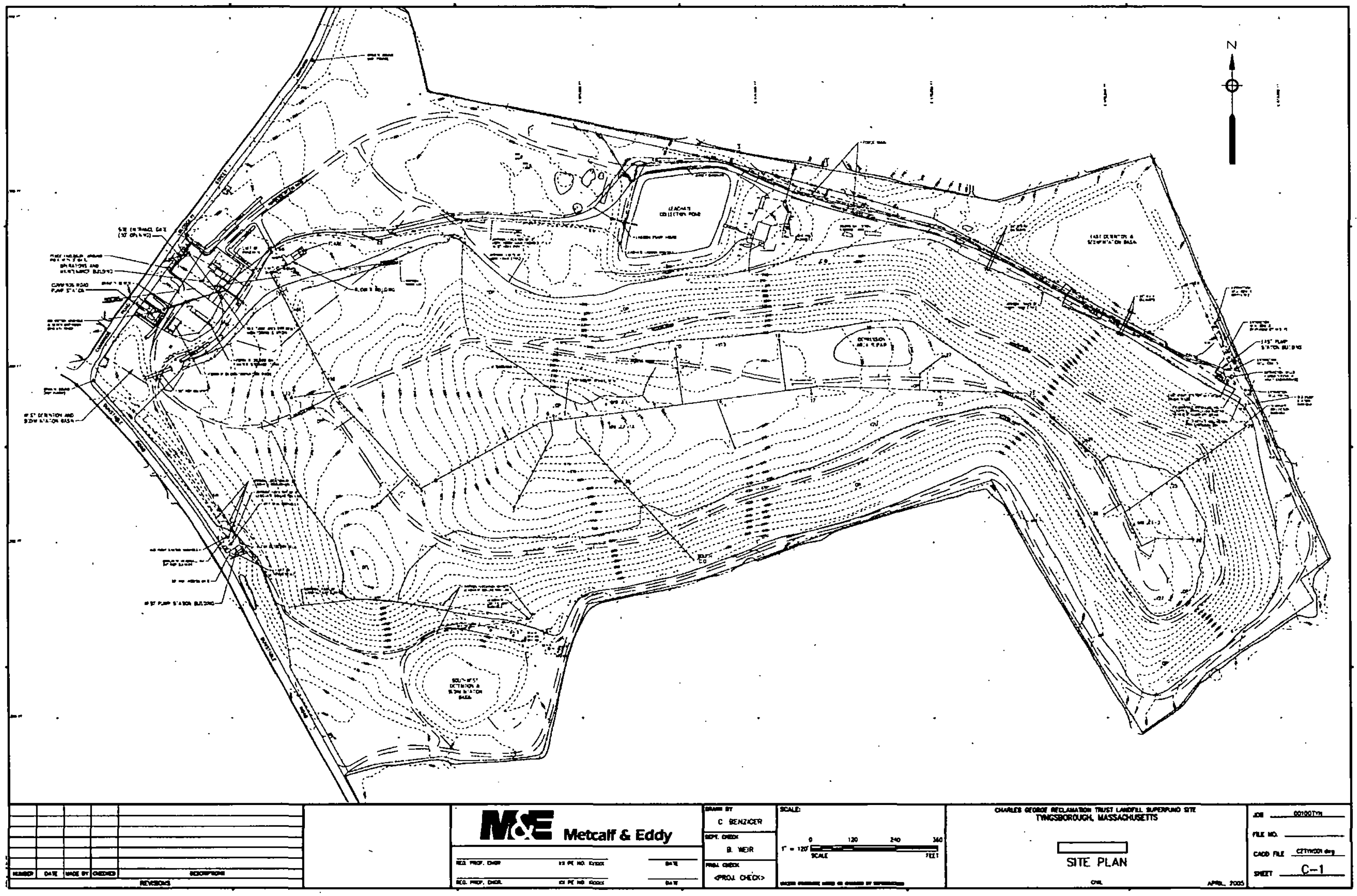


Figure 4. Groundwater Monitoring and Extraction Well Locations

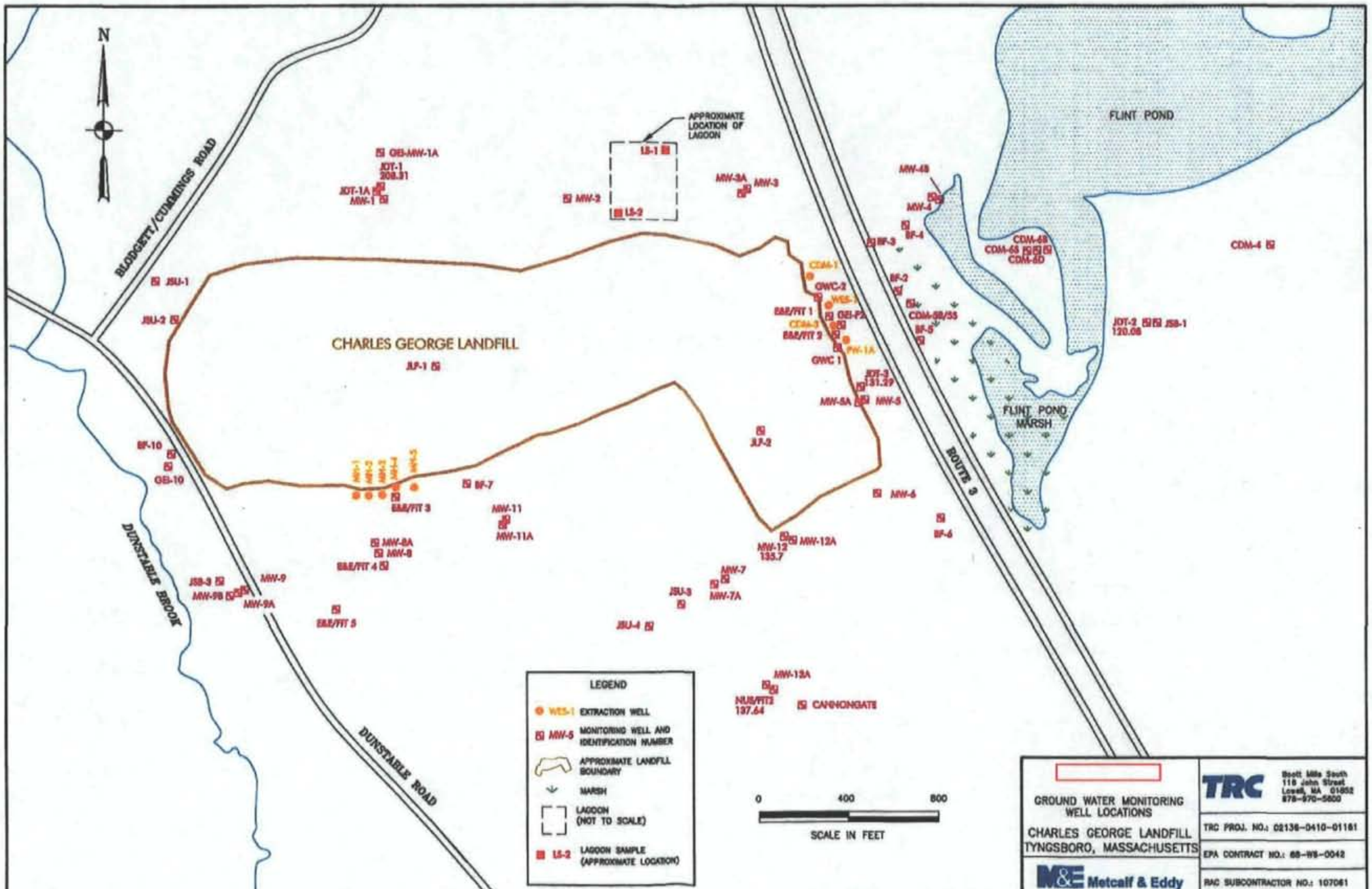


Figure 5. Tetrahydrofuran Concentrations in Groundwater East Extraction Area

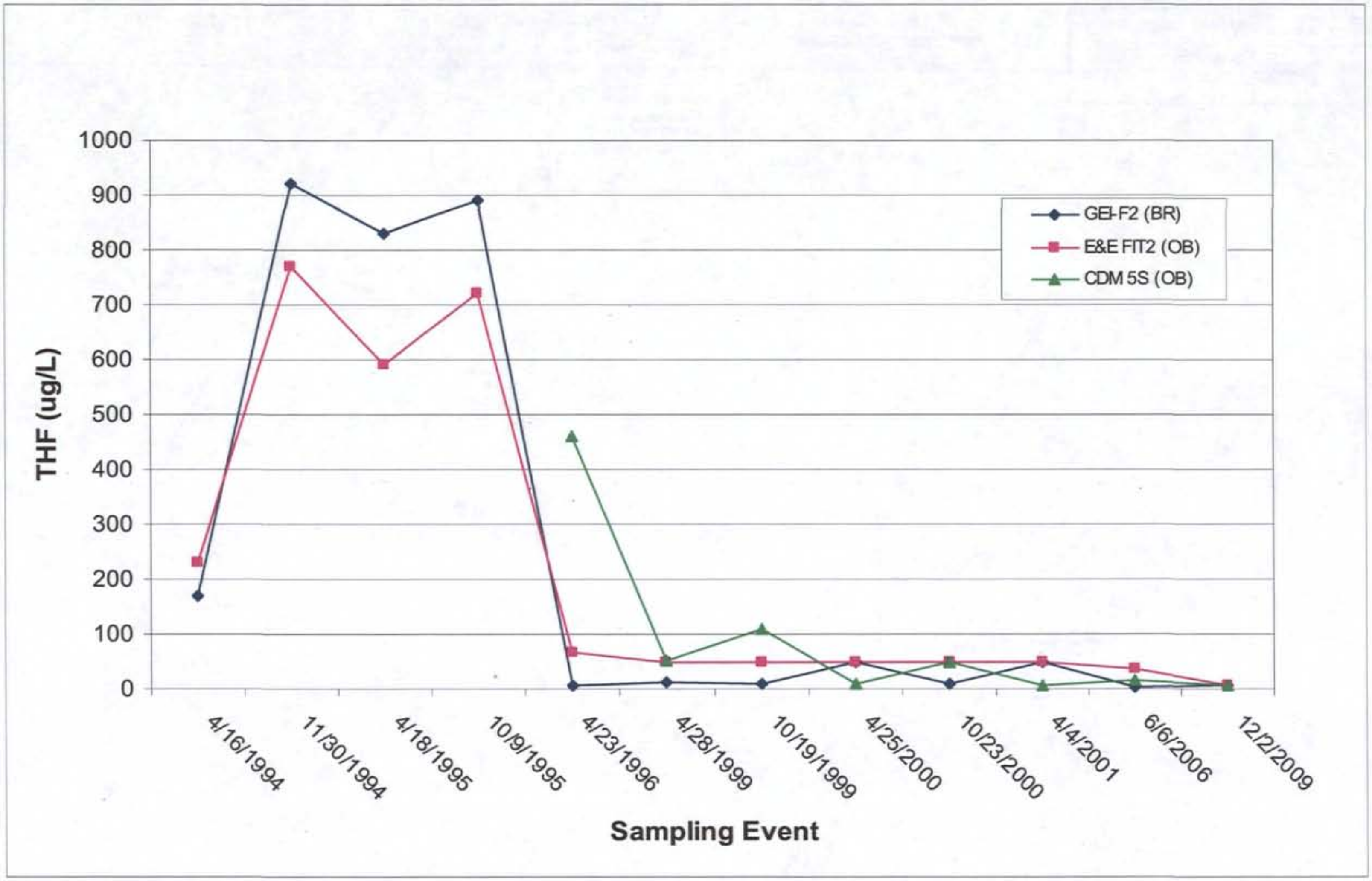


Figure 6. Benzene Concentrations in Groundwater East Extraction Area

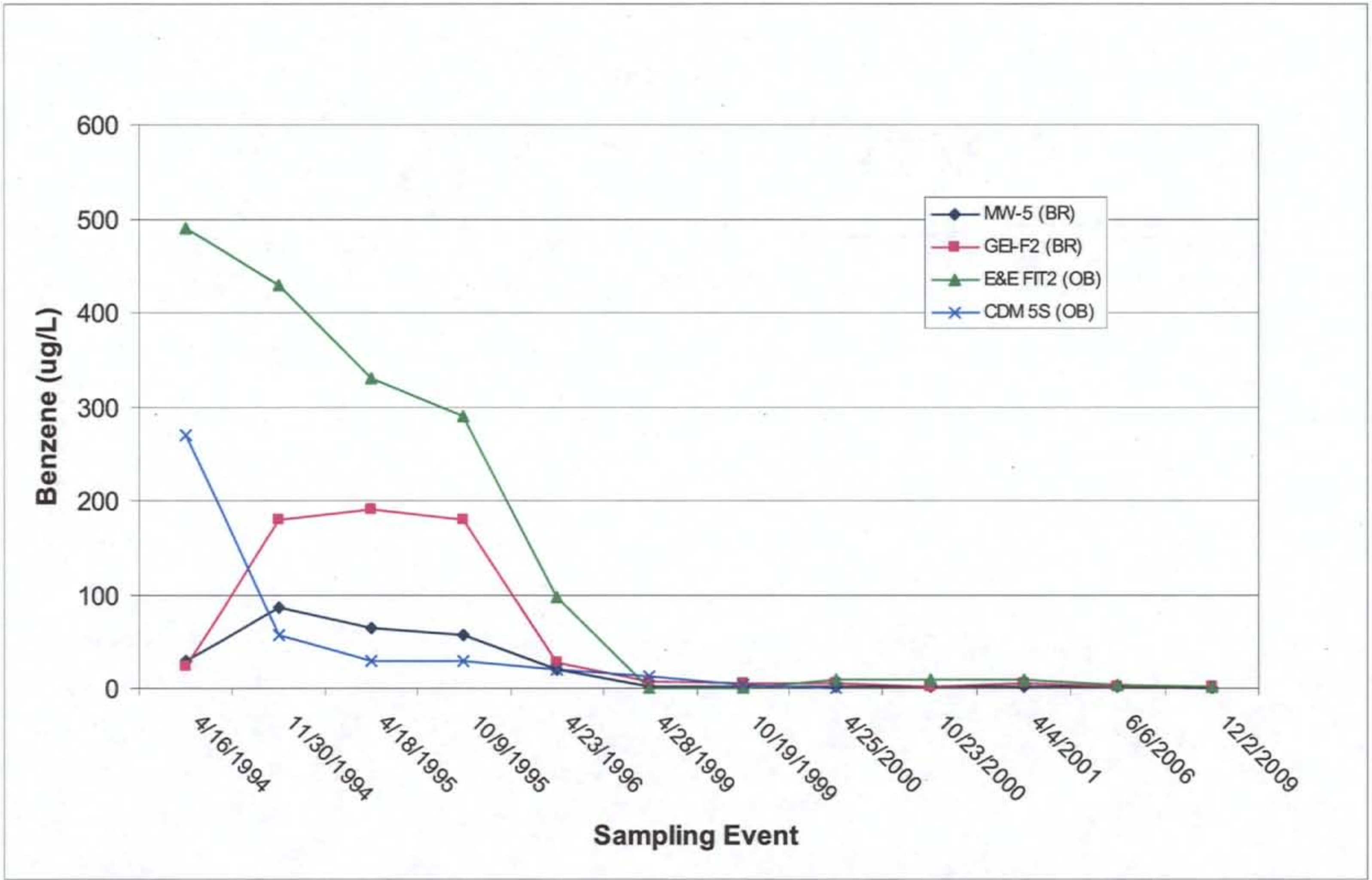


Figure 7a. 1,4-Dioxane Concentrations in Groundwater East Extraction Area within Point of Compliance

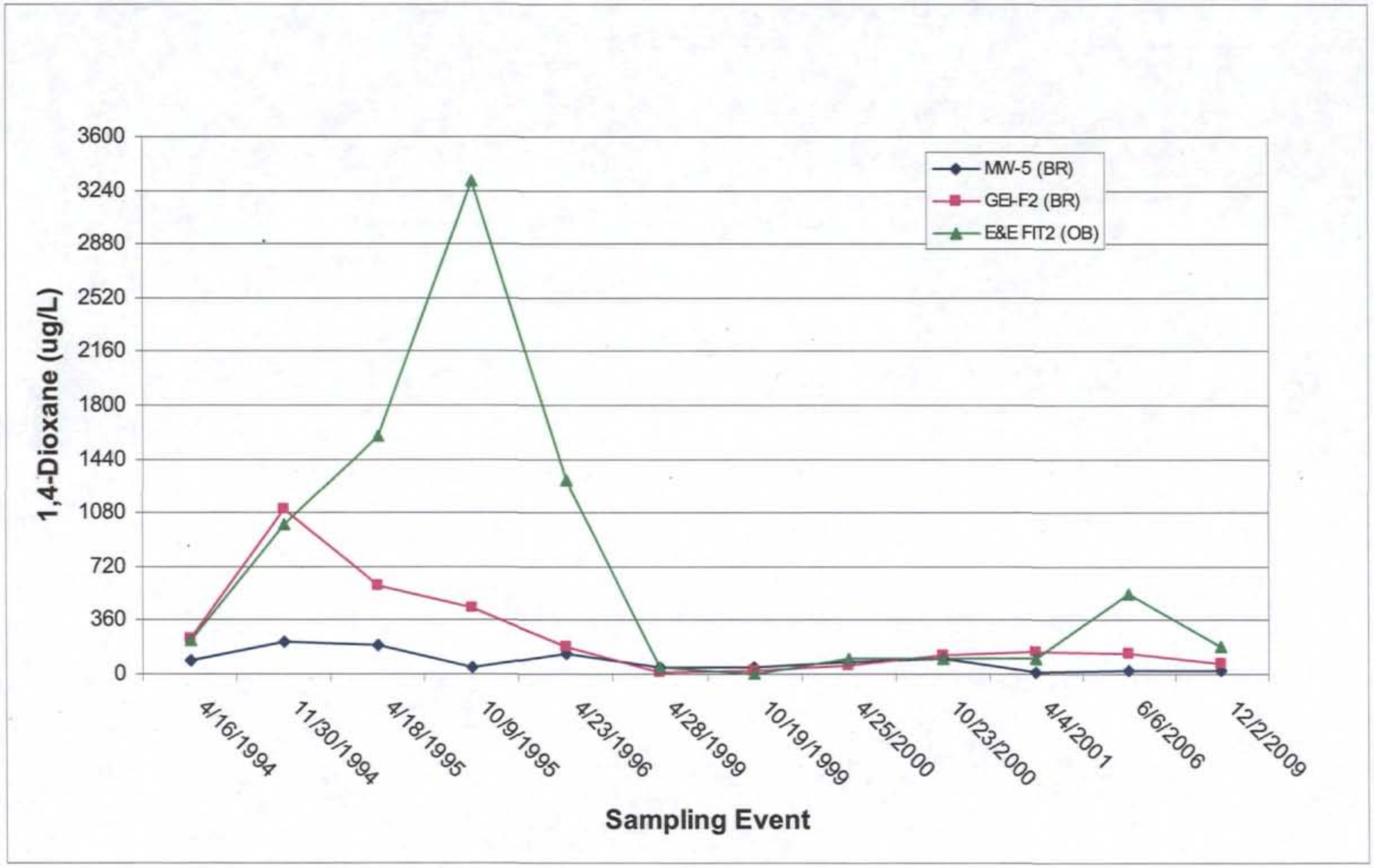


Figure 7b. 1,4-Dioxane Concentrations in Groundwater Downgradient of East Extraction Area

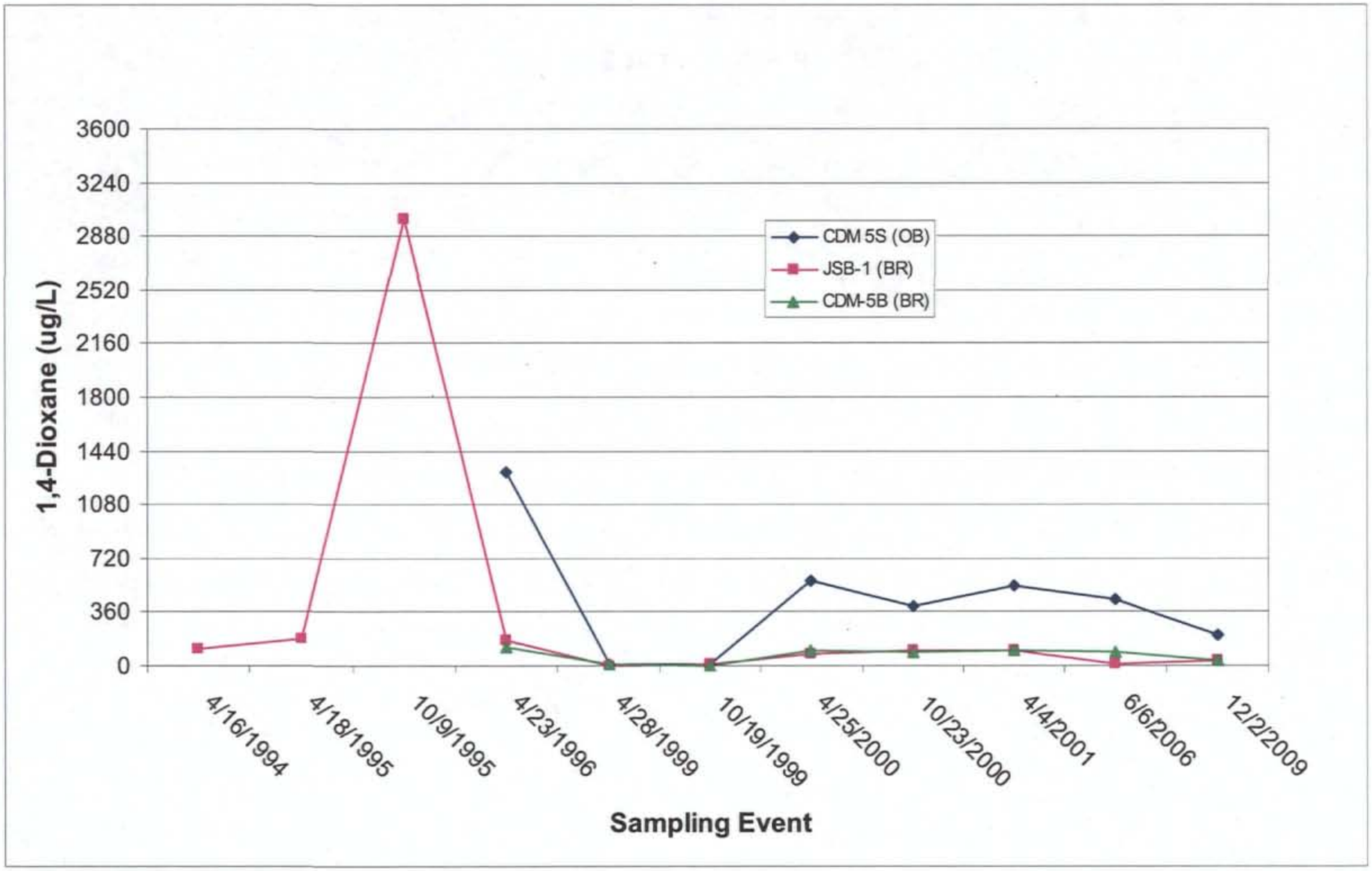


Figure 7c. 1,4-Dioxane Concentrations in Groundwater Southwest Extraction Area

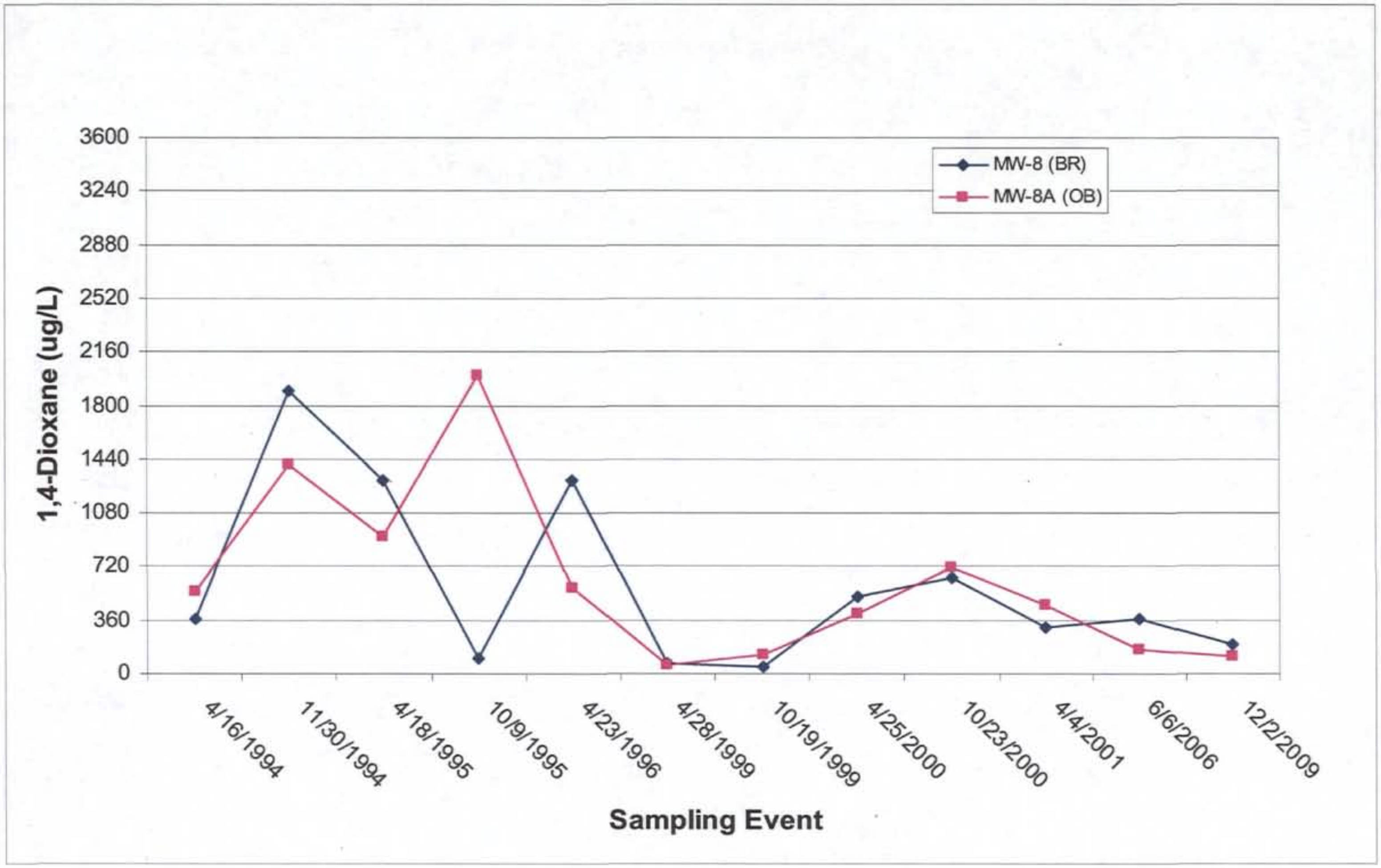


Figure 8a. Arsenic Concentrations in Groundwater East Extraction Area within Point of Compliance

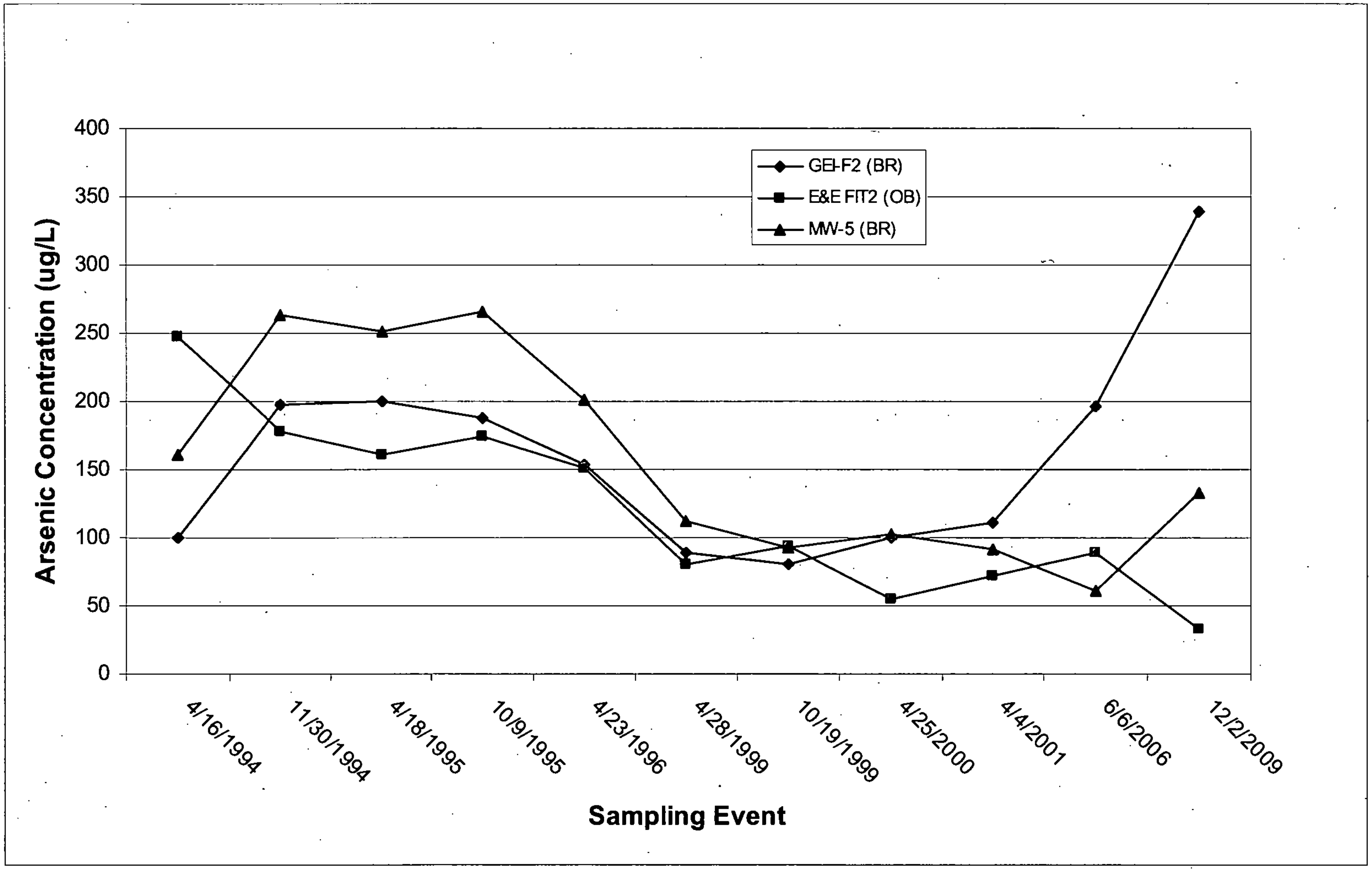


Figure 8b. Arsenic Concentrations in Groundwater Downgradient of East Extraction Area

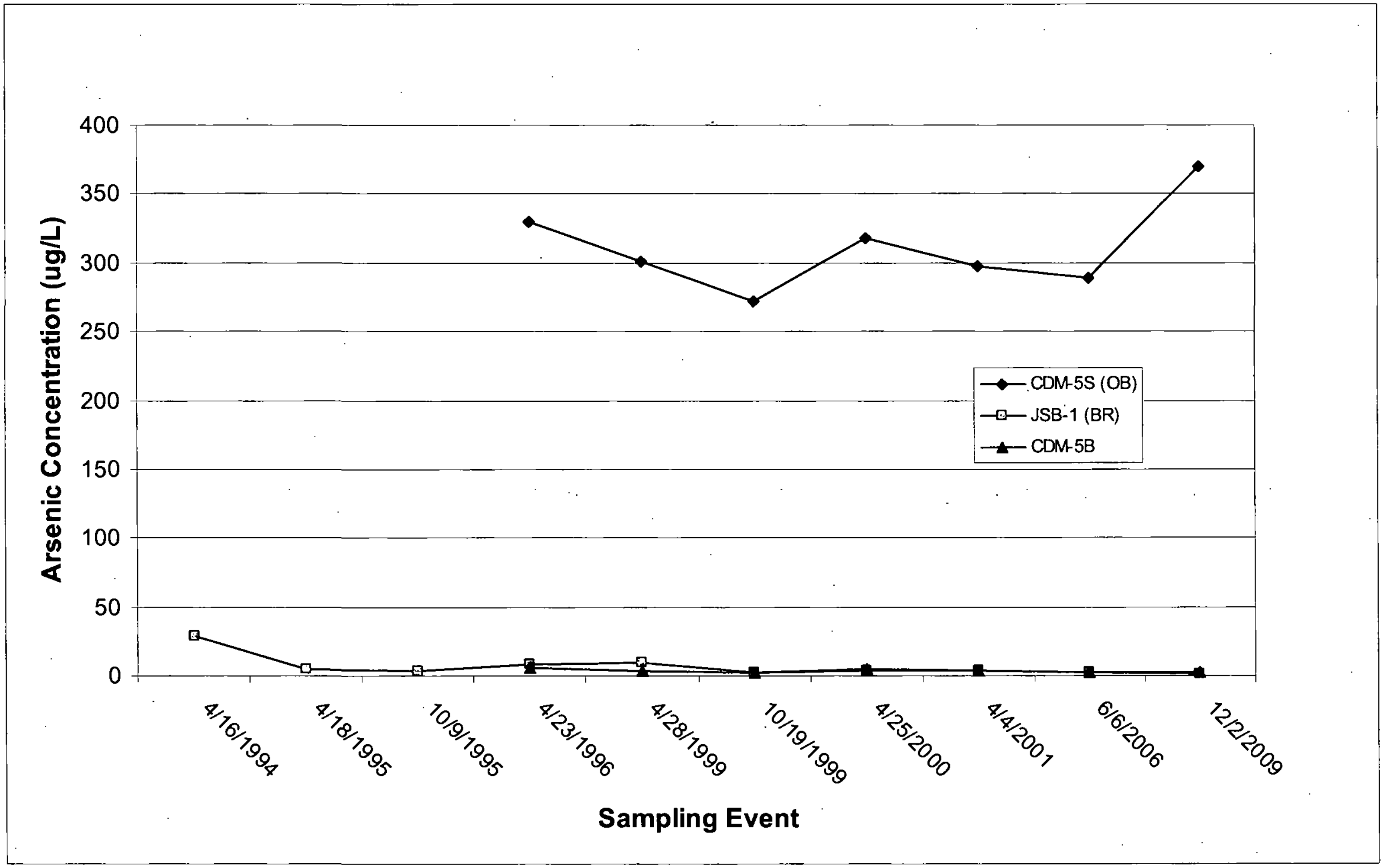


Figure 8c. Arsenic Concentrations in Groundwater Southwest Extraction Area

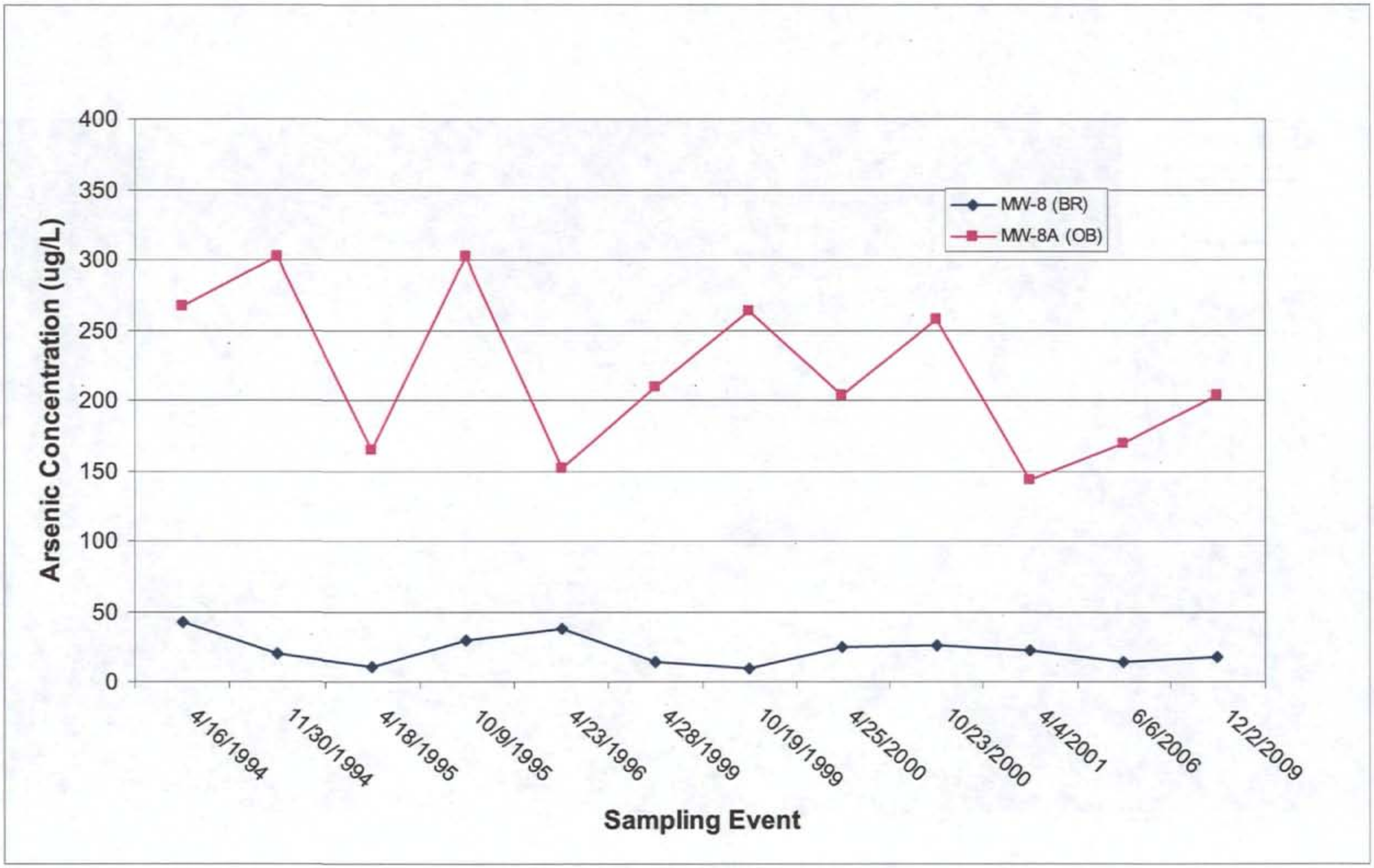
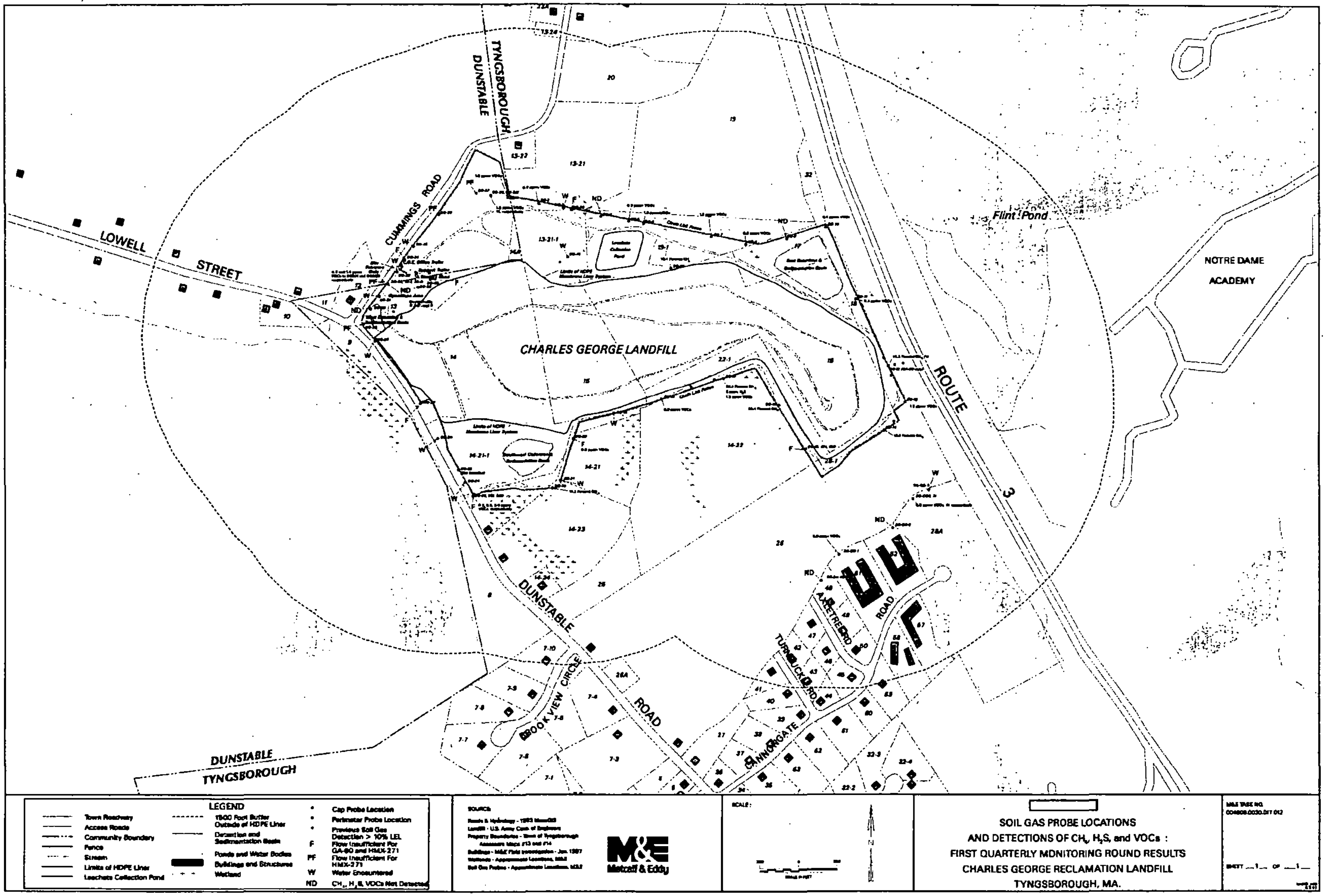


Figure 9. 2009 Surface Water and Sediment Sampling Locations

Figure 10. Soil Gas Probe Locations



ATTACHMENT 2

ARSENIC IN GROUNDWATER

Arsenic in Groundwater

In the main document, concentrations of arsenic in several groundwater well are plotted over time in Figures 8a (zone of compliance), 8b (downgradient of east extraction area), and 8c (southwest extraction area). Figures 8b and 8c show that reported concentrations of arsenic, while variable, have tended to stay within a concentration range at their respective wells.

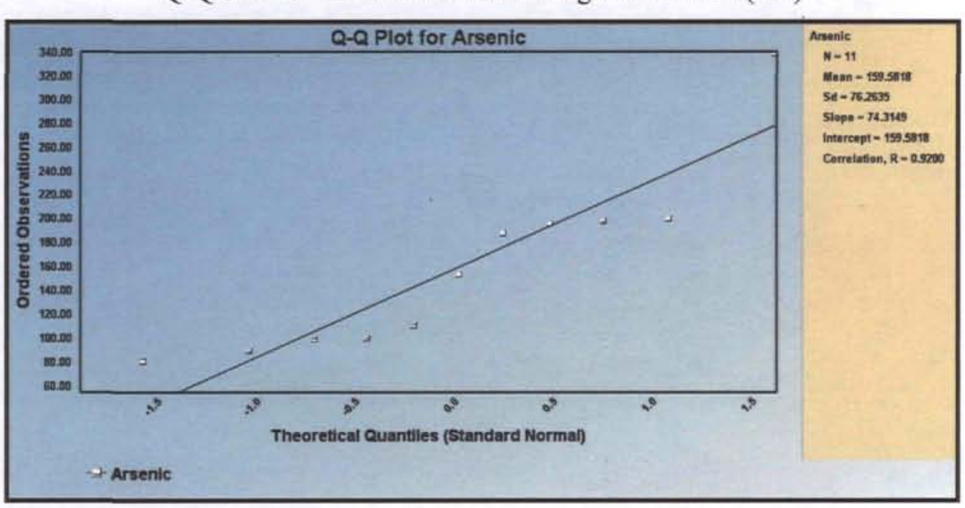
Figures 8a, 8b, and 8c include sample results for both overburden and bedrock wells. Figure 8a indicates that within the compliance zone the reported concentrations of arsenic are similar in overburden and bedrock. Figures 8b and 8c indicate that arsenic levels downgradient of the extraction areas are higher in the overburden rather than the bedrock, but this is not the case for all collocated overburden and bedrock well pairs (e.g., MW-5 and MW-5A in Table 6-3 above). The highest concentration of arsenic detected during the 2009 sampling round (1,120 ug/L) was reported in extraction well CDM-3.

In the case of Figure 8a, the arsenic concentrations at one well (GEI-F2) appear to have increased in recent sampling events. Sample data for that well was collected on the following dates:

- 4/16/1994
- 11/30/1994
- 4/18/1995
- 10/9/1995
- 4/23/1996
- 4/28/1999
- 10/19/1999
- 4/25/2000
- 10/23/2000
- 4/4/2001
- 6/6/2006
- 12/2/2009 (most recent)

Sample concentrations over time are presented in the Q-Q plot below. This chart differs from Figure 8a in that the data are arranged in order of increasing concentration rather than sample date.

Q-Q Plot for Arsenic at Monitoring Well GEI-2 (BR)



The regression line shown above is a reasonable fit to the data, as confirmed by the correlation coefficient of 0.92. Upon inspection, however, the highest value of 339 μg/l (in the upper right corner of the chart) appears to be notably distant from the other values. Such an increase may be an initial indication of worsening conditions with respect to arsenic in groundwater, or it may simply be a variable result that does not indicate a trend. A sudden departure from historic trends may initially be detected as an outlier.

Additional consideration of this potential outlier is provided with *Dixon's Outlier Test for Arsenic* conducted using USEPA's ProUCL data exploration software. The test compares a calculated sample statistic to critical values of a null hypothesis. In this case the null hypothesis is that the sample data are consistent, with no evidence of outliers. A test statistic of less than the critical value is evidence that the sample in question may be random and not an outlier. Conversely, a test statistic that is greater than the critical value may be evidence that the sample may have increased and is an outlier. Note that several significance levels (i.e., 10%, 5%, and 1%) and associated critical values are included. The test statistic is compared to the critical values. The lower the significance level, the stronger the evidence needed.

Dixon's Outlier Test for Arsenic at GEI-2 (BR)

- Number of data = 11
- 10% critical value: 0.517
- 5% critical value: 0.576
- 1% critical value: 0.679

Data Value 339 μg/l is a Potential Outlier (Upper Tail)?

- Test Statistic: 0.565
- For 10% significance level, 339 μg/l is an outlier.
- For 5% significance level, 339 μg/l is not an outlier.
- For 1% significance level, 339 μg/l is not an outlier.

The test statistic of 0.565 exceeds for only one of the critical values. This evidence of an outlier is seen only at the 10% significance level, and only for the single sample observation of 339 μg/l. This means that the evidence for arsenic as an outlier is limited at this time.

Figure 8b and in particular 8c shows periodic variations in concentration with little overall change. Figure 8a shows an apparent increase underway judging from the most recent samples, but it may actually show that the concentrations are cycling over a longer time period. In either case, additional sample data are recommended to determine if arsenic concentrations are significantly increasing over historic levels.

ATTACHMENT 3

SITE INSPECTION TRIP REPORTS AND PHOTOGRAPHS

Five-Year Review Site Inspection Checklist

I. SITE INFORMATION	
Site name: Charles George Reclamation Trust Landfill	**Date of inspections:** 23-Nov-09 & 08-Dec-09
Location and Region: Tyngsboro, MA, Region 1	**EPA ID:** MAD003809266
Agency, office, or company leading the five-year review: USEPA/ACOE	**Weather/temperature:** 40s and overcast
Remedy Includes: (Check all that apply) ■ Landfill cover/containment ■ Access controls ■ Institutional controls ■ Groundwater pump and treatment ☐ Surface water collection and treatment ■ Other Leachate collection and treatment	☐ Monitored natural attenuation ☐ Groundwater containment ☐ Vertical barrier walls
Attachments: ■ Inspection team roster attached in notes	☐ Site map attached

II. INTERVIEWS (Check all that apply)

1. **O&M site manager** (see inspection trip report roster) ______ ______
   Name Title Date
   Interviewed ■ at site ☐ at office ☐ by phone Phone no. ______
   Problems, suggestions; ■ Report attached ______

2. **O&M staff** (see inspection trip report roster) ______ ______
   Name Title Date
   Interviewed ■ at site ☐ at office ☐ by phone Phone no. ______
   Problems, suggestions; ■ Report attached ______

3. **Local regulatory authorities and response agencies** (i.e., State and Tribal offices, emergency response office, police department, office of public health or environmental health, zoning office, recorder of deeds, or other city and county offices, etc.) Fill in all that apply.

Agency: Tyngsborough Board of Selectmen

Contact	Title	Date	Phone no.
Kevin O'Conner	Member (former)	14-Jan-10	978-649-2300

Problems; suggestions; ■ Report attached (see interview records)

Agency: Tyngsborough Conservation Commission

Contact	Title	Date	Phone no.
Matt Marro	Conservation Director	19-Jan-10	978-649-2300

Problems; suggestions; ■ Report attached (see interview records)

Agency ______

Contact	Title	Date	Phone no.

Problems; suggestions; □ Report attached ______

Agency ______

Contact	Title	Date	Phone no.

Problems; suggestions; □ Report attached ______

4. **Other interviews** (optional) □ Report attached.

III. ON-SITE DOCUMENTS & RECORDS VERIFIED (Check all that apply)				
1.	**O&M Documents**			
	■ O&M manual	□ Readily available	□ Up to date	□ N/A
	■ As-built drawings	□ Readily available	□ Up to date	□ N/A
	■ Maintenance logs	□ Readily available	□ Up to date	□ N/A
	Remarks Acquired and reviewed after site inspection			
2.	**Site-Specific Health and Safety Plan**	□ Readily available	□ Up to date	□ N/A
	□ Contingency plan/emergency response plan	□ Readily available	□ Up to date	□ N/A
	Remarks Not reviewed			
3.	**O&M and OSHA Training Records**	□ Readily available	□ Up to date	□ N/A
	Remarks Not reviewed			
4.	**Permits and Service Agreements**			
	□ Air discharge permit	□ Readily available	□ Up to date	□ N/A
	□ Effluent discharge	□ Readily available	□ Up to date	□ N/A
	■ Waste disposal, POTW	□ Readily available	■ Up to date	□ N/A
	□ Other permits ____________	□ Readily available	□ Up to date	□ N/A
	Remarks Acquired and reviewed after site inspection			
5.	**Gas Generation Records**	□ Readily available	■ Up to date	□ N/A
	Remarks Acquired and reviewed after site inspection			
6.	**Settlement Monument Records**	□ Readily available	□ Up to date	■ N/A
	Remarks No longer monitored			
7.	**Groundwater Monitoring Records**	□ Readily available	■ Up to date	□ N/A
	Remarks Acquired and reviewed after site inspection			
8.	**Leachate Extraction Records**	□ Readily available	□ Up to date	■ N/A
	Remarks ____________			
9.	**Discharge Compliance Records**			
	■ Air	□ Readily available	■ Up to date	□ N/A
	■ Water (effluent)	□ Readily available	■ Up to date	□ N/A
	Remarks Acquired and reviewed after site inspection			
10.	**Daily Access/Security Logs**	■ Readily available	■ Up to date	□ N/A
	Remarks Acquired and reviewed after site inspection			

IV. O&M COSTS

1. **O&M Organization**

☐ State in-house ■ Contractor for State
☐ PRP in-house ☐ Contractor for PRP
☐ Federal Facility in-house ■ Contractor for Federal Facility
☐ Other__________

2. **O&M Cost Records**

☐ Readily available ■ Up to date (acquired after site inspection - see report details)
■ Funding mechanism/agreement in place
Original O&M cost estimate__________ ☐ Breakdown attached

Total annual cost by year for review period if available

From (Date)	To (Date)	Total cost	
			☐ Breakdown attached
			☐ Breakdown attached
			☐ Breakdown attached
			☐ Breakdown attached
			☐ Breakdown attached

3. **Unanticipated or Unusually High O&M Costs During Review Period**

Describe costs and reasons: None discovered

V. ACCESS AND INSTITUTIONAL CONTROLS ■ Applicable ☐ N/A

A. Fencing

1. **Fencing damaged** ☐ Location shown on site map ■ Gates secured ☐ N/A
Remarks__________

B. Other Access Restrictions

1. **Signs and other security measures** ☐ Location shown on site map ■ N/A
Remarks__________

C. Institutional Controls (ICs)

1. **Implementation and enforcement**

Site conditions imply ICs not properly implemented ☐ Yes ☐ No ■ N/A

Site conditions imply ICs not being fully enforced ☐ Yes ☐ No ■ N/A

Type of monitoring (*e.g.*, self-reporting, drive by) ____________

Frequency ____________

Responsible party/agency ____________

Contact ____________ ____________ ____________ ____________

Name Title Date Phone no.

Reporting is up-to-date ☐ Yes ☐ No ■ N/A

Reports are verified by the lead agency ☐ Yes ☐ No ■ N/A

Specific requirements in deed or decision documents have been met ☐ Yes ☐ No ■ N/A

Violations have been reported ☐ Yes ☐ No ■ N/A

Other problems or suggestions: ☐ Report attached

2. **Adequacy** ☐ ICs are adequate ☐ ICs are inadequate ■ N/A

Remarks ____________

D. General

1. **Vandalism/trespassing** ☐ Location shown on site map ■ No vandalism evident

Remarks None confirmed

2. **Land use changes on site** ■ N/A

Remarks ____________

3. **Land use changes off site** ■ N/A

Remarks ____________

VI. GENERAL SITE CONDITIONS

A. Roads ■ Applicable ☐ N/A

1. **Roads damaged** ☐ Location shown on site map ■ Roads adequate ☐ N/A

Remarks ____________

B. Other Site Conditions

Remarks ____________________

VII. LANDFILL COVERS ■ Applicable ☐ N/A

A. Landfill Surface

1. **Settlement** (Low spots) ☐ Location shown on site map ☐ Settlement not evident
   Areal Extent Approx. 2000 S.F. Depth Approx. one foot
   Remarks A depression was noted at the eastern end of the top of the landfill, at the end of the upper most access road. This depression was noted in previous five-year review inspections

2. **Cracks** ☐ Location shown on site map ☐ Cracking not evident
   Lengths ______ Widths ______ Depths ______
   Remark None observed

3. **Erosion** ☐ Location shown on site map ☐ Erosion not evident
   Areal extent ______ Depth ______
   Remarks None observed

4. **Holes** ☐ Location shown on site map ☐ Holes not evident
   Areal extent ______ Depth ______
   Remarks None observed

5. **Vegetative Cover** ■ Grass ■ Cover properly established ■ No signs of stress
   ☐ Trees/Shrubs (indicate size and locations on a diagram)
   Remarks ______

6. **Alternative Cover (armored rock, concrete, etc.)** ☐ N/A
   Remarks Crushed stone cover appeared stable without any signs of distress

7. **Bulges** ☐ Location shown on site map ■ Bulges not evident
   Areal extent ______ Height ______
   Remarks ______

8. **Wet Areas/Water Damage** ☐ Wet areas/water damage not evident
☐ Wet areas ☐ Location shown on site map Areal extent______________
■ Ponding ☐ Location shown on site map Areal extent______________
☐ Seeps ☐ Location shown on site map Areal extent______________
☐ Soft subgrade ☐ Location shown on site map Areal extent______________
Remarks Minor ponding and associated vegetative growth was noted in the perimeter drainage swale on the northeast and the south central sides of the landfill

9. **Slope Instability** ☐ Slides ☐ Location shown on site map ■ No evidence of slope instability
Areal extent______________
Remarks______________

B. Benches ■ Applicable ☐ N/A
(Horizontally constructed mounds of earth placed across a steep landfill side slope to interrupt the slope in order to slow down the velocity of surface runoff and intercept and convey the runoff to a lined channel.)

1. **Flows Bypass Bench** ☐ Location shown on site map ■ N/A or okay
Remarks______________

2. **Bench Breached** ☐ Location shown on site map ■ N/A or okay
Remarks______________

3. **Bench Overtopped** ☐ Location shown on site map ■ N/A or okay
Remarks______________

C. Letdown Channels ■ Applicable ☐ N/A
(Channel lined with erosion control mats, riprap, grout bags, or gabions that descend down the steep side slope of the cover and will allow the runoff water collected by the benches to move off of the landfill cover without creating erosion gullies.)

1. **Settlement** ☐ Location shown on site map ■ No evidence of settlement
Areal extent______________ Depth______________
Remarks______________

2. **Material Degradation** ☐ Location shown on site map ■ No evidence of degradation
Material type______________ Areal extent______________
Remarks______________

3. **Erosion** ☐ Location shown on site map ■ No evidence of erosion
Areal extent______________ Depth______________
Remarks______________

4.	**Undercutting** ☐ Location shown on site map ■ No evidence of undercutting Areal extent_________ Depth_________ Remarks____________________
5.	**Obstructions** Type__________ ■ No obstructions ☐ Location shown on site map Areal extent_________ Size________ Remarks____________________
6.	**Excessive Vegetative Growth** Type__________ ■No evidence of excessive growth ☐ Vegetation in channels does not obstruct flow ☐ Location shown on site map Areal extent_________ Remarks____________________
D. Cover Penetrations ■ Applicable ☐ N/A	
1.	**Gas Vents** ■ Active ☐ Passive ☐ Properly secured/locked ☐ Functioning ☐ Routinely sampled ■ Good condition ☐ Evidence of leakage at penetration ☐ Needs Maintenance ☐ N/A Remarks : The gas header connection on the south central perimeter of the landfill cap was disconnected at the time of this inspection
2.	**Gas Monitoring Probes** ☐ Properly secured/locked ☐ Functioning ☐ Routinely sampled ☐ Good condition ☐ Evidence of leakage at penetration ☐ Needs Maintenance ■ N/A Remarks____________________
3.	**Monitoring Wells** (within surface area of landfill) ☐ Properly secured/locked ☐ Functioning ☐ Routinely sampled ☐ Good condition ☐ Evidence of leakage at penetration ☐ Needs Maintenance ■ N/A Remarks____________________
4.	**Leachate Extraction Wells** ☐ Properly secured/locked ☐ Functioning ☐ Routinely sampled ☐ Good condition ☐ Evidence of leakage at penetration ☐ Needs Maintenance ■ N/A Remarks____________________
5.	**Settlement Monuments** ☐ Located ☐ Routinely surveyed ■ N/A Remarks____________________

E. Gas Collection and Treatment ■ Applicable ☐ N/A

1. **Gas Treatment Facilities**
■ Flaring ■ Thermal destruction ☐ Collection for reuse
■ Good condition ☐ Needs Maintenance
Remarks____

2. **Gas Collection Wells, Manifolds and Piping**
■ Good condition ☐ Needs Maintenance
Remarks____

3. **Gas Monitoring Facilities** (*e.g.*, gas monitoring of adjacent homes or buildings)
☐ Good condition☐ Needs Maintenance ■ N/A
Remarks____

F. Cover Drainage Layer ■ Applicable ☐ N/A

1. **Outlet Pipes Inspected** ☐ Functioning ■ N/A
Remarks____

2. **Outlet Rock Inspected** ■ Functioning ☐ N/A
Remarks____

☐. Detention/Sedimentation Ponds ☐ Applicable ■ N/A

1. **Siltation** Areal extent__________ Depth__________ ☐ N/A
☐ Siltation not evident
Remarks____

2. **Erosion** Areal extent__________ Depth__________
☐ Erosion not evident
Remarks____

3. **Outlet Works** ☐ Functioning ☐ N/A
Remarks____

4. **Dam** ☐ Functioning ☐ N/A
Remarks____

H. Retaining Walls ☐ Applicable ■ N/A

1. **Deformations** ☐ Location shown on site map ☐ Deformation not evident
Horizontal displacement____________ Vertical displacement_______________
Rotational displacement____________
Remarks____

2. **Degradation** ☐ Location shown on site map ☐ Degradation not evident
Remarks____

I. Perimeter Ditches/Off-Site Discharge ☐ Applicable ■ N/A

1. **Siltation** ☐ Location shown on site map ☐ Siltation not evident
Areal extent______________ Depth____________
Remarks____

2. **Vegetative Growth** ☐ Location shown on site map ☐ N/A
☐ Vegetation does not impede flow
Areal extent______________ Type____________
Remarks____

3. **Erosion** ☐ Location shown on site map ☐ Erosion not evident
Areal extent______________ Depth____________
Remarks____

4. **Discharge Structure** ☐ Functioning ☐ N/A
Remarks____

VIII. VERTICAL BARRIER WALLS ☐ Applicable ■ N/A

1. **Settlement** ☐ Location shown on site map ☐ Settlement not evident
Areal extent______________ Depth____________
Remarks____

2. **Performance Monitoring** Type of monitoring__________________________
☐ Performance not monitored
Frequency______________________________ ☐ Evidence of breaching
Head differential__________________________
Remarks____

IX. GROUNDWATER/SURFACE WATER REMEDIES ■ Applicable ☐ N/A

A. Groundwater Extraction Wells, Pumps, and Pipelines ■ Applicable ☐ N/A

1. **Pumps, Wellhead Plumbing, and Electrical**
■ Good condition ■ All required wells properly operating ☐ Needs Maintenance ☐ N/A
Remarks

2. **Extraction System Pipelines, Valves, Valve Boxes, and Other Appurtenances**
■ Good condition ☐ Needs Maintenance
Remarks

3. **Spare Parts and Equipment**
☐ Readily available ☐ Good condition ☐ Requires upgrade ☐ Needs to be provided
Remarks

B. Surface Water Collection Structures, Pumps, and Pipelines ☐ Applicable ☐ N/A

1. **Collection Structures, Pumps, and Electrical**
■ Good condition ☐ Needs Maintenance
Remarks

2. **Surface Water Collection System Pipelines, Valves, Valve Boxes, and Other Appurtenances**
☐ Good condition ☐ Needs Maintenance
Remarks N/A

3. **Spare Parts and Equipment**
☐ Readily available ☐ Good condition ☐ Requires upgrade ☐ Needs to be provided
Remarks

C. Treatment System ■ Applicable ☐ N/A

1. **Treatment Train** (Check components that apply)
☐ Metals removal ☐ Oil/water separation ☐ Bioremediation
☐ Air stripping ☐ Carbon adsorbers
☐ Filters______
■ Additive (*e.g.*, chelation agent, flocculent) pH adjustment and biocide
☐ Others______
■ Good condition ☐ Needs Maintenance
☐ Sampling ports properly marked and functional
☐ Sampling/maintenance log displayed and up to date
■ Equipment properly identified
■ Quantity of groundwater treated annually (see report)
☐ Quantity of surface water treated annually______
Remarks______

2. **Electrical Enclosures and Panels** (properly rated and functional)
☐ N/A ■ Good condition ☐ Needs Maintenance
Remarks______

3. **Tanks, Vaults, Storage Vessels**
☐ N/A ■ Good condition ☐ Proper secondary containment ☐ Needs Maintenance
Remarks Combined groundwater and leachate blending vault

4. **Discharge Structure and Appurtenances**
■ N/A ☐ Good condition ☐ Needs Maintenance
Remarks______

5. **Treatment Building(s)**
☐ N/A ■ Good condition (esp. roof and doorways) ☐ Needs repair
■ Chemicals and equipment properly stored
Remarks______

6. **Monitoring Wells** (pump and treatment remedy)
☐ Properly secured/locked ■ Functioning ☐ Routinely sampled ■ Good condition
☐ All required wells located ☐ Needs Maintenance ☐ N/A
Remarks______

D. Monitoring Data

1. Monitoring Data
☐ Is routinely submitted on time ■ Is of acceptable quality

2. Monitoring data suggests:
☐ Groundwater plume is effectively contained ☐ Contaminant concentrations are declining

D. Monitored Natural Attenuation

1. **Monitoring Wells** (natural attenuation remedy)
☐ Properly secured/locked ☐ Functioning ☐ Routinely sampled ☐ Good condition
☐ All required wells located ☐ Needs Maintenance ■ N/A
Remarks______________________________

X. OTHER REMEDIES

If there are remedies applied at the site which are not covered above, attach an inspection sheet describing the physical nature and condition of any facility associated with the remedy. An example would be soil vapor extraction.

XI. OVERALL OBSERVATIONS

A. Implementation of the Remedy

Describe issues and observations relating to whether the remedy is effective and functioning as designed. Begin with a brief statement of what the remedy is to accomplish (i.e., to contain contaminant plume, minimize infiltration and gas emission, etc.).

(documented in site inspection trip reports)

B. Adequacy of O&M

Describe issues and observations related to the implementation and scope of O&M procedures. In particular, discuss their relationship to the current and long-term protectiveness of the remedy.

(documented in five-year review report)

C.	**Early Indicators of Potential Remedy Problems**
	Describe issues and observations such as unexpected changes in the cost or scope of O&M or a high frequency of unscheduled repairs that suggest that the protectiveness of the remedy may be compromised in the future. (documented in five-year review report)
D.	**Opportunities for Optimization**
	Describe possible opportunities for optimization in monitoring tasks or the operation of the remedy. (documented in five-year review report)

Charles George Landfill
24 November Site Inspection Field Notes

Attendees: Larry Cain (USACE), Ian Osgerby (USACE), Peter Hugh (USACE), Ben Rice (USACE), Dave O'Connor (USACE), David Buckley (MADEP), Doug Murphy (Clean Harbors), and Rich Fisher (EPA)

Visual inspections of the landfill are conducted by Clean Harbors 2 to 3 times per week. Evidence of trespassers occur periodically and security fence damage does occur, but repairs are made right away.

Inspection team visited Eastern Pump Station – groundwater from extraction wells (Photo 1) and the leachate collection system are blended in an underground tank (Photo 2), treated with citric acid and biocide (Photo 3) to control iron precipitation, and discharged to a sewer line routed by the site which subsequently discharges to a POTW – the Lowell Regional Wastewater Utility (LRWU). Discrete grab and 24-hour samples are collected from the Effluent Monitoring Station. Discharge monitoring reports are prepared quarterly in accordance with an industrial user discharge permit issued by the (LRWU).

Observed lagoon sediment and liner removal which was nearly complete – this lagoon has not been in use for more than ten years – functioned originally to collect landfill leachate/pumped groundwater and whose contents were subjected to periodic (interim) treatments when near capacity – excavated materials were being hauled offsite as F001 waste at the time of inspection – EPA may have lab data for the sediments – the approximate 5-acre surface has been regraded and seeded (Photo 4).

Inspected top of landfill cap and gas vent system – all operating vents are identical (Photo 5) – pipes penetrate the cap, but not the waste mass – gas pipes are welded (sealed) to the cap membrane – valves at each vent are used for balancing flows though it doesn't work well – highest elevation vent is topped with a pressure relief valve to protect the cap from excessive pressure should the vent system fail.

Elevation survey monuments were noted along the northern flank of the landfill near main office building – these were installed to monitor cap subsidence, but are no longer used.

Visited landfill gas blower house (Photo 6) – frequently shuts down due to excess oxygen (>5%) – usually requires a restart 2 to 3 times per week manually by a Clean Harbors rep – source of the elevated oxygen (Photo 7) is unknown though infiltration/leakage from the vent pipe seals and toe of landfill slope are candidates – supplemental fuel is currently not added – knockout tank has never produced significant condensate or precipitates. Landfill gas constituents are thermally destroyed in an enclosed flare (Photo 8).

Southwestern Pump Station was not visited – functionally the same as the eastern system – connected to five extraction wells and the leachate recovery trench system on that flank of the landfill. Wastewater pump station, which serves as a transfer station to generate pumping head for discharge into the sewer line, also was not visited.

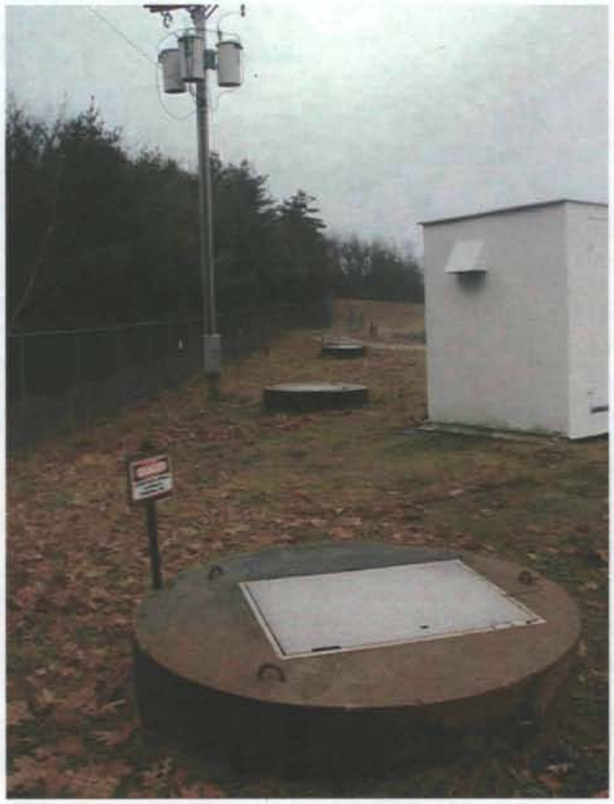


Photo 1

Photo 2

Photo 3

Photo 4

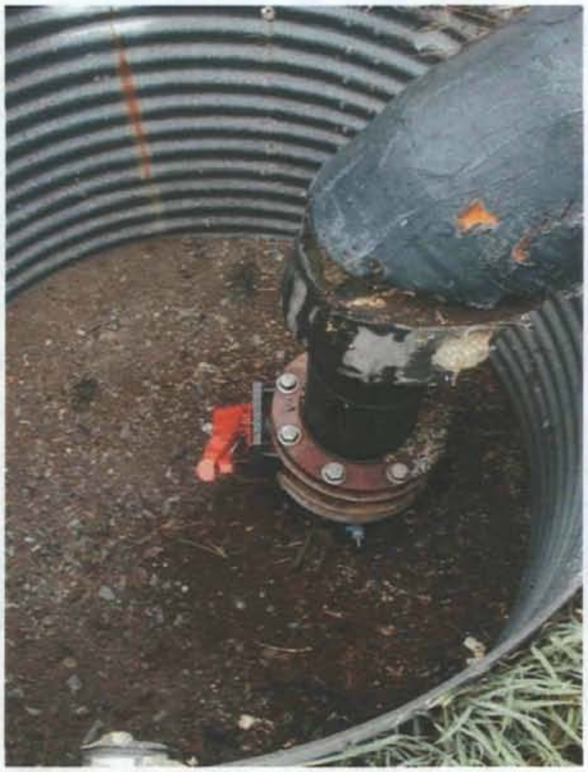


Photo 5

Photo 6

Photo 7

Photo 8

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New England District
Geotechnical Engineering Section
696 Virginia Road
Concord, Massachusetts
01742-2751

TRIP REPORT

Charles George Land Reclamation Trust Landfill Superfund Site
Tyngsboro, Massachusetts

Date: Tuesday December 8, 2009

Time: 1000 to 1230 hrs.

Weather: Clear, Calm, 35°F,

Attendees:
Jon Kullberg, P.E., Geotechnical Engineering Section, USACE, NAE
David O'Connor, Construction Division, USACE, NAE

Purpose: Perform a landfill cap inspection as part of the Five Year Review.

Project Description and Information: The Charles George Land Reclamation Trust Landfill Superfund Site is a 70-acre mixed industrial, municipal, and hazardous waste landfill located approximately one mile southwest of the town center of Tyngsboro, Massachusetts. The Site is bordered to the east by U.S. Route 3, Flint Pond Marsh, and Flint Pond. Dunstable Road and Dunstable Brook border the Site to the west and south. Blodgett Street and Cummings Road form the northwestern border of the Site.

History of Contamination: Waste disposal activity at the Site was initiated in the mid 1950's. During the period between 1955 and when the land was purchased by Charles George Sr. in 1967, the Site was operated as a Municipal dump. The Site continued to operate as a Municipal landfill after acquisition by Charles George Sr. in 1967 and the Charles George Land Reclamation Trust (Charles George Sr. and Dorothy George, Trustees) in 1971. In 1973, the Trust was issued a permit by the Commonwealth of Massachusetts to handle hazardous wastes in addition to Municipal and domestic refuse. Disposal of hazardous wastes and substances primarily in the form of drummed and bulk chemicals containing VOCs and toxic metal sludges continued from January 1973 to at least June 1976.

In 1982, the Tyngsboro Board of Health suspended the assignment of the Trust's land as a landfill. At approximately the same time, the Massachusetts Department of Environmental Quality Engineering (**DEQE**); now the Massachusetts Department of Environmental Protection [MADEP]) ordered the closing of two wells serving the Cannongate Condominiums (800 feet SE of the site) due to the presence of VOC contamination in the well water.

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History of Landfill Cap: ROD II provided a cap for the Site consisting of a synthetic membrane and soil cover, a surface water management system, a passive landfill gas venting system, and a leachate collection system (OU2). These measures minimized the migration of contaminants through the air and groundwater and, therefore, provided a measure of protectiveness to human health.

Construction of a synthetic landfill cap and appurtenant systems was begun in early 1989 and completed in October 1990. A new shallow perimeter leachate toe-drain, two leachate pump stations with force mains flowing to the temporary leachate holding pond, a passive gas collection and venting system, and a surface water diversion and sedimentation system were included in the construction of the cap.

Inspection: The landfill inspection began by travelling the access road at the top of the landfill from west to east. The perimeter access road was then travelled in a clockwise direction starting at the project office building. The landfill had a light coating of snow from the day before, however this did not significantly impede the inspection (Photo 1). Features of the landfill inspected included the cap, the drainage swales, and access roads. Observations were made regarding the vegetative cover, gravel cover, erosion, settlement, and general condition of the various features.

- The landfill surface is in good condition and all slopes appear stable. The areas with vegetated surfaces appeared healthy and dense with full coverage (Photo 2). The areas covered with crushed stone appeared stable without any signs of distress, other than some observed vehicle tracks on the side slopes (most likely off-road vehicle tracks such as ATV)(Photo 3).
- A depression was noted at the eastern end of the top of the landfill, at the end of the upper most access road. This depression was noted in previous inspections, and is about a foot deep and roughly 50 feet across, which matches previous descriptions (Photo 2). It was noted by past project personnel that this area was a truck turnaround during construction of the landfill. There does not appear to be any damage or malfunctioning of the cap in this area.
- Minor ponding and associated vegetative growth was noted in the perimeter drainage swale on the north east and the south central sides of the landfill (Photo 4). The vegetative growth should be controlled with an herbicide.
- The east, southwest and west detention and sedimentation basins all have woody growth, in some areas near the riprap (Photo 5). The woody growth should be controlled by removal and regular application of an herbicide.
- The access roads were in generally good condition.
- The gas header connection on the south central perimeter of the landfill cap was disconnected at the time of this inspection. (Photo 6)

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Conclusions and Recommendations:

The landfill cap, drainage swales and access roads are stable and in good repair. Vegetative growth in the swales and detention ponds should be controlled with herbicide application and removal of woody species. The gas header at the south central perimeter of the landfill should be repaired and reconnected if necessary.

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Photographs:

PHOTO 1

PHOTO 2

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PHOTO 3

PHOTO 4

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PHOTO 5

PHOTO 6

ATTACHMENT 4

INTERVIEW RECORDS

INTERVIEW RECORD

Site Name: Charles George Landfill	**EPA ID No.:** MAD003809266
Subject: Five-Year Review - 2009	**Time:** 10:30 **Date:** 24 Nov 2009
Type: Telephone Visit Other **Location of Visit:** On-site Operations and Maintenance Bldg	Incoming Outgoing

Contact Made By:

Name: Ben Rice	**Title:** Geologist	**Organization:** USACE

Individual Contacted:

Name: see individuals identified below	**Title:**	**Organization:**

Telephone No: **Fax No:** **E-Mail Address:**	**Street Address:** **City, State, Zip:**

Summary Of Conversation

EPA	MADEP
Rich Fisher, USEPA Region 1 5 Post Office Square - Suite 100 Boston, MA 617-918-1721	Dave Buckley, MADEP 1 Winter Street Boston, MA 617-556-1184
Dave O'Connor, USACE 50 MacArthur Ave Devens, MA 978-318-8129	Doug Murphy, Clean Harbors 42 Longwater Drive Norwell, MA 781-953-0731
Bob Santosuosso, H&S Environmental 160 E. Main Street Westborough, MA	
Patrick Schauble, H&S Environmental 160 E. Main Street Westborough, MA 484-880-1896	

Q1. What is the current status of the original permanent water supply and associated extensions?

A1. There are no current problems. [a collective response]. Capacity issues occurred shortly after the lines were installed, but these problems have been corrected by the Lowell Regional Water Utility (LRWU). [D. Buckley]

Q2. Are institutional controls in place to prevent/restrict access to the landfill cap? If so, what are they?

A2. The land owners have entered into a consent decree with EPA regarding institutional controls which may ultimately include land use limitations. [D. Buckley and R. Fisher]

Q3. Have any significant alterations, modifications, or repairs been made to the landfill cap and landfill gas collection and associated treatment facilities?

A3. No major chances have been made to the cap in the past five years. The existing landfill gas remote monitoring system (SCADA) was upgraded recently. [D. O'Connor].

Q4. Have any significant alterations, modifications, or repairs been made to the leachate and ground water recovery and associated treatment systems?

A4. Only removal of sediments and liner from the former leachate collection lagoon, which has been inactive since the permanent leachate and groundwater recovery systems were installed. [D. Buckley]

Q5. Have institutional controls been established to restrict access to groundwater for potable and non-potable (e.g., drinking water, livestock, and irrigation)? If so, what are they?

A5. No. These concerns were discussed with the local municipalities some time ago for nearby residents, but there has been little interest on their part. [R. Fisher] All nearby potential groundwater users are currently on the LRWU pipeline except for one residential property – this property is located up-gradient of the site and not likely to be impacted by groundwater contaminated by the site. [D. Buckley]

Q6. Has an evaluation of risks to ecological receptors been conducted since the last five-year review?

A6. Eight to ten surface water and sediment sample pairs are planned for Flint Pond, Flint Pond Marsh, and Dunstable Brook. Samples are expected to be collected sometime next week. Surface water samples will be analyzed for VOCs and dissolved metals – sediment samples will be analyzed for PAHs, TOC, and metals. Raw (unvalidated) results should be available by the end of December for inclusion in the five-year review report. [R. Fisher. and D. O'Connor]

Q7. Has groundwater monitoring been re-established? If so, which wells are monitored, at what frequency, and for which analytical parameters?

A7. No, but a single sampling round is planned for next week. Approximately 16 samples will be collected from selected wells for analysis of VOCs, 1,4-dioxane, and total metals. Raw results should be available at the end of December for inclusion in the five-year review report. [R. Fisher and P. Schauble]

Q8. What additional characterization tasks (e.g., soil gas, surface water, and sediment) have been performed since the last five-year review was conducted?

A8. Landfill gas has been sampled quarterly throughout the review period – for methane primarily, not VOCs. The latest round was conducted on October 1, 2009. [D. Murphy] Groundwater and surface water and sediment (at Flint Pond, Flint Pond Marsh, and Dunstable Brook) were last sampled in June 2006. That data should be included in the five-year review report. [R. Fisher]

Q9. What additional soil gas characterization work was conducted during the past five years?

A9. None, however, a soil survey at the site perimeter is currently being considered. It is likely to take place sometime next year. [D. Buckley]

Q10. What measures have been taken to address sedimentation in drainage swales?

A11. Sedimentation in the drainage swales is sand applied to the adjacent road in winter by the local municipality. The condition has been corrected by construction of an earthen berm which diverts road runoff away from the site. [D. Buckley and D. Murphy]

Q11. What is the status of iron build-up downstream in the sanitary sewer?

A11. Conversations with the superintendent of the Tyngsboro Sewer Commission revealed that the build-up was essentially a film or sheen and not a significant precipitation of iron flock. No associated mechanical problems have been reported by the superintendent. [D. O'Connor]

INTERVIEW RECORD

Site Name: Charles George Landfill	**EPA ID No.:** MAD003809266	
Subject: Five-Year Review – 2010	**Time:** 09:45	**Date:** 14 Jan 2010
Type: Telephone X Visit Other **Location of Visit:**	Incoming Outgoing X	

Contact Made By:

Name: Ben Rice	**Title:** Geologist	**Organization:** USACE

Individual Contacted:

Name: Kevin O'Conner	**Title:** Member (former)	**Organization:** Tyngsborough Board of Selectmen

Telephone No: 978-649-2300 ext. 119 **Fax No:** **E-Mail Address:**	**Street Address:** 25 Bryant Lane **City, State, Zip:** Tyngsborough, MA 01879

Summary Of Conversation

Mr. O'Conner is currently the Veteran's Agent for the Town of Tyngsborough, but served on the Board of Selectmen for the period 2000 through 2009. He is also a former residential abutter to the Site, living on Brookview Circle for 27 years prior to 2007.

Q1: What is your overall impression of the site (general sentiment)?

A1: Mr. O'Conner could think of no significant issues or negative events associated with the Site that affected him as a residential abutter, or that he was alerted to as a Selectmen. His has been impressed and reassured by the attention to details exhibited by the managing agencies including cap maintenance (grass mowing), prompt repairs of the security fence, and regular and frequent presence of on-site representatives.

Q2: Do you feel well informed about the site's activities and progress?

A2: The Board of Selectmen received many information letters and notices (by MADEP specifically) over the course of his tenure keeping them apprised of site activities and upcoming events – according to Mr. O'Conner, the Board was kept well informed.

Q3: Are you aware of any issues the five-year review should focus on?

A3: Mr. O'Conner could think no problems with the site that the five-year review should focus on.

Q4. Have there been routine communications or activities such as site visits, inspections, reporting activities, etc conducted by your office regarding the site? If so, please give purpose and results.

A4: No routine communications or activities were conducted by the Board of Selectmen during the past five years.

Q5: Have there been any changes in the site or surrounding property in the last 5 years, or are changes planned?

A5: There has been some industrial development abutting the landfill property to the northeast, but Mr. O'Conner was not aware of any residential build-out or use changes in the vicinity of the Site in the past five years.

Q6: Have there been any complaints, violations, or other incidents related to the site requiring a response by your office? If so, please give details of the events and results of the responses.

A6: As a former member of the Board of Selectmen, he would have been aware of any events or situations that would have required a response by Town officials. Mr. O'Conner could not recall any complaints, violations, or incidents during the past five years.

Q7: Do you have any comments, suggestions, or recommendations regarding the site's management or operation?

A7: Mr. O'Conner appreciates that current commitment and attention to the management and operation of the Site exhibited by the regulatory agencies and hopes they continue in the future.

INTERVIEW RECORD

Site Name: Charles George Landfill	**EPA ID No.:** MAD003809266	
Subject: Five-Year Review – 2010	**Time:** 10:55	**Date:** 19 Jan 2010
Type: Telephone **X** Visit Other **Location of Visit:**	Incoming Outgoing **X**	

Contact Made By:

Name: Ben Rice	**Title:** Geologist	**Organization:** USACE

Individual Contacted:

Name: Matt Marro	**Title:** Conservation Director	**Organization:** Tyngsborough Conservation Commission

Telephone No: 978-649-2300 ext. 119 **Fax No:** **E-Mail Address:**	**Street Address:** 25 Bryant Lane **City, State, Zip:** Tyngsborough, MA 01879

Summary Of Conversation

Mr. Marro is currently the Director of Conservation for the Town of Tyngsborough and has served in this capacity for the past three years. He is the Town's full-time environmental affairs investigator.

Q1: What is your overall impression of the site (general sentiment)?

A1: Mr. Marro is familiar with the Charles George Landfill and routinely (3 to 4 times per week) passes by the site as part of his job. Overall, he has no issues with the site, though his knowledge of onsite activities and conditions is limited.

Q2: Do you feel well informed about the site's activities and progress?

A2: To his knowledge, the Conservation Commission has not received any informational letters and notices during the past five years. Mr. Marro is interested in being kept apprised of any site activities and upcoming events that are typically communicated to the Town.

Q3: Are you aware of any issues the five-year review should focus on?

A3: None. Part of Mr. Marro's job is to observe and evaluate environmental conditions such as stressed vegetation, odors, and surface water quality within the Town of Tyngsborough. He is not aware of any problems associated with the site at this time.

Q4. Have there been routine communications or activities such as site visits, inspections, reporting activities, etc conducted by your office regarding the site? If so, please give purpose and results.

A4: Mr. Marro could not recall reporting activities, site visits, or inspections conducted by the Conservation Commission during the past five years.

Q5: Have there been any changes in the site or surrounding property in the last 5 years, or are changes planned?

A5: Yes. Beaver damming along Dunstable Brook in the vicinity of the site has become problematic in recent years. Mr. Marro indicated that dams in that area will ultimately pose an issue to storm water runoff and potential flooding for the site and nearby residential properties. He also mentioned that potential changes in groundwater dynamics resulting from this surface water flooding could adversely impact groundwater recovery on the southwestern side of the landfill.

Q6: Have there been any complaints, violations, or other incidents related to the site requiring a response by your office? If so, please give details of the events and results of the responses.

A6: No, it has been quite. Neither Mr. Marro nor the Conservation Commission office has received calls or complaints associated with the site.

Q7: Do you have any comments, suggestions, or recommendations regarding the site's management or operation?

A7: Mr. Marro asked that he be included in any regular correspondence between site management and the Town. In addition, he recommended that beaver damming along Dunstable Brook be monitored periodically throughout the year by site management to evaluate possible current and future impacts on site operations.

ATTACHMENT 5

ARARS REVIEW

ATTACHMENT 5, TABLE 1
POTENTIAL CHEMICAL-SPECIFIC ARARS AND CRITERIA, ADVISORIES, AND GUIDANCE
CHARLES GEORGE RECLAMATION LANDFILL, TYNGSBOROUGH, MASSACHUSETTS

MEDIA and AUTHORITY	REQUIREMENT	ROD STATUS	ROD REQUIREMENT SYNOPSIS and CONSIDERATION IN RI/FS	FIVE-YEAR REVIEW
<u>Groundwater</u>				
Federal Regulatory Requirements	SDWA - Maximum Contaminant Levels (MCLs) (40 CFR 141.11 - 141.16)	Relevant and Appropriate	MCLs have been promulgated for a number of common organic and inorganic contaminants. These levels regulate the concentration of contaminants in public drinking water supplies, but may also be considered relevant and appropriate for groundwater aquifers used for drinking water. When risks to public health due to consumption of groundwater were assessed, concentrations of contaminants of concern, including benzene and TCE, were compared to their MCLs. Projected concentrations of benzene exceeded the MCL in several locations. SDWA MCLs also were used in setting discharge requirements.	MCLs and non-zero MCLGs have the status of ARARs for areas not directly overlain by waste. Some MCLs and MCLGs have changed since ROD completion. An update of the MCLs/MCLGs is provided in Table 2. Residential well monitoring did not indicate any exceedences of groundwater COCs. This ARAR is being attained. The MCL for arsenic is changed from 50 ppb to 10 ppb, effective 1/23/06. This change will need to be considered during evaluation of when the groundwater extraction system can be shut down.
	RCRA - Subpart F, Groundwater Protection Standards, Concentration Limits (40 CFR 264.94(a))	Relevant and Appropriate	The onsite landfill contains material sufficiently similar to RCRA Subtitle C wastes; therefore RCRA landfill rules are relevant and appropriate. The groundwater protection regulations require the setting of groundwater protection standards which must be protective of the public health and the environment. RCRA standards for 14 toxic compounds have been adopted as part of RCRA groundwater protection standards. These limits were originally set at MCLs. RCRA sets the limit for organic constituents at background levels. Groundwater contaminant levels were compared to these limits. Although eastern shallow groundwater is not a potential drinking water source, it does exceed these limits. Therefore it requires remediation.	Site COCs arsenic, chromium, mercury and cadmium are included in the 14 toxic compounds for which standards have been adopted. Currently, only COC cadmium has a RCRA MCL (0.01 mg/L) that differs from the SDWA MCL (0.005 mg/L). RCRA sets the limit for organic constituents at background levels. Constituents in site groundwater exceed RCRA MCLs for background concentrations for a few, scattered organic constituents, at very low levels. Groundwater requires continued remediation under this rule.

MEDIA and AUTHORITY	REQUIREMENT	ROD STATUS	ROD REQUIREMENT SYNOPSIS and CONSIDERATION IN RI/FS	FIVE-YEAR REVIEW
	RCRA - Subpart F Groundwater Protection Standards, Alternate Concentration Levels (ACLs) (40 CFR 264.94(b))	Relevant and Appropriate	ACLs are one of three possible standards (aside from MCLs and background concentrations) available under Subpart F for setting a clean-up level for remediation of groundwater contamination from a RCRA facility. ACLs may be relevant and appropriate if certain conditions relating to transport and exposure are met. ACLs may need to be determined by EPA. Procedures for developing ACLs are outlined in RCRA Subpart F, Section 264.94(b).	There is no change from the ROD presentation for this ARAR. At this time, ACLs are not being sought.
Massachusetts Regulatory Requirements	Massachusetts Groundwater Quality Standards (314 CMR 6.00)	Applicable	Massachusetts Groundwater Quality Standards have been promulgated for a number of contaminants. When state levels are more stringent than federal levels, the state levels will be used. DEP Groundwater Standards were considered when determining discharge levels.	Massachusetts groundwater standards are updated and presented in Table 2. Groundwater underlying the site is designated Class I.
	Massachusetts Drinking Water Requirements (310 CMR 22.05 to 22.09)	Relevant and Appropriate	Requirements were considered; however, standards do not apply to contaminants found in site groundwater.	Because the site is within 500 feet of a private water supply well that was in use at the time of site discovery, drinking water requirements are relevant and appropriate. Many of the Massachusetts MCLs have changed since ROD completion; an updated list is provided in Table 2. Residential well monitoring did not indicate any exceedences of groundwater COCs. This ARAR is being attained.
Federal Criteria, Advisories, and Guidance	SDWA - Maximum Contaminant Level Goals (MCLGs)	Relevant and Appropriate /To Be	MCLGs are health-based criteria that are to be considered for drinking water sources as a result of SARA. These goals are available for a number of organic and inorganic contaminants.	Non-zero MCLGs have the status of ARAR for areas not directly overlain by waste. Zero MCLGs cannot have the status of ARARs but are,

MEDIA and AUTHORITY	REQUIREMENT	ROD STATUS	ROD REQUIREMENT SYNOPSIS and CONSIDERATION IN RI/FS	FIVE-YEAR REVIEW
		Considered	Projected groundwater concentrations of copper, trans-1,2-dichloroethene, toluene, benzene, and TCE were compared to their MCLGs. For benzene and TCE, MCLGs are set at zero.	however, to be considered in developing site remedies. Many of the MCLGs have changed since ROD completion. An update of MCLGs is provided in Table 2. There are scattered organic constituent hits which are low but do exceed zero MCLGs. These compounds, however, were not listed as groundwater COCs in the ROD. They include: chloroform, bromoform, 1,4-dioxane, 1,2-dichlorobenzene, methylene chloride, 1,1,2,2-trichloroethane, and others. Groundwater requires continued remediation under this rule.
	Health Advisories (EPA Office of Drinking Water)	To Be Considered	Health Advisories are estimates of risk due to consumption of contaminated drinking water; they consider non-carcinogenic effects only. Health Advisories were considered for contaminants in groundwater that may be used for drinking water.	These criteria are no longer maintained by EPA. These health advisories are not updated on the accompanying tables.
	EPA Risk Reference Doses (RfDs)	To Be Considered	RfDs are dose levels developed by EPA for non-carcinogenic effects. EPA RfDs were used to characterize risk due to exposure to contaminants in groundwater, as well as other media. They were considered for non-carcinogens including toluene, 2-butanone, n-dibutylphthalate, acetone, mercury, and thallium.	This factor is one of several factors used to calculate risk at a site. Reference doses and slope factors have changed from 1988. See Section 7 for discussion.
	EPA Carcinogen Assessment Group	To Be Considered	Potency factors are developed by EPA from Health Effects Assessments of evaluation by the	This factor is one of several factors used to calculate risk at a site.

MEDIA and AUTHORITY	REQUIREMENT	ROD STATUS	ROD REQUIREMENT SYNOPSIS and CONSIDERATION IN RI/FS	FIVE-YEAR REVIEW
	Potency Factors (CAGs)		Carcinogenic Assessment Group. EPA Carcinogenic Potency Factors were used to compute the individual incremental cancer risk resulting from exposure to benzene, arsenic, PAHs, trichloroethene, and 1,1-dichloroethene.	Reference doses and slope factors have changed from 1988. See Section 7 for discussion.
	Acceptable Intake - Chronic (AIC) and Subchronic (AIS) - EPA Health Effects Assessment (HEA) Documents	To Be Considered	AIC and AIS values are developed from RfDs and HEAs for noncarcinogenic compounds. AIC and AIS values were used to characterize the risks due to several noncarcinogens in various media. These noncarcinogens include cadmium, chromium, copper, and lead.	AICs and AISs have essentially been replaced by RfDs, and are not used in the 1999 updates.
	EPA Office of Water Guidance - Water-related Fate of 129 Priority Pollutants (1979)	To Be Considered	This guidance manual gives transport and fate information for 129 priority pollutants. The manual was used to assess the transport and fate of a variety of contaminants.	There is no change from the ROD presentation for this ARAR.
Massachusetts Criteria, Advisories, and Guidance	Massachusetts Office of Research and Standards Guidelines (ORSGs)	To Be Considered	DEP Health Advisories are guidance criteria for drinking water. DEP Health Advisories were used to develop discharge levels for surface water and groundwater.	The MADEP Office of Research and Standards issues guidelines for chemicals for which state MCLs have not yet been promulgated. These guidelines apply to non-chlorinated water supplies and represent a level at or below which adverse, non-cancer health effects are not expected to occur, and which generally has associated with it an excess lifetime cancer risk of less than or equal to one in one million. These criteria are included in Table 2.

MEDIA and AUTHORITY	REQUIREMENT	ROD STATUS	ROD REQUIREMENT SYNOPSIS and CONSIDERATION IN RI/FS	FIVE-YEAR REVIEW
				There is now an ORSG established for 1,4-dioxane of 3 ppb. This value will need to be considered during evaluation of when the groundwater extraction system can be shut down.
Discharge to Publicly Owned Treatment Works				
Federal Regulatory Requirements	RCRA - Pretreatment Standards (40 CFR 403) - Local POTW Approved Pretreatment Program Requirements	Applicable	Discharges to a POTW must comply with the POTW's EPA-approved pretreatment requirements. POTWs in the area with approved pretreatment programs are being identified and the discharge must be treated to those levels required by the program.	Collected leachate and groundwater are treated and discharged to the Lowell Regional Wastewater Utility (LRWU). This discharge is permitted and is in compliance with permit limits.
Discharge to Surface Water				
Massachusetts Regulatory Requirements	Massachusetts Surface Water Quality Standards (314 CMR 4.05)	Formerly Applicable - now not ARAR	DEP Surface Water Quality Standards are given for dissolved oxygen, temperature increase, pH, and total coliform and there is a narrative requirement for toxicants in toxic amounts. In the absence of a state standard for a compound, federal AWQC would be appropriate. Requirements were considered; however, no numerical standards exist for contaminants found in site groundwater which would be discharged to surface water. Federal AWQC will be used in the absence of narrative standards.	These regulations classify the surface waters of the Commonwealth according to the uses of those waters. The Merrimack River has a Class B waterway classification. Class B waters are designated as habitat for fish, other aquatic and wildlife, and for primary and secondary contact recreation. The state surface water minimum criteria for Class B waters are consistent with federal AWQC. These rules are applicable to the Merrimack River, Bridge Meadow Brook, Dunstable Brook, Flint Marsh, and Flint Pond. No discharges to these surface water bodies are occurring. Hence

MEDIA and AUTHORITY	REQUIREMENT	ROD STATUS	ROD REQUIREMENT SYNOPSIS and CONSIDERATION IN RI/FS	FIVE-YEAR REVIEW
				SWQC are no longer ARAR.
Surface Water				
Federal Criteria, Advisories, and Guidance	Federal Ambient Water Quality Criteria (AWQC)	Formerly Relevant and Appropriate - now Not ARAR	Federal AWQC are health-based and ecologically based criteria which have been developed for 95 carcinogenic and non-carcinogenic compounds. AWQC were considered in characterizing public health risks to aquatic organisms due to contaminant concentrations in surface water at Flint Pond. Because this water is not used as a drinking water source, the criteria developed for aquatic organism protection and ingestion of contaminant aquatic organisms were considered. AWQC were also used as limits for discharge to the Merrimack River.	CERCLA Sec. 121 (d)(2)(A) specifically states that remedial actions shall at least attain federal AWQC established under the Clean Water Act if they are relevant and appropriate. Many of the AWQC have changed since ROD completion. These criteria are ARAR for establishing discharge limits to the Merrimack River, Bridge Meadow Brook, Flint Marsh, and Flint Pond. No discharges to these water bodies are occurring. Hence AWQC are no longer ARAR.
Air				
Federal Regulatory Requirements	CAA - National Ambient Air Quality Standards (NAAQS) - 40 CFR 50	Relevant and Appropriate	These standards were primarily developed to regulate stack and automobile emissions. Standards for sulfur dioxide, carbon monoxide and nitrogen dioxide apply.	NAAQS need to be taken into account when establishing discharges to the atmosphere. This includes the landfill gas treatment system.
Massachusetts Regulatory Requirements	Massachusetts - Air Quality, Air Pollution (310 CMR 6.00 - 8.00)	Relevant and Appropriate	These standards were primarily developed to regulate stack and automobile emissions.	310 CMR 6.00 provide ambient air quality standards for the Commonwealth, standards for dust are contained in 310 CMR 7.09, and 310 CMR 7.08 provides incinerator standards. No further land-disturbing activities are planned. In the event of further excavation, dust control standards would become

MEDIA and AUTHORITY	REQUIREMENT	ROD STATUS	ROD REQUIREMENT SYNOPSIS and CONSIDERATION IN RI/FS	FIVE-YEAR REVIEW
				applicable.
Federal Criteria, Advisories, and Guidance	Threshold Limit Values (TLVs)	To Be Considered	These standards were issued as consensus standards for controlling air quality in workplace environments. TLVs could be used to assess site inhalation risks for soil removal operations.	There is no change from the ROD presentation for this criteria.
Massachusetts Criteria, Advisories, and Guidance	Massachusetts Threshold Effects Exposure Limits (TELs) and Allowable Ambient Levels (AALs), DEP Revised, December 1995.	To Be Considered	These are guidelines in emission permit writing. This guidance evaluates acute and chronic toxicity and sets TELs/ AALs for 115 chemicals. These criteria are used when evaluating human health risks from ambient air. AALs were considered when assessing the significance of monitored and modeled residential contamination from air emissions.	There is no change from the ROD presentation for this guidance.
<u>Soil and Sediment</u>				
Federal Regulatory Criteria, Advisories, and Guidance Federal Criteria, Advisories and Guidance	Toxicological Benchmarks for Screening Contaminants of Potential Concern for Effects on Sediment-Associated Biota: EPA 1997 Revision	To Be Considered	None.	Guidelines have been developed by EPA for organic and inorganic compounds. These criteria represent levels protective of aquatic life. These benchmark criteria are summarized from three reports (Jones et. al. 1997; Jones et. al., 1996; and Hull and Suter 1994.)

ATTACHMENT 6, TABLE 2. CURRENT NUMERICAL STANDARDS FOR CONTAMINANTS OF CONCERN FOR GROUNDWATER AND LEACHATE, CHARLES GEORGE RECLAMATION LANDFILL, TYNGSBOROUGH, MASSACHUSETTS

Contaminants Of Concern (COC)[1]	SDWA[2] MCL (mg/L)	SDWA[2] MCLG (mg/L)	RCRA MCL[3] (mg/L)	Massachusetts Drinking Water Stds[4] (mg/L)	Massachusetts Groundwater Quality Stds. Class I[5] (mg/L)	Massachusetts ORSGs[6] (mg/L)
Organic Compounds						
Acetone	–	–	–	–	[13]	6.3
Benzene	0.005	0	–	0.005	[13]	–
Benzo(a)anthracene	–	–	–	–	[13]	–
Benzo(a)pyrene	0.0002	0	–	0.0002	[13]	–
Benzo(k)fluoranthene	–	–	–	–	[13]	–
Benzo(o)fluoranthene	–	–	–	–	[13]	–
Benzoic acid	–	–	–	–	[13]	–
Bromoform	0.08[12]	0	–	0.08[12]	[13]	–
Bromomethane	–	–	–	–	[13]	0.01
2-Butanone (MEK)	–	–	–	–	[13]	4.0
Carbon disulfide	–	–	–	–	[13]	–
Carbon tetrachloride	0.005	0	–	0.005	[13]	–
Chlorobenzene	0.1	0.1	–	0.1	[13]	–
Chloroform	0.08[12]	–	–	0.08[12]	[13]	0.07[13]
Chrysene	–	–	–	–	[13]	–
Dibenzo(ah)anthracene[11]	–	–	–	–	[13]	–
1,2-Dichloroethane	0.005	0	–	0.005	[13]	0.07
1,1-Dichloroethene	0.007	0.007	–	0.007	[13]	–
Ethylbenzene	0.7	0.7	–	0.7	[13]	–
Indeno(1,2,3-cd)pyrene	–	–	–	–	[13]	–
4-Methyl,2-pentanone	–	–	–	–	[13]	0.35
4-Methylphenol	–	–	–	–	[13]	–
2-Methylphenol	–	–	–	–	[13]	–
Methylene chloride	0.005	0	–	0.005	[13]	–
PAHs[1]	See indiv. compound		–	–	[13]	–
Phenol	–	–	–	–	[13]	–
1,1,2,2-Tetrachloroethane	–	–	–	–	[13]	–
Tetrachloroethene	0.005	0	–	0.005	[13]	–
Toluene	1	1	–	1	[13]	–
1,1,2-Trichloroethane	0.005	0.003	–	0.005	[13]	–
Trichloroethene	0.005	0	–	0.005	[13]	–
Vinyl chloride	0.002	0	–	0.002	[13]	–
Xylenes (total)	10	10	–	10	[13]	–
Inorganic Compounds						
Arsenic	0.010 as of 1/23/06	0	0.05	0.05*	0.05	–
Cadmium	0.005	0.005	0.01	0.005	0.01	–
Chromium (total)	0.1	0.1	0.05	0.1	0.05	–
Copper	TT[8]	1.3	–	TT[8]	1.0	–
Mercury (inorganic)	0.002	0.002	0.002	0.002	0.002	–

ATTACHMENT 6, TABLE 2. CURRENT NUMERICAL STANDARDS FOR CONTAMINANTS OF CONCERN FOR GROUNDWATER AND LEACHATE, CHARLES GEORGE RECLAMATION LANDFILL, TYNGSBOROUGH, MASSACHUSETTS

Contaminants Of Concern (COC)[1]	SDWA[2] MCL (mg/L)	SDWA[2] MCLG (mg/L)	RCRA MCL[3] (mg/L)	Massachusetts Drinking Water Stds[4] (mg/L)	Massachusetts Groundwater Quality Stds. Class I[5] (mg/L)	Massachusetts ORSGs[6] (mg/L)
Other Chemicals[7]						
Tetrahydrofuran	–	–	–	–	[10]	1.3
1,4-Dioxane	–	–	–	–	[10]	0.003
Antimony	0.006	0.006	–	0.006	--	--
Lead	TT[9]	0	0.05	TT[9]	0.05	--
Nickel	–	–	–	–	[10]	0.1
Thallium	0.002	0.0005	–	0.002	[10]	--

FOOTNOTES

1 Contaminants of concern (COCs) are those listed in Table 6 of ROD III. PAHs include: benzo(a)anthracene, chrysene, benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(a)pyrene, indeno(1,2,3-cd)pyrene.

2 *National Primary Drinking Water Standards*, June 2003. Office of Water (4606M), EPA 816-F-03-016. www.epa.gov/safewater.

3 264.94, Table 1.
RCRA sets the limits for organic contaminants at background levels.

4 Massachusetts Drinking Water Regulations, 310 CMR 22.06, MA Maximum Contaminant Level (MMCL), last promulgated April 2004.

5 Massachusetts Groundwater Quality Standards, 314 CMR 6.06.

6 Massachusetts Department of Environmental Protection, Office of Research and Standards, Drinking Water Standards and Guidelines, April 2004.

7 Analytes detected in groundwater.

8 TT: Treatment technique. NOTE: 90% of tap samples must meet a "no action" level of 1.3 mg/L copper.

9 TT: Treatment technique. NOTE: 90% of tap samples must meet a "no action" level of 0.015 mg/l lead at the tap.
Public water systems exceeding the action level must for further treatment; b) undertake a public education program to inform consumers about how to reduce exposure to lead in drinking level continues, replace all lead service pipes.

10 None in such concentrations which in the opinion of the department would impair the waters for use as a source of potable water or to cause or contribute to a condition in contravention of standards for other classified waters of the Commonwealth.

11 Even though dibenzo(ah)anthracene was not included in the ROD, it was included in the list of carcinogenic PAHs for which human health risk was calculated and is, thus, included here.

12 Criteria is for total trihalomethanes. TTHM equal the sum of bromodichloromethane, dibromochloromethane, bromoform, and chloroform.

13 This drinking water guideline is for non-chlorinated supplies only.

* The MCL for arsenic was changed in 2001 and will become effective at 0.01 mg/L as of 1/23/06 following Implementation Guidance issued in August 2002.

ATTACHMENT 5, TABLE 3
POTENTIAL ACTION-SPECIFIC ARARS
CHARLES GEORGE RECLAMATION LANDFILL, TYNGSBOROUGH, MASSACHUSETTS

ARAR	ROD REQUIREMENT SYNOPSIS AND REQUIREMENT STATUS	ROD-SPECIFIED ACTION TO BE TAKEN TO ATTAIN ARARS	FIVE-YEAR REVIEW
Federal Regulatory Requirements			
RCRA - Standards for Owners and Operators of Permitted Hazardous Waste Facilities (40 CFR 264.10 - 264.18)	General facility requirements outline general waste analysis, security measures, inspections, and training requirements - **Relevant and Appropriate**	All facilities on-site will be constructed, fenced, posted, and operated in accordance with this requirement. All workers will be properly trained. Process wastes will be evaluated for the characteristics of hazardous wastes to assess further requirements. Treatment residuals from wastewater treatment will be disposed of according to RCRA Subtitle C.	These requirements remain relevant and appropriate, and are being complied with.
RCRA - Preparedness and Prevention (40 CFR 264.30-264.37)	This regulation outlines safety equipment and spill control requirements for hazardous waste facilities. Part of the regulation includes a requirement that facilities be designed, maintained, constructed, and operated so that the possibility of an unplanned release which could threaten public health or the environment is minimized - **Relevant and Appropriate**.	Safety and communication equipment will be installed at the site; local authorities will be familiarized with site operations. RCRA requirements must be considered when evaluating extensions to the present landfill.	These requirements remain relevant and appropriate, and are being complied with.
RCRA - Contingency Plan and Emergency Procedures (40 CFR 264.50-264.56)	This regulation outlines the requirements for emergency procedures to be used following explosions, fires, etc. This regulation also requires that threats to public health and the environment be minimized - **Relevant and Appropriate**.	Plans will be developed and implemented during site work including installation of monitoring wells, and implementation of site remedies. Copies of the plans will be kept on-site. RCRA requirements must be considered when evaluating extensions to the present landfill.	These requirements remain relevant and appropriate, and are being complied with.
RCRA - Manifesting, Recordkeeping, and Reporting (40 CFR 264.70-264.77)	This regulation specifies the recordkeeping and reporting requirements for RCRA facilities - **Relevant and Appropriate**.	Records of facility activities will be developed and maintained during remedial actions.	These requirements remain relevant and appropriate, and are being complied with.

ARAR	ROD REQUIREMENT SYNOPSIS AND REQUIREMENT STATUS	ROD-SPECIFIED ACTION TO BE TAKEN TO ATTAIN ARARS	FIVE-YEAR REVIEW
RCRA - Groundwater Protection (40 CFR 264.90-264.109)	This regulation details requirements for a groundwater monitoring program to be installed at the site - **Relevant and Appropriate**.	A groundwater monitoring system must be installed as part of any alternative. During site characterization, the location and depth of monitoring wells will be evaluated for use in this monitoring program.	These requirements remain relevant & appropriate. A groundwater monitoring program has been implemented at the site.
RCRA - Closure and Post-Closure (40 CFR 264.110-264.120)	This regulation details specific requirements for closure and post-closure of hazardous waste facilities - **Relevant and Appropriate**.	Those parts of the regulations concerned with long-term monitoring and maintenance of the site will be considered during remedial design. A post-closure plan will be developed.	These requirements remain relevant & appropriate. A post closure plan has been developed by the EPA and USACE.
OSHA - General Industry Standards (29 CFR Part 1910)	This regulation specifies the 8-hour time-weighted average concentration for various organic compounds - **Not ARAR.**	Proper respiratory equipment will be worn if it is impossible to maintain the work atmosphere below the concentrations.	OSHA has promulgated standards for protection of workers at hazardous waste operations at RCRA or CERCLA sites. These regulations are designed to protect workers who would not be exposed to hazardous waste.
OSHA - Safety and Health Standards (29 CFR Part 1926)	This regulation specifies the type of safety equipment and procedures to be followed during site remediation - **Not ARAR.**	All appropriate safety equipment will be on-site. In addition, safety procedures will be followed during on-site activities.	OSHA requirements are no longer considered ARAR by the EPA as OSHA is viewed as an employee protection law rather than an "environmental" law, and as OSHA standards apply directly to all CERCLA response actions. (see Federal Register volume 55, page 8679, March 8, 1990). EPA requires compliance with the OSHA standards in the NCP (40 CFR 300.150), not through the ARAR process. OSHA standards are discussed in the Site Health and Safety Plan.
OSHA - Recordkeeping, Reporting, and Related Regulations (29 CFR 1904)	This regulation outlines the recordkeeping and reporting requirements for an employer under OSHA - **Not ARAR.**	These requirements apply to all site contractors and subcontractors and must be followed during all site work.	

ATTACHMENT 5, TABLE 3 (CONTINUED)
POTENTIAL ACTION-SPECIFIC ARARS
CHARLES GEORGE RECLAMATION LANDFILL, TYNGSBOROUGH, MASSACHUSETTS

ARAR	ROD REQUIREMENT SYNOPSIS AND REQUIREMENT STATUS	ROD-SPECIFIED ACTION TO BE TAKEN TO ATTAIN ARARS	FIVE-YEAR REVIEW
RCRA - EPA Regulations on Land Disposal Restrictions (40 CFR 268)	This regulation outlines land disposal requirements and restrictions for hazardous wastes - **Relevant and Appropriate**.	Regulations to be phased in over the next few years require contaminated soils to be treated to the Best Demonstrated Available Technology levels before being placed or replaced on the land. Hazardous waste cannot be stored except when accumulated for recovery, treatment, or disposal. Land disposal restrictions for PAHs have not yet been developed.	Land disposal restrictions (LDR) apply (or are relevant and appropriate) only to wastes being placed on the land and not to wastes already in place. These rules may be applied only to new wastes generated on-site as a result of treatment or to wastes excavated or dredged that meet RCRA characteristics for hazardous wastes. LDR criteria have been developed for most site contaminants.
Clean Water Act - 40 CFR Parts 122, 125	Any point source discharges must meet NPDES permitting requirements, which include compliance with applicable water quality standards; establishment of a discharge monitoring system; and routine completion of discharge monitoring records. **Not ARAR.**	If groundwater that has been treated by on-site treatment processes is discharged to surface waters on-site, treated groundwater must be in compliance with applicable water quality standards. In addition, a discharge monitoring program must be implemented. Routine discharge monitoring records must be completed.	Identified as applicable in the ROD, these requirements are no longer ARAR. Collected leachate is treated and discharged to the LRWU, a local POTW. Currently, these NPDES requirements do not apply and are not relevant or appropriate. No direct, point-source surface water discharge is occurring. If discharge to a surface water body were to occur in the future, these requirements would need to be reconsidered.
CWA - 40 CFR Part 403	This regulation specifies pretreatment standards for discharges to a POTW - **Applicable.**	If a leachate collection system is installed and the discharge is sent to a POTW, the POTW must have an approved pretreatment program. The collected leachate runoff must be in compliance with the approved program. Prior to discharging, a report must be submitted containing identifying information, list of approved permits, description of operations, flow measurements, measurement of pollutants, certification by a qualified professional, and a compliance schedule.	Identified as not ARAR in the ROD, these requirements are now applicable, and are being complied with. Collected leachate is treated and discharged to the LRWU, a local POTW, under permit.

ARAR	ROD REQUIREMENT SYNOPSIS AND REQUIREMENT STATUS	ROD-SPECIFIED ACTION TO BE TAKEN TO ATTAIN ARARS	FIVE-YEAR REVIEW
CWA - 40 CFR Part 230	This regulation outlines requirements for discharges of dredged or fill material. Under this requirement, no activity that impacts a wetland will be permitted if a practicable alternative that has less impact on the wetland is available. If there is no other practicable alternative, impacts must be mitigated - **Applicable**	During the identification, screening, and evaluation of alternatives, the effects on wetlands must be evaluated.	There were no practicable alternatives that would have prevented impacts to adverse impacts to wetlands. This requirement is no longer an ARAR as there are no longer any wetlands on-site.
CAA - NAAQS for Total Suspended Particulates (40 CFR 129.105,750)	This regulation specifies maximum primary and secondary 24-hour concentrations for particulate matter - **Not ARAR**	Fugitive dust emissions from site excavation activities will be maintained below 260 • g/m^3 (primary standard) by dust suppressants, if necessary.	These requirements were applicable to excavation and landfilling activities. Landfill construction is now completed. These requirements are only applicable if further land disturbing activities are conducted. None are currently planned.
Protection of Archeological Resources (32 CFR Part 229, 229.4; 43 CFR Parts 107, 171.1-171.5)	This regulation develops procedures for the protection of archeological resources - **Not ARAR**	If archeological resources are encountered during soil excavation, work will stop until the area has been reviewed by federal and state archaeologists.	No archeological resources have been, or are expected to be encountered at the site.
DOT Rules for Transportation of Hazardous Materials (49 CFR Parts 107, 171.1-171.5)	This regulation outlines procedures for the packaging, labeling, manifesting, and transportation of hazardous materials - **Not ARAR**	Contaminated materials shipped off-site will be packaged, manifested, and transported to a licensed off-site disposal facility in compliance with these regulations.	Shipping of hazardous materials has been in compliance. EPA no longer considers DOT rules an ARAR as they are not environmental rules and must always be complied with for all off-site shipments.

ATTACHMENT 5, TABLE 3 (CONTINUED)
POTENTIAL ACTION-SPECIFIC ARARS
CHARLES GEORGE RECLAMATION LANDFILL, TYNGSBOROUGH, MASSACHUSETTS

ARAR	ROD REQUIREMENT SYNOPSIS AND REQUIREMENT STATUS	ROD-SPECIFIED ACTION TO BE TAKEN TO ATTAIN ARARS	FIVE-YEAR REVIEW
State Regulatory Requirements			
Massachusetts Hazardous Waste Regulations, Phase I and II (310 CMR 30.000, MGL Ch. 21C)	These regulations provide a comprehensive program for the handling, storage, and recordkeeping at hazardous waste facilities. They supplement RCRA regulations - **Relevant and Appropriate**	Because these requirements supplement RCRA hazardous waste regulations, they must also be considered at the site.	These requirements remain relevant and appropriate, and are being complied with.
Massachusetts General Laws, Ch. III, Sec. 150B	Under this regulation, the local board of health may require a local site assignment for hazardous waste treatment, storage, and/or disposal facilities - **Relevant and Appropriate**	The local board of health should be made aware of any hazardous waste activities.	The local board of health is aware of all site activities and has been a participant in remediation efforts.
Acts of 1982, Ch. 232, Sec. 150A and 150B. (Now Codified in Massachusetts Solid Waste Management regulations at 310 CMR 19.141)	This regulation requires that notice be recorded in the Registry of Deeds whenever certain types of solid or hazardous waste activity occur on property - **Applicable.**	Notification of remedial actions will be given to the County Registry of Deeds.	This requirement remains to be fulfilled.

ATTACHMENT 5, TABLE 3 (CONTINUED)
POTENTIAL ACTION-SPECIFIC ARARS
CHARLES GEORGE RECLAMATION LANDFILL, TYNGSBOROUGH, MASSACHUSETTS

ARAR	ROD REQUIREMENT SYNOPSIS AND REQUIREMENT STATUS	ROD-SPECIFIED ACTION TO BE TAKEN TO ATTAIN ARARS	FIVE-YEAR REVIEW
Massachusetts - Air Quality, Air Pollution (310 CMR 6.00 - 8.00)	This regulation outlines the standards and requirements for air pollution control in Massachusetts; all provisions, procedures, and definitions are described - **Applicable.**	Particulate matter emissions from site excavation activities must be maintained at an annual geometric mean of 75 • g/m_3, and a maximum 24-hour concentration of 40 mg/m^3 (primary standards).	Engineering controls are specified to prevent excessive emissions of particulate matter (310 CMR 7.09). These requirements were applicable to excavation and landfilling activities. Landfill construction is now completed. These requirements are only applicable if further land disturbing activities are conducted. None are currently planned. All air emissions facilities as defined in 310 CMR 7.02 must meet Best Available Control Technology (BACT) requirements (310 CMR 7.02(2)(a)(2)(g) and (b)(2)(g)). The Charles George site remediation does not include any facilities that meet the definition of 310 CMR 7.02.
Massachusetts Wetlands Protection (310 CMR 10.00)	This regulation outlines the requirements necessary to work within 100 feet of a coastal or inland wetland. The act sets forth a public review and decision-making process by which activities affecting waters of the state are to be regulated to contribute to their protection - **Applicable.**	Wetland remediation will comply with the substantive but not the administrative requirements for wetland protection.	There were no practicable alternatives that would have prevented impacts to adverse impacts to wetlands. This requirement is no longer an ARAR as there are no longer any wetlands on-site.

ATTACHMENT 5, TABLE 3 (CONTINUED)
POTENTIAL ACTION-SPECIFIC ARARS
CHARLES GEORGE RECLAMATION LANDFILL, TYNGSBOROUGH, MASSACHUSETTS

ARAR	ROD REQUIREMENT SYNOPSIS AND REQUIREMENT STATUS	ROD-SPECIFIED ACTION TO BE TAKEN TO ATTAIN ARARS	FIVE-YEAR REVIEW
Massachusetts Surface Water Discharge Permit Program (314 CMR 2.00 - 4.00)	This section outlines the requirements for obtaining an NPDES permit in Massachusetts - **Not ARAR**	Pollutant discharges to surface water must comply with NPDES permit requirements. Permit conditions and standards for different classes of water are specified.	314 CMR 3.00 establishes the program whereby discharges of pollutants to surface waters are regulated. Outlets for such discharges and any associated treatment works are also regulated. Surface water at the site is classified "B - warm water, treated water supply" under 314 CMR 4.06. The wastewater treatment facility addresses toxic pollutants listed under 314 CMR 3.16. Treated leachate is discharged to LRWU. Currently, these requirements do not apply and are not relevant or appropriate. No direct, point-source surface water discharge is occurring. If discharge to a surface water body were to occur in the future, these requirements would need to be reconsidered.
Massachusetts Groundwater Permit Program and Groundwater Quality Standards (314 CMR 2.00, 5.00, 6.00)	These rules specify the requirements for obtaining a groundwater discharge permit in Massachusetts - **Not ARAR**	Pollutant discharges to groundwater must comply with permit requirements. Permit conditions and standards for different classes of water are specified.	314 CMR 5.00 establishes the program whereby discharges of pollutants to groundwater are regulated, as are outlets for such discharges and any associated treatment works. 314 CMR 6.00 establishes groundwater quality standards and the designation and assignment of groundwater classifications. Groundwater underlying the site is designated Class I. Reinjection of treated groundwater is not planned at this time, so discharge permit-equivalent documentation is not required.

ATTACHMENT 5, TABLE 3 (CONTINUED)
POTENTIAL ACTION-SPECIFIC ARARS
CHARLES GEORGE RECLAMATION LANDFILL, TYNGSBOROUGH, MASSACHUSETTS

ARAR	ROD REQUIREMENT SYNOPSIS AND REQUIREMENT STATUS	ROD-SPECIFIED ACTION TO BE TAKEN TO ATTAIN ARARS	FIVE-YEAR REVIEW
Supplemental Requirements for Hazardous Waste Management Facilities (314 CMR 8.00)	This regulation outlines the additional requirements that must be satisfied in order for a RCRA facility to comply with the NPDES regulations. These regulations apply to a water treatment unit; a surface impoundment that treats influent wastewater; and a POTW that generates, accumulates, and treats hazardous waste - **Not ARAR**.	All owners and operators of RCRA facilities shall comply with the management standard of 310 CMR 30.500, the technical standards of 310 CMR 30.600, the location standards of 310 CMR 30.700, the financial responsibility requirements of 310 CMR 30.900 and, in the case of POTWs, the standards for generators in 310 CMR 30.300.	314 CMR 8.00 establishes the program whereby wastewater treatment works exempted from RCRA rules would be regulated here. Since the wastewater treatment facility is being managed as a RCRA/MGL 21C facility, these rules are redundant. In the event that the facility is reclassified, these rules may become applicable.
Certification for Dredging, Dredged Material Disposal, and Filling in Waters (314 CMR 9.00, MGL Ch. 21, ss. 26-53)	This regulation is promulgated to establish procedures, criteria, and standards for the water quality certification of dredging and dredged material disposal - **Not ARAR**.	Applications for proposed dredging/fill work need to be submitted and approved before work commences. Three categories have been established for dredge or fill material based on the chemical constituents. Approved methods for dredging, handling, and disposal options for the three categories must be met.	No dredging, discharge of dredge material, or filling in of navigable waters is occurring or planned to occur. However, during remedial actions the discharge of pollutants into surface water bodies will occur; this situation triggers Wetlands Protection Act (MGL Ch. 131) and waterways (MGL ch. 91) requirements.
Operation and Maintenance and Pretreatment Standards for Wastewater Treatment Works, and Indirect Discharges (314 CMR 12.00)	The regulations establish requirements that ensure the proper operation and maintenance of wastewater facilities within the Commonwealth - **Applicable**.	A wastewater treatment facility would be operated and maintained in compliance with this regulation.	These rules are applicable and being complied with.
Implementation of M.G.L. C.111F, Employee and Community "Right to Know" (310 CMR 33.00)	The regulations establish rules and requirements for the dissemination of information related to toxic and hazardous substances to the public - **Applicable**	Information applicable to site activities and characteristics will be made available to the public.	The EPA has implemented an active community relations program to disseminate information about the site to the local community.
Worker "Right to Know" (441 CMR 21.00)	These regulations establish requirements for worker "Right to Know."	These requirements apply to all site workers and must be followed during all site work.	Each contractor performing site work is responsible for compliance with this requirement.

ATTACHMENT 5, TABLE 3 (CONTINUED)
POTENTIAL ACTION-SPECIFIC ARARS
CHARLES GEORGE RECLAMATION LANDFILL, TYNGSBOROUGH, MASSACHUSETTS

ARAR	ROD REQUIREMENT SYNOPSIS AND REQUIREMENT STATUS	ROD-SPECIFIED ACTION TO BE TAKEN TO ATTAIN ARARS	FIVE-YEAR REVIEW
Massachusetts Solid Waste Management Regulations under MGL Ch. 21D (310 CMR 19.000)	Not identified in ROD, but identified in O&M Plan and Post-Closure Plan - **Applicable**.	None.	These rules are applicable and are generally being complied with. Maintenance requirements of a solid waste landfill identified here include: prevention of unauthorized access by fences and other barriers; locked gates at all points of entry; and posting of warning signs. Maintenance requirements are being met. Groundwater protection systems are specified to control migration of leachate out of the landfill and into the groundwater. A leachate collection system has been installed at the site. All solid waste landfills must include groundwater, surface water and gas monitoring systems designed, operated, and maintained in accordance with applicable rules. Explosive gases must be controlled to no greater than 25% LEL within on-site structures or at the property boundary. Long-term groundwater and surface water monitoring requirements are being met. Gas monitoring is conducted at the property boundary. Limitations on post-closure construction and use are outlined in the regulations. Alternative end uses need to be proposed. Use restrictions, such as deed restrictions, must be provided for after completion of remedial activities.

ATTACHMENT 5, TABLE 3 (CONTINUED)
POTENTIAL ACTION-SPECIFIC ARARS
CHARLES GEORGE RECLAMATION LANDFILL, TYNGSBOROUGH, MASSACHUSETTS

ARAR	ROD REQUIREMENT SYNOPSIS AND REQUIREMENT STATUS	ROD-SPECIFIED ACTION TO BE TAKEN TO ATTAIN ARARS	FIVE-YEAR REVIEW
Massachusetts Solid Waste Management Regulations under MGL Ch. 21D (310 CMR 19.000) (continued)			Final cover system standards and landfill closure/post-closure care requirements are applicable to the site. Applicable post-closure care requirements include: monitor the site during the post-closure period in order to ensure the integrity of the closure measures and to detect and prevent any adverse impacts of the site on public health, safety or the environment; take corrective actions in response to any conditions which would compromise the integrity and purpose of the final cover; maintain the integrity of the liner system and final cover system; collect leachate from and monitor and maintain leachate collection systems; monitor and maintain the surface water, groundwater, and air quality monitoring systems; maintain landfill gas control systems; maintain access roads; protect and maintain surveyed benchmarks. The site cap is designed to meet the more stringent requirements for a hazardous waste landfill and, thus, achieves compliance with solid waste rules.

ATTACHMENT 5, TABLE 4
POTENTIAL LOCATION-SPECIFIC ARARS AND CRITERIA, ADVISORIES, AND GUIDANCE
CHARLES GEORGE RECLAMATION LANDFILL, TYNGSBOROUGH, MASSACHUSETTS

SITE FEATURE and AUTHORITY	REQUIREMENT	ROD STATUS	ROD REQUIREMENT SYNOPSIS and CONSIDERATION IN RI/FS	FIVE-YEAR REVIEW
Wetlands				
Federal Regulatory Requirements	Clean Water Act (CWA) - (40 CFR Part 230)	Applicable	Under this requirements, no activity that adversely affects a wetland shall be permitted if a practicable alternative that has less effect is available. During identification, screening, and evaluation of alternatives, the effects on wetlands are evaluated.	There were no practicable alternatives that would have prevented impacts to adverse impacts to wetlands. This requirement is no longer an ARAR as there are no longer any wetlands on-site.
	Fish and Wildlife Coordination Act (16 U.S.C. 661)	Applicable	This regulation requires that any federal agency proposing to modify a body of water must consult with the U.S. Fish and Wildlife Service. This requirement is addressed under CWA Section 404 requirements.	This ARAR was met; consultation occurred as part of the RI/FS process.
State Regulatory Requirements	Massachusetts - Wetlands Protection (310 CMR 10.00)	Applicable	These requirements are promulgated under Wetlands Protection Laws, which regulate dredging, filling, altering, or polluting inland wetlands. Work within 100 feet of a wetland is regulated under this requirement. The requirement also defines wetlands based on vegetation type and requires that effects on wetlands be mitigated. If alternatives require that work be completed within 100 feet of a defined wetland, these regulations will be considered. Mitigation of impacts on wetlands will be addressed under CWA 404.	There were no practicable alternatives that would have prevented impacts to adverse impacts to wetlands. This requirement is no longer an ARAR as there are no longer any wetlands on-site.
	Hazardous Waste Facility Siting Regulations (990 CMR 1.00)	Relevant and Appropriate	These regulations outline the criteria for the construction, operation, and maintenance of a new facility or increase in an existing facility for the storage, treatment, or disposal of hazardous	A permanent groundwater treatment facility was not constructed because groundwater and leachate are instead being discharged to the

SITE FEATURE and AUTHORITY	REQUIREMENT	ROD STATUS	ROD REQUIREMENT SYNOPSIS and CONSIDERATION IN RI/FS	FIVE-YEAR REVIEW
			waste. Specifically, no portion of the site may be located within a wetland or bordering a vegetated wetland. These regulations will be addressed during the design phase of the treatment facility construction.	Lowell POTW. Also, there are no longer any wetlands on-site. This requirement is no longer an ARAR.
Federal Requirements to be Considered	Wetlands Executive Order (EO 11990)	To Be Considered	Under this regulation, federal agencies are required to minimize the destruction, loss, or degradation of wetlands, and preserve and enhance natural and beneficial values of wetlands. Many of the requirements of this EO will be addressed under CWA Section 404. Any remaining requirements will also be considered during the identification, screening, and evaluation of alternatives.	There were no practicable alternatives that would have prevented impacts to adverse impacts to wetlands. This requirement is no longer an ARAR as there are no longer any wetlands on-site.
<u>Landfill and Leachate Ponds</u>				
Federal Regulatory Requirements	RCRA - Standards for Owners and Operators of Permitted Hazardous Waste Facilities (40 CFR 264.10-264.18)	Relevant and Appropriate	General facility requirements outline waste analysis, security measures, and training requirements. Treatment residuals from the wastewater treatment facility will be disposed according to RCRA Subtitle C.	This action-specific ARAR is discussed in Table 3.
	RCRA -	Relevant	This regulation outlines safety equipment and	This action-specific ARAR is

SITE FEATURE and AUTHORITY	REQUIREMENT	ROD STATUS	ROD REQUIREMENT SYNOPSIS and CONSIDERATION IN RI/FS	FIVE-YEAR REVIEW
	Preparedness and Prevention (40 CFR 264.30-264.37)	and Appropriate	spill control requirements for hazardous waste facilities. Part of the regulation includes a requirement that facilities be designed, maintained, constructed, and operated so that the possibility of an unplanned release which could threaten public health or the environment is minimized. RCRA requirements must be considered when evaluating extensions to the present landfill.	discussed in Table 3.
<u>Landfill and Leachate Ponds</u> (contd.)	RCRA - Contingency Plan and Emergency Procedures (40 CFR 264.50-264.56)	Relevant and Appropriate	This regulation outlines requirements for emergency procedures to be used following explosions and fires. This regulation also requires that threats to public health and the environment be minimized. RCRA requirements must be considered when evaluating extensions to the present landfill.	This action-specific ARAR is discussed in Table 3.
	RCRA - Groundwater Protection (40 CFR 264.90-264.109)	Relevant and Appropriate	Under this regulation, groundwater monitoring program requirements are outlined. A groundwater monitoring system must be installed as part of any alternative. During site characterization, the location and depth of monitoring wells will be evaluated for use in this monitoring program.	This action-specific ARAR is discussed in Table 3.
	RCRA - Closure and Post-Closure	Relevant and	This requirement details the specific requirements for closure and post-closure of	This action-specific ARAR is discussed in Table 3.

ATTACHMENT 5, TABLE 4 (continued)
POTENTIAL LOCATION-SPECIFIC ARARS AND CRITERIA, ADVISORIES, AND GUIDANCE
CHARLES GEORGE LANDFILL, TYNGSBORO, MASSACHUSETTS

SITE FEATURE and AUTHORITY	REQUIREMENT	ROD STATUS	ROD REQUIREMENT SYNOPSIS and CONSIDERATION IN RI/FS	FIVE-YEAR REVIEW
	(40 CFR 264.110-264.120)	Appropriate	hazardous waste facilities. A post-closure plan is currently being developed for the site by EPA.	
State Regulatory Requirements	Massachusetts Hazardous Waste Regulations, Phase I and II (310 CMR 30.000)	Relevant and Appropriate	These regulations provide a comprehensive program for the handling, storage, and recordkeeping at hazardous waste facilities. They supplement RCRA regulations. Because these requirements supplement RCRA hazardous waste regulations, they must also be considered at the site.	This action-specific ARAR is discussed in Table 3.

ATTACHMENT 6

RISK ESTIMATES FOR RECENT SEDIMENT SAMPLES

Attachment 6. Risk Estimates for Recent Sediment Samples for the Fourth Five Year Review of the Charles George Landfill Superfund Site

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Attachment 6. Risk Estimates for Recent Sediment Samples for the Fourth Five Year Review of the Charles George Landfill Superfund Site

1.0 Human Health and Exposures to Sediment

The ROD dated 1988 called for dredging Dunstable Brook to achieve a risk-based concentration of 1 mg/kg PAHs in the residual sediment. The goal to protect human health was stated as follows:

> *To reduce to acceptable levels the existing incremental cancer risks above 1x10(-6) for a most probable exposure scenario.*

The cleanup goal of 1 mg/kg total PAH was in 1988 expected to achieve a residual cancer risk of 4×10^{-6}. None of the recently reported concentrations for PAHs exceed this limit. However, methods for risk assessment of PAHs have evolved since 1988, such that concentrations of less than 1 mg/kg could be of concern. Also, evaluation of each PAH present in the sediment rather than total PAHs is important since their toxicities vary. Due to these changes, a brief evaluation is provided below for the purpose of this five year review. The evaluation will help evaluate concerns about protectiveness for human health based on the recent observed changes in sediment concentrations.

The risk estimates are presented in this appendix in an abbreviated form, and are intended to support Section 7 of the five year review. Although streamlined, the methods are in accordance with the USEPA Risk Assessment Guidance for Superfund (RAGS), Volume I: Human Health Evaluation Manual, Part A (USEPA, 1989), Part E (USEPA, 2004a) for dermal assessment guidance, and the draft exposure factors handbook (USEPA, 2009) for exposure factors used to evaluate exposures during different stages of life (e.g., childhood).

1.1 Sediment Data

Recently reported concentrations of target analytes (VOCs and PAHs) in sediment at Dunstable Brook, Flint Pond, and Flint Pond Marsh are shown in Table A6-1. The recent sediment samples indicate that some concentrations of PAHs exceed current USEPA regional screening levels for residents exposed to PAHs in soil.

Three carcinogenic PAHs in Dunstable Brook and two PAHs in Flint Marsh Pond exceed their respective RSLs. None exceed in Flint Pond. The highest concentrations were found in Dunstable Brook. In order to assess the cumulative effects of multiple carcinogens and mutagens for the purpose of this review, risks were calculated for all of the PAHs that were detected in Dunstable Brook sediment in December 2009.

Attachment 6. Risk Estimates for Recent Sediment Samples for the Fourth Five Year Review of the Charles George Landfill Superfund Site

Table A6- 1. Recently Detected (December 2009) PAHs in Sediment.

Maximum Reported Concentration in Sediment in December 2009				EPC		USEPA Regional Screening Level (RSL) Soil Exposures to a Resident	Exceeds RSL? (Yes/No)			Magnitude of Exceedance (Conc/RSL)		
	Dunstable Brook	Flint Pond	Flint Pond Marsh	Max of Any	Max Location		Dunstable Brook	Flint Pond	Flint Pond Marsh	Dunstable Brook	Flint Pond	Flint Pond Marsh
Target Analyte	mg/kg	mg/kg	mg/kg	mg/kg		mg/kg						
Anthracene	0.095	0.013	0.026	0.095	Dunstable Brook	17,000	No	No	No	--	--	--
Benzo(a)anthracene	0.17	0.014	0.093	0.17	Dunstable Brook	0.15	**Yes**	No	No	1	--	--
Benzo(a)pyrene	0.11	0.006	0.10	0.11	Dunstable Brook	0.015	**Yes**	No	**Yes**	7	--	7
Chrysene	0.16	0.015	0.12	0.16	Dunstable Brook	15	No	No	No	--	--	--
Dibenzo(a,h)anthracene	0.03	0.0063	0.026	0.031	Dunstable Brook	0.015	**Yes**	No	**Yes**	2	--	2
Fluoranthene	0.52	0.042	0.21	0.52	Dunstable Brook	2,300	No	No	No	--	--	--
Fluorene	0.29	0.027	0.025	0.29	Dunstable Brook	2,300	No	No	No	--	--	--
Naphthalene	0.60	0.051	0.025	0.60	Dunstable Brook	3.6	No	No	No	--	--	--
Phenanthrene	0.87	0.086	0.16	0.87	Dunstable Brook	NA	No	No	No	--	--	--
Pyrene	0.43	0.039	0.22	0.43	Dunstable Brook	1,700	No	No	No	--	--	--

RSLs are the lower concentrations associated with a target hazard quotient of 1 or a cancer risk of 1:1,000,000.
Max - Maximum Concentration. See Table 6-5 of the five year review for more sample result details.
NA- Not available.
Highlighted and bolded cells are exposure point concentrations.
EPC – Exposure Point Concentration used for risk estimates.

As mentioned previously, the exposures evaluated are for soil in a residential setting. The risk estimates offered simply as an interim check of the observations made during the five year review, since screening levels are exceeded.

1.2 Toxicity Assessment

The toxicity assessment summarizes the toxicological data (cancer unit risk or slope values, and non-cancer reference doses or reference concentrations) for the identified COPCs. The preferred hierarchy of toxicological information and toxicity values is as follows:

Tier 1: The Integrated Risk Information System (IRIS), which is an on-line USEPA database containing current toxicity values for many chemicals that have gone through a rigorous peer review and USEPA consensus review process (USEPA, 2007);

Tier 2: Provisional Peer Reviewed Toxicity Values (PPRTVs) developed by the USEPA Office of Research and Development/National Center for Environmental Assessment/ Superfund Health Risk Technical Support Center (NCEA); and

Tier 3: Additional USEPA and non-USEPA sources of toxicity information, including but not limited to the state agency toxicity values, the Agency for Toxic Substances and Disease Registry (ATSDR) Minimum Risk Levels, and toxicity values published in the Health Effects Assessment Summary Tables (HEAST) (USEPA, 1997).

Tables A6-3 and A6-4 present toxicity values used in the risk assessment for noncarcinogenic and carcinogenic effects. The values are compiled from the USEPA IRIS database and the Oak Ridge National Laboratory Risk Assessment Information System, and are up-to-date at the time of this document

Oral toxicity values were adjusted to estimate the potential risk associated dermal exposures when the gastric absorption efficiency (GIABS) of the COPC is greater than 50 percent (USEPA, 2004).

Benzo(a)pyrene (and related carcinogenic polynuclear aromatic hydrocarbons) are considered by USEPA to be mutagens[1]. Because mutagens are of special concern for growth and development, they are evaluated with additional precautions that increase the risk estimates for children relative to those of adults. If appropriate chemical-specific data are not available (and they are limited at this time), then the default age-dependent adjustment factors (ADAFs) should be applied to the cancer slope factor, as follows:

- 10-fold adjustment for ages 0 - <2 years;
- 3-fold adjustment for ages 2 - <16 years;
- No adjustment for ages 16 years and older.

USEPA currently provides appropriate chemical-specific data only for vinyl chloride, which means that default factors are applied to the carcinogenic polynuclear aromatic hydrocarbons in this risk assessment.

Attachment 6. Risk Estimates for Recent Sediment Samples for the Fourth Five Year Review of the Charles George Landfill Superfund Site

Table A6- 2. Chemical-Specific Parameters Used in the Risk Estimates for This Five-Year Review

Analyte	GIABS	Dermal ABS	RfDo (mg/kg/day)	RfDd (mg/kg/day)	RFC (mg/m^3)
Anthracene	0.76	0.13	3.00E-01	3.00E-01	NA
Benzo(a)anthracene	0.31	0.13	NA	NA	NA
Benzo(a)pyrene	0.31	0.13	NA	NA	NA
Chrysene	0.31	0.13	NA	NA	NA
Dibenzo(a,h)anthracene	0.31	0.13	NA	NA	NA
Fluoranthene	0.31	0.13	4.00E-02	1.24E-02	NA
Fluorene	0.31	0.13	4.00E-02	1.24E-02	NA
Naphthalene	0.80	0.13	2.00E-02	2.00E-02	3.00E-03
Phenanthrene	0.73	0.01	NA	NA	NA
Pyrene	0.31	0.13	3.00E-02	9.30E-03	NA

GIABS – Gastrointestinal Absorption Factor
ABS – Absorption Factor
RfDo – Oral Reference Dose
RfDd – Dermal Reference Dose
RFD – Reference Concentrations

Table A6- 3. Chemical-Specific Parameters Used for Mutagenic and Cancer Risk Estimates for This Five-Year Review

Analyte	Evaluated as a Mutagen?		Dermal ABS	CSFo $(mg/kg*d)^{-1}$	CSFd $(mg/kg*d)^{-1}$	URi $(mg/m^3)^{-1}$
	Yes/No	ADAF				
Anthracene	No	--	0.13	NA	NA	NA
Benzo(a)anthracene	Yes	3	0.13	7.3E-01	2.3E-01	1.1E-01
Benzo(a)pyrene	Yes	3	0.13	7.3E+00	2.3E+00	1.1E+00
Chrysene	No	--	0.13	7.3E-03	2.3E-03	1.1E-02
Dibenzo(a,h)anthracene	Yes	3	0.13	7.3E+00	2.3E+00	1.2E+00
Fluoranthene	No	--	0.13	NA	NA	NA
Fluorene	No	--	0.13	NA	NA	NA
Naphthalene	No	--	0.13	NA	NA	3.4E-02
Phenanthrene	No	--	0.01	NA	NA	NA
Pyrene	No	--	0.13	NA	NA	NA

ADAF – Age-Dependent Adjustment Factor
ABS – Absorption Factor
CSFo – Oral Cancer Slope Factor
CSFd – Dermal Cancer Slope Factor
URi – Inhalation Unit Risk

1.3 Exposure Assessment

The exposure assessment identified the potential human receptors, exposure points for the various media, potential exposure pathways, and quantification of the magnitude and frequency of receptors' potential exposure to the identified COPCs in sediment. Reasonable maximum exposure (RME) scenarios are evaluated in this risk assessment, which reflect conservative exposure assumptions for each identified receptor (USEPA, 1999). This approach is intentionally conservative, and in reality most individuals will not be at the RME. This means that lesser potential exposures and risks are most likely.

Complete exposures pathways are evaluated for the following receptors:

- Residents under hypothetical conditions in which residences are nearby or hypothetically built on the sampled areas at some time in the future. While this is unlikely, the scenario is included to determine the need for responses such as land use controls.

The working assumption for the risk assessment is that these areas will be fully accessible, which may be biased toward over-estimation if access to any of the areas is particularly difficult or varies through the seasons.

1.3.1 Exposure Parameters

The receptor's exposure factors evaluated in the HHRA are summarized in Table A6-4. Exposure parameters are used to quantify chronic exposures occurring at low levels in the environment over time. Examples include:

- Ingestion rate for incidental exposure to soil and sediment.
- Surface area of exposed skin surface.
- Exposure frequency (i.e., how many days per year?).
- Exposure duration (i.e., how many years?).
- Exposure point concentration (i.e., at what concentration?).

High level, subchronic or acute short-term exposures are not likely in this situation given the low environmental concentrations and land uses at the site. This is noted because different evaluation methods would be used, for example, for a emergent release of toxic chemical products (i.e., industrial processes, spills, fires, etc.).

Exposures to submerged sediments are likely to be minimal for humans since the water tends to wash off the sediment and minimize exposure. For this reason, all sediment exposures are evaluated as if they were deposited in an accessible drier upland location as a soil. Although this may tend to over-estimate exposure, this is done to simplify the evaluation by focusing on the more intense exposures.

Table A6-4 is arranged to show exposures parameters for a resident child and adult. Because children are especially sensitive to environmental toxins, special consideration is made to ensure the sensitive life stages as represented in the exposure estimates. In particular, exposures are relatively great due to the lower body weight of a child. Separate estimates are made for 30 years of exposure for a person as a growing into adulthood. For exposure to noncarcinogens, exposures are considered for 6 years from ages 1 to 7, and separately for an adult for the remaining part of the 30 years. This approach is consistent with USEPA recommendations for evaluating noncancer exposures (USEPA 1989). For carcinogens, a single exposure estimate is made for 28 years with 14 years of exposure averaged over a lifetime for a child aged 2 to 16 years, and 14 years as an adult. This approach is consistent with more recent USEPA guidance for evaluating carcinogenic exposures during sensitive life stages (USEPA 2005b).

The following subsections describe the exposure parameters presented in Table A6-4 as they relate to the three routes of exposure considered; incidental ingestion, dermal contact, and inhalation of particulates.

1.3.1.1 Soil and Sediment Ingestion Rates

The sediment and soil ingestion rates shown in Table A6-4 are derived from USEPA guidance including the recently updated Exposure Factors Handbook published in 2009. The child is assumed to consume 100 mg of sediment or soil per day through incidental hand-mouth activities. Similarly, the ingestion rate for an adult is lower at 50 mg/day.

1.3.1.2 Surface Area (of exposed skin)

The surface area of exposed skin is that which is in contact with soil. In this case, an assumption is made that 25 percent of the total surface area is exposed. Although a higher percentage would be appropriate at some places like a beach area, the selected value is appropriate for the perimeter of the landfill under review. Using tables provided by USEPA in the recent update to the *Exposure Factors Handbook*, a reasonable total surface area for a child is about 1 square meter, and for an adult about 2 square meters. With clothing, this translates to an exposed area of 2,500 cm^2 for the child, and 5,000 cm^2 for the adult.

1.3.1.3 Adhesion Factor (soil on skin)

Some amount of soil sticks to skin when it is dirty. An amount of 0.2 mg/cm^2 is used for children and 0.07 mg/cm^2 for adults. Children tend to get dirtier than adults in similar settings because of the higher level of activity during play.

1.3.1.4 Absorption Factor (through skin)

The amount of chemical absorbed through the skin varies according to the chemical characteristics. Only a few chemical-specific absorption factors are available for use in risk assessment, and most chemicals use defaults, as is the case for the PAHs. The applied value is presented with the chemical-specific values in Tables A6-2 and A6-3.

Attachment 6. Risk Estimates for Recent Sediment Samples for the Fourth Five Year Review of the Charles George Landfill Superfund Site

Table A6- 4. Ingestion, Dermal, and Inhalation Factors for Exposures to Sediment

Exposure Parameters	Non-cancer		Cancer		Units
	Resident Child (1 - <7 yrs)	Resident Adult (7-<31 yrs)	Resident Child (2-<16 yrs)	Resident Adult (16-<30 yrs)	
Ingestion Exposures					
IR	100	50	100	50	mg/day
EF	350	350	350	350	days/year
ED	6	24	14	14	years
CF	0.000001	0.000001	0.000001	0.000001	kg/mg
BW	15	70	15	70	kg
AT	2,190	8,760	25,550	25,550	days
Dermal Exposures					
SA	2,500	5,000	2,500	5,000	cm^2/day
AF	0.2	0.07	0.2	0.07	mg/cm^2
EF	350	350	350	350	days/year
ED	6	24	14	14	years
ABS	CS	CS	CS	CS	Unitless
CF	0.000001	0.000001	0.000001	0.000001	kg/mg
BW	15	70	15	70	kg
AT	2,190	8,760	25,550	25,550	days
Inhalation Exposures					
PEF	1.36E+09	1.36E+09	1.36E+09	1.36E+09	m^3/kg
ET	24	24	24	24	hours/day
CF	0.042	0.042	0.042	0.042	day/hours
EF	350	350	350	350	days/year
ED	6	24	6	24	years
AT	2,190	8,760	--	--	days

CS - Chemical-specific
NA - not applicable

1.3.1.5 Particulate Emission Factor (for airborne dust)

The particulate emission factor (PEF) is used to generate an exposure point concentration of wind-generated airborne dust. The applied particulate inhalation is a default value developed by USEPA in their effort to develop Soil Screening Levels (USEPA 1996). Note that the chemicals of potential concern for this risk assessment are not volatile organic chemicals. Also note that although sediment and soil in a wet area would tend to minimize airborne dust, and as such the exposures based on PEF may be over-estimates.

1.3.1.6 Exposure Time (daily)

Although most of the other daily exposure parameters define a full day's increment of exposure, evaluation of inhalation exposures requires an estimate of exposure time (ET) during a day of exposure. In the case of the resident, an assumption is made that contaminated dust may be present throughout the day at home for 24 hours per day.

1.3.1.7 Exposure Frequency (annual)

The exposure frequency (EF) term relates to the number of days per year exposed. Selection of an appropriate value involves consideration of activity patterns that may vary with the seasons. In the case of the resident, 350 days per year is used because the contaminated soil is all around the home.

1.3.1.8 Exposure Duration (years)

The exposure duration (ED) term is the timeframe within which the exposure occurs. In the case of the child resident, the exposure duration is 6 years for noncancer effects or 14 years cancer effects. The adult resident is exposed for a 24 years (noncancer) or 14 years (cancer). The 14 year term is based on recent USEPA guidance for evaluating carcinogenesis in children.

1.3.1.9 Conversion Factors

In the case of ingestion and dermal contact exposures, conversion factors (CF) are used to balance mass terms used in the exposure equation. A conversion factor is used in the inhalation equation to balance time measurements.

1.3.1.10 Body Weight

The body weight term is important since ingestion and inhalation exposures are distributed over variable body weights. For example, an exposure may be of greater consequence for a low body weight receptor if the chemical is distributed over less body mass. The body mass for the child is 15 kg, and for the adult it is 70 kg. Although human body weights tend to increase over time, the applied values are reasonable approximations.

1.3.1.11 Averaging Time (noncancer versus cancer effects)

The averaging time for noncancer exposures is equivalent to the exposure duration shown in Table A6-4. Carcinogenic exposures are averaged over an entire lifetime, which is assumed to be 70 years.

1.3.2 Exposure Point Concentrations

Exposure point concentrations (EPCs) are used in conjunction with exposure estimates to determine the average daily dose to receptors. In this case, the most recent sediment samples collected in December 2009 are used as EPCs. Table A6-1 shows how the EPCs are derived from the location with the highest reported PAH detections, at Dunstable Brook. Since a variety of PAHs have been present over time in Dunstable Brook, non-detected values were evaluated by applying the reporting limit as the exposure point concentration.

1.4 Risk Characterization

Noncancer effects are evaluated with the hazard index, which is the sum of hazard quotients for a chemical in a given route of exposure (i.e., ingestion, dermal, and inhalation), as follows:

Equation 1

$$HQ = \left(\frac{Ingestion_{nc}}{RfD_{oral}}\right) or \left(\frac{Dermal_{nc}}{RfD_{dermal}}\right) or \left(\frac{Inhalation_{nc}}{RfC}\right)$$

The HQs may then be summed to a form that combines exposures, as follows:

Equation 2

$$HQ = \left(\frac{Ingestion_{nc}}{RfD_{oral}}\right)_i + \left(\frac{Dermal_{nc}}{RfD_{dermal}}\right)_i + \left(\frac{Inhalation_{nc}}{RfC}\right)_i$$

The sum of the hazard quotients is the hazard index. Hazard indices may be calculated for all exposures to a single constituent if that is the focus of the risk assessment. In this risk assessment multiple constituents are evaluated, so the hazard quotients for each constituent and each exposure route are tallied, and the sum total of those HQs are the hazard index for a given receptor, as follows:

Equation 3

$$\sum_{i=1}^{N} HI = \left(\frac{Ingestion_{nc}}{RfD_{oral}}\right)_i + \left(\frac{Dermal_{nc}}{RfD_{dermal}}\right)_i + \left(\frac{Inhalation_{nc}}{RfC}\right)_i$$

Cancer effects are evaluated with the excess lifetime cancer risk (ELCR), which is an estimate of the likelihood for an individual to contract cancer following exposure to carcinogens, as follows:

Equation 4

$$ELCR = (Ingestion_c * CSF_{oral})\ or\ (Dermal_c * CSF_{dermal})\ or\ (Inhalation_c * UR_i)$$

In a multimedia risk assessment of multiple constituents, the cancer risk estimates for all the substances and exposure routes may be combined in a similar manner as for the noncancer exposures, as follows:

Equation 5

$$\sum_{i=1}^{N} ELCR = (Ingestion_c * CSF_{oral})_i + (Dermal_c * CSF_{dermal})_i + (Inhalation_c * UR_i)_i$$

The terms of the equations above are:

HQ	= hazard quotient for each constituent of potential concern (unitless)
ELCR	= excess lifetime cancer risk
$Ingestion_{nc}$	= ingestion intake for noncancer effects (mg/kg/day)
$Ingestion_c$	= ingestion intake for cancer effects (mg/kg/day)
$Dermal_{nc}$	= dermal intake for noncancer effects (mg/kg/day)
$Dermal_c$	= dermal intake for cancer effects (mg/kg/day)
$Inhalation_{nc}$	= inhalation exposure for noncancer effects (mg/m^3)
$Inhalation_c$	= inhalation exposure for cancer effects (mg/m^3)
N	= count of the constituents of potential concern
i	= each constituent of potential concern
RfD_{oral}	= Reference dose for noncancer effects via ingestion (mg/kg/day)
RfD_{dermal}	= Reference dose for noncancer effects via dermal contact (mg/kg/day)
RfC	= Reference concentration for noncancer effects (mg/m^3)

The ingestion intakes used in the equations above are based on chemical-specific estimates, as follows:

Equation 6

$$Ingestion_{nc} = EPC * IR * EF * ED * CF * \frac{1}{BW} * \frac{1}{AT_{nc\ or\ ca}}$$

Where:

EPC	= Exposure point concentration of a given constituent in sediment (mg/kg)
IR	= Ingestion rate for sediment (mg/day)
EF	= Exposure frequency (days/year)
ED	= Exposure duration (years)
CF	= Conversion factor (kg/mg)
BW	= Body weight (kg)
ATnc	= Averaging time for noncancer effects
ATc	= Averaging time for cancer effects

Equation 7

$$Dermal_{nc} = EPC * SA * AF * EF * ED * ABS * CF * \frac{1}{BW} * \frac{1}{AT_{nc\ or\ ca}}$$

Where:

EPC	= Exposure point concentration of a given constituent in sediment (mg/kg)
SA	= Exposed surface area for skin (cm^2)
AF	= Adhesion factor for soil on skin (mg/cm^2)
ABS	= Absorption factor for dermal penetration (unitless)

EF = Exposure frequency (days/year)
ED = Exposure duration (years)
CF = Conversion factor (kg/mg)
BW = Body weight (kg)
ATnc = Averaging time for noncancer effects
ATc = Averaging time for cancer effects

Equation 8

$$Inhalation_{nc} = EPC * PEF * ET * EF * ED * CF * \frac{1}{AT_{nc\ or\ ca}}$$

Where:

EPC = Exposure point concentration of a given constituent in sediment (mg/kg)
PEF = Particulate emission factor for airborne dust (m^3/kg)
ET = Exposure time (hours/day)
EF = Exposure frequency (days/year)
ED = Exposure duration (years)
CF = Conversion factor (kg/mg)
AT_{nc} = Averaging time for noncancer effects
AT_c = Averaging time for cancer effects

1.5 Results

Table A6-5 indicates that the greatest summed noncancer hazard index is for the child, at 0.0004. This estimate is far below the limit of 1 that is used under CERCLA to determine the need for remediation. Table A6-6 indicates that the total cancer risk estimate for the resident is 2×10^{-6}, which is below the upper limit and at the low end of the range (i.e., 1×10^{-6} to 1×10^{-4}) that often is used to set cleanup goals for carcinogens under CERCLA response actions.

Attachment 6. Risk Estimates for Recent Sediment Samples for the Fourth Five Year Review of the Charles George Landfill Superfund Site

Table A6- 5. Noncancer Hazard Estimates for Sediment Exposures Evaluated in This Five-Year Review

Analyte	EPC	Oral				Dermal				Inhalation		Sum			
		Child		Adult		Child		Adult		Resident		Child		Adult	
	(mg/kg)	Intake	HQ	Intake	HQ	Intake	HQ	Intake	HQ	Intake	HQ	HQ	% of Total	HQ	% of Total
Anthracene	9.5E-02	2.6E-07	8.7E-07	2.8E-08	9.3E-08	1.7E-07	5.6E-07	2.5E-08	8.5E-08	2.9E-11	NA	1.4E-06	3.3E-03	1.8E-07	0%
Benzo(a)anthracene	1.7E-01	4.7E-07	NA	5.0E-08	NA	3.0E-07	NA	4.5E-08	NA	5.1E-11	NA	0	0	0	0%
Benzo(a)pyrene	1.1E-01	3.0E-07	NA	3.2E-08	NA	2.0E-07	NA	2.9E-08	NA	3.3E-11	NA	0	0	0	0%
Chrysene	1.6E-01	4.4E-07	NA	4.7E-08	NA	2.8E-07	NA	4.3E-08	NA	4.8E-11	NA	0	0	0	0%
Dibenzo(a,h)anthracene	3.1E-02	8.5E-08	NA	9.1E-09	NA	5.5E-08	NA	8.3E-09	NA	9.4E-12	NA	0	0	0	0%
Fluoranthene	5.2E-01	1.4E-06	3.6E-05	1.5E-07	3.8E-06	9.3E-07	7.5E-05	1.4E-07	1.1E-05	1.6E-10	NA	1.1E-04	2.6E-01	1.5E-05	26%
Fluorene	2.9E-01	7.9E-07	2.0E-05	8.5E-08	2.1E-06	5.2E-07	4.2E-05	7.7E-08	6.2E-06	8.8E-11	NA	6.2E-05	1.4E-01	8.4E-06	15%
Naphthalene	6.0E-01	1.6E-06	8.2E-05	1.8E-07	8.8E-06	1.1E-06	5.3E-05	1.6E-07	8.0E-06	1.8E-10	6.0E-08	1.4E-04	3.2E-01	1.7E-05	3.0E-01
Phenanthrene	8.7E-01	2.4E-06	NA	2.6E-07	NA	1.2E-07	NA	1.8E-08	NA	2.6E-10	NA	0	0	0	0%
Pyrene	4.3E-01	1.2E-06	3.9E-05	1.3E-07	4.2E-06	7.7E-07	8.2E-05	1.1E-07	1.2E-05	1.3E-10	NA	1.2E-04	2.8E-01	1.7E-05	29%
	Sum		2E-04		2E-05		3E-04		4E-05		6E-08	4E-04	100%	6E-05	100%

EPC - Exposure Point Concentration
HQ – Hazard Quotient

Table A6- 6. Cancer Risk Estimates for Sediment Exposures Evaluated in This Five-Year Review

Analyte	EPC	Oral			Dermal			Inhalation			Sum	
	(mg/kg)	Child's Intake	Adult's Intake	ELCR	Child's Intake	Adult's Intake	ELCR	Child's Intake	Adult's Intake	ELCR	ELCR	% of Total
Anthracene	9.5E-02	5.2E-08	5.6E-09	NA	3.4E-08	5.1E-09	NA	5.7E-12	5.7E-12	NA	0	0%
Benzo(a)anthracene	1.7E-01	2.8E-07	1.0E-08	2.1E-07	1.8E-07	9.1E-09	4.3E-08	3.1E-11	1.0E-11	4.5E-12	2.5E-07	11%
Benzo(a)pyrene	1.1E-01	1.8E-07	6.5E-09	1.4E-06	1.2E-07	5.9E-09	2.8E-07	2.0E-11	6.7E-12	2.9E-11	1.6E-06	70%
Chrysene	1.6E-01	8.8E-08	9.4E-09	7.1E-10	5.7E-08	8.5E-09	1.5E-10	9.7E-12	9.7E-12	2.1E-13	8.6E-10	0%
Dibenzo(a,h)anthracene	3.1E-02	5.1E-08	1.8E-09	3.9E-07	3.3E-08	1.7E-09	7.9E-08	5.6E-12	1.9E-12	9.0E-12	4.6E-07	20%
Fluoranthene	5.2E-01	2.8E-07	3.1E-08	NA	1.9E-07	2.8E-08	NA	3.1E-11	3.1E-11	NA	0	0%
Fluorene	2.9E-01	1.6E-07	1.7E-08	NA	1.0E-07	1.5E-08	NA	1.8E-11	1.8E-11	NA	0	0%
Naphthalene	6.0E-01	3.3E-07	3.5E-08	NA	2.1E-07	3.2E-08	NA	3.6E-11	3.6E-11	2.5E-12	2.5E-12	0%
Phenanthrene	8.7E-01	4.8E-07	5.1E-08	NA	2.4E-08	3.6E-09	NA	5.3E-11	5.3E-11	NA	0	0%
Pyrene	4.3E-01	2.4E-07	2.5E-08	NA	1.5E-07	2.3E-08	NA	2.6E-11	2.6E-11	NA	0	0%
	Sum			2E-06			4E-07			5E-11	2E-06	100%

EPC – Exposure Point Concentration
ELCR – Excess Lifetime Cancer Risk

As noted, the ROD focused on human health effects related to exposures to sediment. Ecological risks were considered subsequent to the RODs and ESD. The prior five year review reported the findings were of that effort (ESAT, 2000) as follows:

> *The surface water of Flint Pond, Flint Pond Marsh, and Dunstable Brook had benchmark exceedances only for metals in 1999. These exceedances included overlaps in barium, copper, and manganese at all three sites, and individual exceedances for aluminum and iron at Flint Pond Marsh and Dunstable Brook. However, many of these exceedances also occurred in the upgradient background sample of Dunstable Brook, including aluminum, manganese, copper, and barium.*
>
> *Sediment samples from Flint Pond and Flint Pond Marsh showed a few less benchmark exceedances in 1999 compared to 1993, but as of 1999, 10 and 8 COPCs were still evident in these water bodies. Dunstable Brook showed less sediment contamination with only 3 COPCs, but it was not sampled in 1999 for recent comparison. The upgradient site on Dunstable Brook revealed extremely high levels of acetone in 1993 sediment samples, but no other organics were found above benchmarks. This site also showed the highest sediment concentrations of manganese, suggesting a source above the landfill for this and other metals. Bridge Meadow Brook showed only one COPC in sediments, but it was the farthest water body from the landfill and is diluted by the waters of Dunstable Brook.*
>
> *Toxicity tests run with 1993 sediment samples on Hyallela azteca and Chironomus tentans showed significant decreases in the survival rates of both species (but not growth) when tested from Dunstable Brook and an unnamed tributary compared with the upstream background sample.*

Tables 6-4 (inorganic chemicals in surface water), 6-5 (organic chemicals in sediment), and 6-6 (inorganic chemicals in sediment) presented previously in Section 6 indicate that there are continued exceedances of ecological benchmarks at this time.

1.6 Conclusions

The conclusion is that although there are exceedances of screening levels for several PAHs in the sediments, none of the human health risk estimates for the highest levels all of the detected PAHs approach levels of concern. As noted above, ecological effects remain as a concern.

1.7 Uncertainty

All risk assessments contain elements of uncertainty. The assumptions made in this risk assessment were intentionally biased toward health protectiveness, that is, toward overestimating rather than underestimating risk.

As there are no such screening values for sediment, use of the risk-based concentrations for soil are uncertain since human exposures to sediments may differ from soil. Using soil exposures to estimate risk for sediments exposures is uncertain, but in this case the uncertainty is believed to tend toward overestimation of actual risks. Typical sediment exposures tend to be less intense than for soil due to limited access and the tendency for sediments to wash off in overlying surface water. Exposures to sediments not overlain by surface water might more closely resemble exposures to soil.

Also, the use of the most recent sample concentrations is believed to best represent current conditions, and is particular note since the concentrations may not be stable. The intent is to present a reasonable degree of certainty that the risks at the landfill perimeter are consistent with the protectiveness goals of the ongoing remedy.

1.8 References

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