SHEPLEY'S HILL LANDFILL

LONG-TERM MONITORING AND MAINTENANCE PLAN UPDATE

September 2015

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LONG-TERM MONITORING AND MAINTENANCE PLAN UPDATE

SHEPLEY'S HILL LANDFILL

FORMER FORT DEVENS ARMY INSTALLATION, DEVENS, MA

REVISED
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Prepared for:
US Army Corp of Engineers
New England District
Concord, Massachusetts

Prepared by:
Sovereign Consulting Inc.
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SOVEREIGN CONSULTING INC.

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Long-Term Monitoring and Maintenance Plan Update

FINAL

Devens, Massachusetts

Revised
September 2015

CERTIFICATION:

I hereby certify that the enclosed Report, shown and marked in this submittal, is that proposed to be incorporated with Contract Number W912WJ-10-D-0003 DO#0013. This Document has been prepared in accordance with USACE Scope of Work and is hereby submitted for Government Approval.

Reviewed By:

11/2/15

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ABBREVIATIONS, ACRONYMS, AND SYMBOLS

ADR	Automated Data Review
AOC	Area of Contamination
As	Arsenic
ATP	Arsenic Treatment Plant
BOH	Board of Health
BCT	Base Closure Team
bgs	Below Ground Surface
BRAC	Base Realignment and Closure
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CH_4	Methane
CIP	Clean in Place
ClO_2	Chlorine Dioxide
CO	Carbon Monoxide
CO_2	Carbon Dioxide
COC	Contaminant of Concern
CQC	Contractor Quality Control
CSM	Conceptual Site Model
cy	Cubic Yard
Devens	Former Fort Devens
DOD	Department of Defense
DPT	Direct Push Technology
DO	Dissolved Oxygen
DQO(s)	Data Quality Objectives
DTW	Depth to Water
ELAP	Environmental Laboratory Accreditation Program
EW	Extraction Well
FBRO	Filter Bed Roll-off
FM	Flux Maintenance
ESD	Explanation of Significant Differences
FS	Feasibility Study
gpm	Gallon per Minute
H_2S	Hydrogen Sulfide
IDW	Investigation-Derived Wastes
LEL	Lower Explosive Limit
LTM	Long Term Monitoring
LTMMP	Long Term Monitoring and Maintenance Plan
LUC	Land Use Control
LUCIP	Land Use Control Implementation Plan
MA	Massachusetts
MassDEP	Massachusetts Department of Environmental Protection
MCL	Maximum Contaminant Level
MCP	Massachusetts Contingency Plan
MF	Microfiltration
MS/MSD	Matrix Spike/Matrix Spike Duplicate
NAE	New England District

NAVD	North American Vertical Datum
NELAC	National Environmental Lab Accreditation Conference
NIA	North Impact Area
NTCRA	Non-Time Critical Removal Action
O_2	Oxygen
ORP	Oxidation-Reduction Potential
PID	Photoionization Detector
POTW	Publically Owned Treatment Works
PVC	Polyvinyl Chloride
QA/QC	Quality Assurance/Quality Control
QAPP	Quality Assurance Project Plan
QSM	Quality Systems Manual
RAO	Removal Action Objective
RI	Remedial Investigation
ROD	Record of Decision
RQS	Rock Quality Designation
SAR	Supplemental Assessment Report
SDG	Sample Delivery Group
SHL	Shepley's Hill Landfill
SOP	Standard Operating Procedure
Sovereign	Sovereign Consulting Inc.
PPE	Personal Protective Equipment
USACE	United States Army Corp of Engineers
USEPA	United States Environmental Protection Agency
VOC	Volatile Organic Compound

1.0 INTRODUCTION

Pursuant to the Contract Modification for #W912WJ-10-D-0003 Task Order 0013, Sovereign Consulting Inc. (Sovereign), on behalf of the US Army Corps of Engineers New England District (USACE-NAE) and the Army Base Realignment and Closure (BRAC) Environmental Office at Devens, Massachusetts has updated the 2007 Shepley's Hill Landfill (SHL) Revised Long Term Monitoring and Maintenance Plan (LTMMP) (CH2M Hill, 2007) and the 2009 SHL Revised LTMMP Addendum (ECC, 2009). The updated LTMMP includes revisions, as deemed appropriate, to the groundwater monitoring program, treatment plant monitoring, landfill gas monitoring, and landfill cap inspection/maintenance. Further, this update documents long-term monitoring associated with the installation of a hydraulic barrier wall on the eastern side of SHL which is designed to restrict arsenic flux from SHL towards Plow Shop Pond and the implementation of land use controls (LUCs) in the north impact area (NIA) north of SHL. Lastly, the updated LTMMP provides information such that the long-term effectiveness of the cap and Contingency Remedy may be evaluated per the remedial action objectives of the 1995 Record of Decision (ROD), the 2005 and 2013 Explanations of Significant Differences (ESDs).

1.1 Objectives and Report Organization

The objectives of this updated LTMMP are as follows:

- Summarize the site description and historical background;
- Summarize the current Removal Action Objectives (RAOs) and the remedy components applied to address these RAOs;
- Summarize the Conceptual Site Model (CSM);
- Define and evaluate the existing LTMMP program by assessing the fate and transport of Contaminants of Concern (COCs), the CSM, and the groundwater model;
- Specify all Data Quality Objectives (DQOs) to be utilized in remedy performance assessments within the established groundwater decision framework;
- Incorporate the barrier wall remedy for the SHL and the Long Term Monitoring (LTM) for the NIA; and
- Incorporate necessary monitoring for the LUCs in the NIA.

Section 2.0 of this report summarizes the existing LTMMP technical approach as it relates to the CSM, remedy performance objectives, and new data collection. **Section 3.0** of this report presents the DQOs for the revised monitoring and maintenance for the landfill, barrier wall, arsenic treatment plant, and other monitoring locations. **Section 4.0** summarizes all the updated LTMMP monitoring procedures, analyses, frequencies, and quality assurance/quality control and data validation. **Section 5.0** summarizes the Institutional Control Monitoring Plan. Finally, **Section 6.0** outlines all necessary reports to be completed following each monitoring event within the LTMMP.

1.2 Background and Site Description

Devens, Massachusetts (MA) is located approximately 35 miles northwest of the city of Boston, within the towns of Ayer, Shirley (Middlesex County), Harvard and Lancaster (Worcester

County). The former Fort Devens was established in 1917 for military training and logistical support during World War I. Fort Devens became a permanent base in 1931, and continued service until its Base Realignment and Closure Committee closure in 1996. **Figure 1** depicts the area and topography of the former base and surrounding area.

SHL encompasses approximately 84 acres in the northeast corner of the main post of the former Fort Devens (**Figure 2**). The landfill is bordered to the northeast by Plow Shop Pond, to the west by Shepley's Hill, to the south by recent commercial development, and to the east by land formerly containing a railroad roundhouse. Nonacoicus Brook, which drains Plow Shop Pond, is located north of the landfill.

SHL was reportedly operating by the early 1940s, and evidence from test pits within the landfill suggests earlier usage, possibly as early as the mid-nineteenth century. The landfill contains a variety of waste materials, including incinerator ash, demolition debris, asbestos, sanitary wastes, glass, and other wastes. The maximum depth of the refuse occurs in the central portion of the landfill and is estimated to be about 40 feet below ground surface (bgs). The volume of waste in the landfill has been estimated at over 1.3 million cubic yards (cy), of which approximately 160,000 cy (11%) is below the water table. The saturated wastes appear to be emplaced in a wetland; at least two areas previously mapped as wetlands were filled (Harding ESE, 2002) and have been found to be underlain by peat deposits (Sovereign, 2011).

The landfill was closed in five phases between 1987 and 1992-93 in accordance with Massachusetts Regulations at 310 CMR 19.000. The Massachusetts Department of Environmental Protection (MassDEP) approved the closure plan in 1985. Closure consisted of installing a 30 to 40-mil polyvinyl chloride (PVC) membrane cap, covered with soil and vegetation and incorporating gas vents. Closure also included installation of wells to monitor groundwater quality around the landfill, and construction of drainage swales to control surface water runoff. MassDEP issued a Landfill Capping Compliance Letter approving the closure in February 1996.

Subsequent to closure of the landfill, remedial investigations (RIs) completed under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) evaluated soil, sediment, surface water, and groundwater conditions at and in the immediate vicinity of the landfill. The results confirmed the presence of various contaminants, particularly certain inorganics including arsenic and volatile organic compounds (VOCs), in groundwater, sediment, and surface water at or adjacent to SHL. A Feasibility Study (FS) and ROD resulted in a remedy that required long term monitoring and maintenance of the existing landfill cap and groundwater monitoring.

The ROD (USAEC, 1995) required the Army to perform groundwater monitoring and five-year reviews to evaluate the effectiveness of the selected remedial action, which relied heavily on the previously installed landfill cap to attain groundwater cleanup goals by 2008 and to reduce potential exposure risks. If groundwater contaminant concentrations, primarily arsenic, met risk-based performance standards (cleanup goals) over time, the ROD did not require further action; however, if cleanup goals were not met, the ROD required implementation of a groundwater extraction contingency remedy. Due to continued elevated contaminant concentrations, the Army installed and operated a groundwater extraction and treatment system in March 2006 as a contingency remedy to address groundwater contamination emanating from the northern portion of the landfill (CH2M Hill, 2005a).

In 2011, the AOC 72 RI (AMEC, 2011) concluded that components of the current remedy – landfill capping and groundwater extraction – did not eliminate groundwater flow and arsenic migration from SHL into Red Cove / Plow Shop Pond, identified as Area of Contamination (AOC) 72. The AOC 72 RI results suggested that groundwater discharge contributed arsenic to sediment that could accumulate to levels resulting in conditions that posed unacceptable risks, and therefore a remedy that minimized such arsenic-in-groundwater flux to Red Cove would be most protective. Consequently, a low-permeability groundwater barrier wall was installed between the SHL and AOC 72 as part of a Non-Time Critical Removal Action (NTCRA) from August to September 2012 to mitigate arsenic flux to Red Cove/Plow Shop Pond by groundwater flow from the SHL. Documentation of the barrier wall installation was provided in the Removal Action Completion Report (Sovereign, 2013d).

1.3 Remedial Action Objectives

The following Remedial Action Objectives (RAOs) were stipulated in the ROD (USAEC, 1995):

- Protect potential residential receptors from exposure to contaminated groundwater migrating from the landfill having chemicals in excess of maximum contaminant levels (MCLs).
- Prevent contaminated groundwater from contributing to the contamination of Plow Shop Pond sediments in excess of human health and ecological risk-based concentrations.

1.4 Summary of Remedy Components to Address RAOs

The current components of the SHL remedy selected to address the RAOs are as follows:

Landfill Capping Remedy Component: The landfill was closed in five phases between 1987 and 1992-93 in accordance with Massachusetts regulations at 310 CMR 19.000. The MassDEP approved the closure plan in 1985. Closure consisted of installing a 30 to 40-mil PVC membrane cap, covered with soil and vegetation and incorporating gas vents. Closure also included installation of wells to monitor groundwater quality around the landfill, and construction of drainage swales to control surface water runoff. MassDEP issued a Landfill Capping Compliance Letter approving the closure in February 1996. Inspections of the landfill cap are conducted yearly and include vegetative maintenance, landfill gas monitoring, and visual inspections of the capped area. Results and/or corrective actions are detailed in annual reports.

Groundwater Extraction Contingency Remedy Component: In the years following the capping of the landfill, data gathered at SHL indicated that the capping of the landfill was not resulting in a reduction of arsenic concentration in groundwater north of the landfill as originally expected. This triggered the installation of a contingency supplemental remedy for

SHL, a groundwater extraction system/Arsenic Treatment Plant (ATP). The ATP was designed to remove arsenic from extracted groundwater through co-precipitation with iron followed by microfiltration (MF). The extraction system consists of two extraction wells (EWs) located at the northwestern portion of the landfill cap. These extraction wells, EW-1 and EW-4 are capable of achieving the required combined target extraction rate of 50 gallons per minute (gpm) by either operating simultaneously or independently of one another to maximize plant influent flow. Subsequently, groundwater enters the ATP influent stream, and then is dosed with chlorine dioxide which oxidizes and precipitates the inorganic metals, arsenic, iron, and manganese. These precipitates are then filtered by a microfiltration system, and the effluent or treated water is discharged to the Devens publically owned treatment works (POTW) collection system. Every 15 minutes, the MF control unit conducts flux maintenance (FM), which backwashes the filtered precipitates from the membranes. These solids are fed to the inclined plate clarifier (IPC) and allowed to settle out of suspension and form a residual sludge. The backwash effluent supernatant is fed through two bag filters configured in parallel and discharged to the plant effluent sump. The sludge is then pumped out of the IPC, dosed with polymer to increase flocculation, and carried over to the filter bed roll-off (FBRO). The accumulated sludge is removed from the plant at least once a month for disposal. This remedy has been in place since September 2005.

Barrier Wall Remedy Component: Following several years of operation of the ATP and monitoring of the landfill cap, it was determined that neither remedy was preventing the flow of impacted groundwater to the Red Cove area of Plow Shop Pond. To mitigate the arsenic-in-groundwater flux from SHL to Red Cove/Plow Shop Pond and reduce risk to environmental receptors consistent with local conditions in Plow Shop Pond, a low permeable barrier wall was installed along the eastern limit of the landfill and to the west of Red Cove in 2012 as part of a NTCRA. The barrier wall extended from the ground surface, through the landfill cap and a thin mantling of waste, through native sandy glacial deposits and glacial till, and to the bedrock surface. The boundaries and length of the barrier wall were based on the identified areas of impacted sediment in Red Cove, groundwater concentrations along the eastern edge of the SHL, and particle track analysis as predicted by the SHL groundwater model. The barrier wall was designed to intercept and divert groundwater flowing in the overburden soils away from Red Cove. It consists of an 850-foot long minimum barrier that extends through the overburden soils to the top of competent rock, with an effective hydraulic conductivity of 1×10^{-7} cm/sec.

1.5 Background of Existing LTMMP

The ROD and the original LTMMP established incremental reduction of risk rather than incremental reduction in concentration of individual contaminants as a measure of progress toward attainment of cleanup levels to focus on the cleanup of arsenic, which was the primary contributor to risk.

The existing LTMMP provides the basis for monitoring groundwater within and adjacent to the SHL, landfill gas sampling, and landfill inspections that have been conducted since the mid-1990s and includes monitoring of the arsenic groundwater extraction, treatment, and POTW discharge system. Therefore, as outlined above, the existing LTMMP is germane to only the landfill cap and the ATP remedy components. The LTMMP provides a framework of operation, monitoring, and sampling to meet the objectives of the ROD (USAEC, 1995). During the five-year review in 2007, the revised LTMMP made use of methods utilized historically and optimized the location and frequency of monitoring based upon historical analytical data collected under the LTMMP and the implemented goals of the ATP Contingency Remedy Component. This LTMMP Update is designed to outline a revised monitoring and maintenance plan for all of the planned and implemented remedy components at SHL, inclusive of the landfill cap, the ATP, the barrier wall, and the impacts in the NIA.

2.0 EXISTING LTMMP PROGRAM AND CONCEPTUAL SITE MODEL

The following is a description of the existing LTMMP Program, overall conceptual site model and status of the continued evaluation of selected remedy components in achieving the necessary RAOs at SHL.

2.1 Summary of the Current LTMMP

The current LTMMP program consists of the collection of data to monitor the performance of the landfill cap and the ATP system conducted through the long-term monitoring of groundwater and landfill gas. The objective of the current program was to provide a comprehensive, revised LTMMP, thereby merging previous LTM and remedy performance monitoring activities into a single program. It was/is intended to be a dynamic monitoring program that will be further optimized through the process of annual evaluations of collected data and the issuance of annual reports with recommendations.

The objective and technical approach of the current program consists of a series of quantitative monitoring programs designed to meet the goals of the ROD (USACE, 1995) such as hydraulic monitoring including quarterly and semiannual sampling and gauging events at select wells and treatment system operation and maintenance including monthly and/or quarterly monitoring of system influent and effluent. The *Revised Long Term Monitoring and Maintenance Plan for Shepley's Hill Landfill Devens, Massachusetts,* (CH2M Hill, 2007) and *Revised Long Term Monitoring and Maintenance Plan Addendum –Shepley's Hill Landfill and Treatment Plant, Long-Term Monitoring and O&M Services* (ECC, 2009) present in great detail the existing LTMMP. The current LTMMP network of wells was selected based on remediation effectiveness from the evaluation of historical data in conjunction with annual landfill cover and treatment plant monitoring.

Annual performance assessments of the current program have been focused on system hydraulics and capture/control of groundwater at the north end of SHL. Consistent with EPA guidance including *A Systematic Approach for Evaluation of Capture Zones at Pump and Treat Systems* (USEPA, 2008), a multiple lines of evidence approach has been taken with respect to the performance assessment. The individual assessment components, their data requirements, and a brief summary of the results are provided in the various Shepley's Hill Landfill Annual Reports and within the 2010 Five Year Review Report.

The data quality objectives for the collection of future data outlined in this LTMMP are to gather the data necessary to document and evaluate the performance of all of the remedy components, including the landfill cap/cover, the arsenic treatment plant, the barrier wall and the associated long-term monitoring of environmental media designed to document the performance of the selected remedy. The data are also used to further expand upon the overall CSM as it relates to the long term performance of the remedy. The CSM is detailed in **Section 2.2**., below.

2.2 Conceptual Site Model

2.2.1 Background / Summary

The CSM for SHL is updated through the collection of new data which include but are not limited to supplemental investigations conducted between 2009 and 2014 as documented in the 2009 *Supplemental Groundwater and Landfill Cap Assessment for Long-Term Monitoring and Maintenance Report* (AMEC, 2009), the 2011 *Shepley's Hill Landfill Supplemental Groundwater and Landfill Cap Assessment for Long-term Monitoring and Maintenance - Addendum Report* (Sovereign, 2011), and the *Shepley's Hill Landfill 2012 and 2013 Annual Reports* (Sovereign, 2013c and 2014a) and long term monitoring and operation of the ATP. Potential sources of arsenic in groundwater include bedrock, till, landfill waste, peat, and aquifer sand overlying bedrock and underlying waste or peat. Due to the placement of the cap on the landfill, any potential leachate from the landfill waste is now limited to the ~10% of the waste that is present within the saturated zone. Recent studies (Harding ESE, 2002; Sovereign, 2011) indicate that the predominant source of the dissolved arsenic beneath the landfill is naturally occurring arsenic entrained in iron oxyhydroxides in the aquifer sand that is released into groundwater from the aquifer sands by naturally occurring and landfill-induced reducing conditions caused by carbon degradation and oxygen depletion leading to anaerobic conditions. Evidence for this conclusion is several-fold and includes results of vertical profiling in the landfill that does not exhibit an arsenic vertical concentration profile suggestive of the landfill waste as the primary source of arsenic in the system, results of scanning electron microscopy of aquifer sands detailing the prevalence and volume of arsenic entrained in iron oxyhydroxides, and column studies associated with the flushing of oxygen-depleted water through aquifer sands resulting in the release of dissolved arsenic in the test cells. In addition, concurrent research on arsenic occurrence in groundwater in other parts of the world noted the importance of buried peat layers in mobilizing arsenic through the very same reductive dissolution mechanism (Appelo, 2006).

There is further evidence that indicates the landfill is not the primary source of arsenic and that conditions favoring a natural origin for the elevated arsenic in groundwater are known to be present [e.g., regional occurrence of high arsenic in both bedrock minerals and in overburden iron oxyhydroxide coatings, presence of peat deposits, low oxidation-reduction potential (ORP), etc.] (Gannett Fleming, 2011). If significant amounts of arsenic leached from the landfill waste, then the underlying sands would be enriched with arsenic (Keimowitz et al., 2005). This has not been observed (Sovereign, 2011). The arsenic concentrations in the soil profiles increase with depth to the top of the till and bedrock, and arsenic contents found in the aquifer sands are similar in concentration as those found locally and regionally in the vicinity of Fort Devens (USACE, 2004). Arsenic in all materials (aquifer sand, waste, bedrock, etc.) is mobilized by reducing conditions at the site, and this process will persist for as long as reducing conditions remain.

There are two sources of carbon and reducing conditions at the SHL. Historically, the peat and wetlands underlying the landfill and in the NIA likely provided reducing conditions that mobilized arsenic through reductive dissolution of iron oxyhydroxides on which arsenic was entrained. This would have occurred prior to the development of the landfill extending back over 10,000 years, as this process is well documented in published scientific literature. The landfill was placed on top of the existing wetlands and underlying peat, and degradation of the waste rapidly created additional reducing conditions.

These processes are similar to those noted at the Winthrop Landfill in southern Maine (Keimowitz, 2005). For example, (1) the aquifer at both sites has an arsenic source not derived from landfill waste but from geologically naturally occurring arsenic that was and is mobilized by reducing conditions imposed by landfill waste and by peat deposits and wetlands (bogs); (2) studies at SHL (Harding ESE, 2002; Sovereign, 2011) and Winthrop (MACTEC, 2006) have shown that the source is arsenic entrained in iron oxyhydroxides in the aquifer sand underlying and surrounding the landfill; and (3) evidence indicates the landfills were unlikely significant sources of arsenic. Arsenic leached from the landfill waste would have enriched the sands, especially immediately below the waste, with arsenic (Keimowitz et. al., 2005). This has not occurred at either site, and the arsenic concentrations in the soil profiles at SHL generally increase with depth to the top of the till and bedrock. Further, (4) both landfills are impacted by pre-existing wetlands and underlying peat deposits whereby degradation of the landfill waste created additional reducing conditions that added to the mobilization of the arsenic in the underlying aquifer sands and increased the aerial extent of the reducing conditions beyond the boundaries of the wetlands and peat. The main exception is that peat bogs and wetlands lie adjacent to the Winthrop landfill and not beneath it such as exists at SHL. The ability of peat and reduced wetlands to behave like landfill waste as a source of reducing conditions is well documented (Bozkurt et al., 2001).

Further, the mechanisms responsible for the elevated arsenic at the SHL appear to be the same as those at the Winthrop Landfill where arsenic contamination occurs (Keimowitz et. al., 2005). The difference between the concentrations of arsenic in groundwater at SHL and at the Winthrop Landfill is attributed to the difference in concentrations of naturally occurring arsenic located in the aquifer material beneath each landfill. The aquifer material at SHL contains an average of 14,000 μg/kg in the upper aquifer sands in contrast to the average of 4,900 μg/kg arsenic reported for aquifer material at Winthrop. More importantly, the bottom 10-20 feet of each boring at the SHL consisted of sand, glacial till or bedrock containing an average 38,000 μg/kg of arsenic. Thus a higher potentially soluble source of arsenic exists at SHL compared to Winthrop, and the SHL inventory of arsenic can be expected to be an order of magnitude greater than that found at the Winthrop Landfill. In addition, it is important to note that the pump and treat system at the Winthrop Landfill was ultimately terminated, as it was determined to be not effective in remediating arsenic to achieve restoration of the aquifer and that land use and institutional controls were sufficient to meet the RAO for receptor protection (MACTEC, 2006).

Estimates of the time it would take to flush aqueous phase arsenic in the system to background conditions through the landfill and up to Nonacoicus Brook and wetlands approach 300 years under best case conditions (clean, oxic water replaces groundwater with no arsenic remobilization). The residual or background level of arsenic that is achievable by flushing is not known but could approach 1,500 ug/L based on the solubility of expected residual arsenic solid phases (Appelo, 2006; Smedley and Kinniburgh, 2002; USGS, 2011). Thus even with no new additions of arsenic from any non-native source, significant time to achieve local background is required and the new ambient arsenic level will almost certainly be several orders of magnitude above current MCLs for groundwater. Estimates of flushing residual carbon in the landfill footprint to lessen reducing conditions is estimated to be at least two times (2x) the time it takes to flush arsenic from the system or over 500 years (Keimowitz, 2005; Bozkurt et al., 2001).

Restoration of the aquifer to MCLs or even to less than 100 ppb throughout the area downgradient of the landfill in the NIA in a reasonable time frame appears unlikely given (1) the volume of naturally occurring arsenic in aquifer sands beneath SHL and longevity of reducing conditions exacerbated by the presence of the landfill, and (2) the continuing enrichment of the aquifer sands and groundwater with arsenic via the upwelling of arsenic rich groundwater from Shepley's Hill as documented by recent EPA studies.

The existing data set from groundwater investigations along Nonacoicus Brook does not suggest that arsenic is discharging to the Brook at appreciable concentrations and continues to suggest that an oxygenated zone is present which naturally precipitates arsenic into iron solids near or beneath Nonacoicus Brook as the low-dissolved oxygen groundwater mixes with oxidized water from the north and beneath the Brook (Sovereign, 2014a). Investigations completed in 2013 and 2014 continues to document that arsenic remains at depth, more than 40 feet below the Brook elevation and, taken with the 2010 data collected north of the Brook, indicates that the arsenic concentrations appear to decline rapidly at depth in proximity of Nonacoicus Brook, which appears to represent a groundwater discharge divide.

Historically, elevated arsenic concentrations in groundwater at SHL have impacted Red Cove/Plow Shop Pond which is located down-gradient and in close proximity to the northern portion of the landfill. To mitigate arsenic-in-groundwater flux from SHL to Red Cove/Plow Shop Pond and reduce risk to environmental receptors consistent with local conditions in Plow Shop Pond, a low permeable barrier wall was installed in 2012 along the eastern edge of SHL. The barrier wall has subsequently intercepted and diverted groundwater flowing in the overburden soils away from Red Cove and toward the northern end of the landfill. With the installation of the barrier wall between the landfill and Red Cove, the arsenic flux to Red Cove is expected to be significantly reduced (Sovereign, 2013d). The effects of the barrier wall are being monitored and the CSM will be updated as necessary to account for the effects of the barrier wall with respect to flow and flux to the east and north.

2.2.2 Contaminant Fate and Transport

As outlined above, arsenic is released into groundwater from the aquifer sands and bedrock by both naturally-occurring and landfill-induced reducing conditions caused by carbon degradation and oxygen depletion that lead to anaerobic conditions. Portions of the landfill overlay pre-existing, buried peat deposits that induced reducing conditions prior to emplacement of the landfill over the buried peat and associated wetlands. Therefore, it can be concluded that the buried peat deposits within the landfill footprint also likely caused arsenic mobilization to the north end of the site toward Nonacoicus Brook as well as east toward Plow Shop Pond prior to the placement of waste.

2.2.2.1 North Impact Area

In order to refine the understanding of the extent of chemically-reducing conditions in the NIA and update the CSM, a supplemental investigation was conducted in the spring of 2013 and the winter of 2014 in the NIA. The scope of this investigation was detailed in the May 2013 *Work Plan for Long-Term Monitoring and Maintenance Update* (Sovereign, 2013b). As part of this investigation dissolved arsenic concentrations, ORP, dissolved oxygen, and other geochemical parameters were measured at select locations in the NIA. Components of this evaluation included the completion of vertical arsenic profiling, permanent monitoring well installation, and monitoring well sampling and analysis. Data tables summarizing the data collected in the spring 2013 and winter 2014 supplemental investigation are presented in **Appendix A**, and a full discussion and interpretation of all of the data will be provided in the 2013 and 2014 Annual Reports (Sovereign, 2014a).

Well sampling north of the landfill and in the NIA since 2001 indicates that both in-situ carbon degradation and the presence of the landfill has resulted in reducing conditions in the aquifer. This has been confirmed by the low dissolved oxygen, elevated dissolved methane concentrations, elevated dissolved carbon, elevated ammonia concentrations, and elevated arsenic and iron concentrations. Thus, both the geochemistry of the landfill has induced reducing conditions and the naturally occurring conditions continue to mobilize arsenic in that area.

Nonacoicus Brook appears to represent a groundwater discharge divide. Recent (2013) sampling continues to document no elevated arsenic in the monitoring wells directly north of the brook. The bedrock delineation and general elevation of the northern-most wells indicates that the bedrock surface is much higher in elevation on the north side of the wetlands and brook than the southern side. Hydraulic data gathered from wells on the north side of the brook suggest a westerly/southwesterly groundwater flow component. This flow of groundwater from the north contains higher concentrations of dissolved oxygen that would create a redox boundary which should precipitate arsenic into iron solids near or beneath Nonacoicus Brook as oxygen-depleted groundwater emanating from the landfill area migrates north and mixes with oxidized water from the north and beneath the Brook.

Recent work (2013) included advancement of vertical profiles and groundwater monitoring wells immediately near the southern edge of Nonacoicus Brook to address concerns that arsenic may discharge to the Brook in localized areas. As presented in the *2013 Shepley's Hill Landfill Annual Report* (Sovereign, 2014a), arsenic-impacted groundwater was encountered at 50 to 60 feet below grade immediately south of the Brook and has not been encountered from 10 to 40 feet below grade at each location based on the results of groundwater profiling activities conducted in 2013 at SHM-13-03 and in 2014 at SHM-13-14S/D and SHM-13-15. Consequently, the existing data set does not suggest that arsenic is discharging to the Brook at appreciable concentrations and continues to suggest that an oxygenated zone is present which naturally precipitates arsenic into iron solids near or beneath Nonacoicus Brook as the low-dissolved oxygen groundwater mixes with oxidized water from the north and beneath the Brook. Work completed in 2013 and 2014 continues to document that arsenic remains at depth, more than 40 feet below the Brook elevation and, taken with the 2010 data collected north of the Brook, indicates that the arsenic concentrations appear to decline rapidly at depth in proximity of the Brook.

Previous modeling work suggested that groundwater flow direction curves westward as groundwater approaches the brook and previous assessments assumed that as groundwater flow curved westward, elevated concentrations of arsenic would be found in a similar pattern. However, the amalgam of data collected between 2001 and 2014 at this time do not show any elevated arsenic in groundwater in monitoring wells installed in line with the groundwater flow bend to the west at the Brook. Arsenic appears to remain in the aquifer in a relatively narrow band trending north, between profile point SHM-10-21 and SHM-10-25 as shown on **Figure 3**.

As the existing LTMMP does not include the monitoring of any of the new investigation points in the NIA, **Section 3**, below, provides updates to the monitoring plan that will provide long term monitoring of locations in the core of the impact area, along the edge of the Brook and in downgradient locations to the west.

2.2.2.2 Red Cove

Elevated arsenic concentrations in groundwater at SHL have subsequently impacted Red Cove/Plow Shop Pond which is located down-gradient and in close proximity to the northern portion of the landfill. Red Cove is a shallow cove with a water depth of less than one meter. As detailed by AMEC within the 2011 *Remedial Investigation Report for AOC 72*, arsenic flux to Red Cove was estimated at approximately 14.6 to 20 g/day with the landfill cap in place before the groundwater extraction and ATP were installed (AMEC, 2011).

The Army evaluated whether a significant risk to human health or the environment exists at Plow Shop Pond/Red Cove (AMEC, 2011) and determined the evaluation of a removal action was warranted to reduce current and potential risks to human health and the environment posed by contaminants that originate from SHL. As a result, a low-permeability groundwater barrier wall between the SHL and AOC 72 was determined to be an acceptable SHL remedy component to help mitigate impacts associated with AOC 72. The installation of the barrier wall in 2012 along the eastern edge of SHL, in combination with the landfill cap and ATP remedy components, was intended to meet the RAO objective (i.e., *prevent contaminated groundwater from contributing to the contamination of Plow Shop Pond sediments in excess of human health and ecological risk-based concentrations).*

Prior to the installation of the barrier wall, supplemental pre-construction data collection activities were performed from 2011 to 2012 in the area of the proposed wall as detailed in the 2012 *Removal Action Work Plan for the Shepley's Hill Barrier Wall* (Sovereign, 2012) to refine and update the CSM in the area of the proposed wall and address several of the field data needs identified during the conceptual design of the barrier wall. As part of this investigation, geotechnical composition of the submerged aquifer sands, bedrock depth and competency along the proposed wall, hydraulic conductivity of the shallow bedrock aquifer, and arsenic concentrations in groundwater along the proposed wall were evaluated.

The geotechnical samples collected from the overburden documented a generally homogeneous overburden consisting of loose sand material generally from the surface to bedrock, with locally-absent layers of dense till material immediately above bedrock. No significant geological variation was observed over the length of the wall. The maximum depth to bedrock was 64 feet below grade, and the shallowest depth to rock was 20 feet below grade. Bedrock hydraulic conductivity and transmissivity were determined to be low, and groundwater arsenic concentrations within the bedrock ranged from 71 µg/L in shallower fractures to 3 µg/L in deeper fractures. Conversely, dissolved arsenic profiling in the overburden documented arsenic concentrations ranging from 269 µg/L to 512 µg/L. The difference in concentration from the overburden to the shallow rock fractures suggested that the primary source of the arsenic flux into Red Cove was through the overburden (Sovereign, 2012).

Following the installation of the wall, hydraulic monitoring events were conducted periodically along both the up- and down-gradient sides of the wall to provide hydraulic monitoring data for the barrier wall. Results of the monitoring events demonstrated a positive difference in hydraulic head between the up- and down-gradient monitoring locations along the barrier wall and indicated that the barrier wall was effective in mitigating flow to Red Cove/Plow Shop Pond. With the barrier wall in place, flow patterns in the Red Cove area have changed permanently, with reduced gradient toward the pond east of the wall and greater gradient to the north on the west side of the wall (Sovereign, 2014a). Consequently, with the installation of the barrier wall between the landfill and Red Cove in 2012, the arsenic flux is expected to be significantly reduced (see **Section 3.5.2**).

The investigation data collected prior to and following the installation of the barrier wall has been utilized in the LTMMP to refine the understanding of the CSM and to evaluate remedy performance. However, the existing LTMMP does not incorporate sufficient monitoring for the long-term evaluation of the effectiveness of the barrier wall in achieving the RAO and, therefore, will be updated to achieve that DQO **(Section 3).**

2.3 Groundwater Model Update

An update to the Shepley's Hill Landfill groundwater flow model version SHL104 was completed in 2013(Sovereign, 2013f). The update included a series of significant revisions, as well as a thorough review and modification of various model parameters based upon available data where possible. To address the 2014 BCT comments on the model, ongoing model revisions will be documented in a separate report to be finalized and submitted in 2015.

During the annual reporting process, the model will incorporate LTMMP generated site-wide hydraulic data to continually evaluate model calibration and sensitivity and will be utilized to conduct advective travel time analysis and reverse (backward in time) and forward (forward in time) particle tracking simulations to evaluate remedy performance. The results of the model analysis will be documented in each subsequent Annual Report for SHL.

2.4 Evaluation of New Data to Existing LTMMP

The USEPA installed a series of piezometers in the area of the ATP extraction wells in 2012 to delineate the ATP capture zone and to provide a baseline of data from this area following the construction of the barrier wall. Two piezometers, the first screened across the water table and the second screened within the deep overburden aquifer, were installed at each location (Lockheed Martin, 2012). These wells will be incorporated into the LTMMP monitoring program (see **Section 3.1.2**), and hydraulic and geochemical data from these piezometers will be used with data collected from other nearfield and downgradient monitoring wells to evaluate remedy performance in the area of the ATP through gradient vector analysis, capture zone width calculation, drawdown assessment, and model simulations.

The results of the data collected to-date define the down-gradient extent of the arsenic impacted groundwater at Nonacoicus Brook in a band measuring approximately 300-350 ft wide bound generally between SHM-10-10 to the west and SHM-10-27 to the east, at a depth of 25 to 50 ft below grade. This observation along with the geochemistry data suggests that either Nonacoicus Brook is protected from arsenic impacts by naturally occurring redox conditions near the Brook and/or the groundwater flow divide north of the Brook and/or the extent of arsenic-impacted groundwater at this area has reached its downgradient extent of migration.

This redox zone appears to be located in the vicinity of SHM-10-10. The boundary appears to consist of three features: (1) a bedrock surface that controls the flow of landfill impacted water to the Brook but also brings groundwater from the north and northeast of the Brook that counters the landfill flow, (2) intrusion of more oxidized groundwater from the north side of the landfill, and (3) mixing of clean water resulting in precipitation of arsenic that does not impact the water quality in the Brook or wetlands.

Further, the data collected during the 2010 through 2014 field investigations are consistent with data collected historically throughout the NIA. This indicates the arsenic plume in the NIA is stable and limited to an area along West Main and Shirley Streets. In addition, data collected from the western area of the NIA does not indicate that the core of the arsenic impacted groundwater extends westward, but rather trends roughly north.

The northern most wells currently monitored as part of the LTMMP are located along Sculley Road. Based on recent data from the NIA, select wells between the current LTM wells and Nonacoicus Brook will be added to the LTM well network to monitor the fate and transport of arsenic as reducing groundwater approaches the Brook and to monitor the overall stability of arsenic concentrations in the core of the impacted area beneath West Main Street.

Furthermore, the existing LTMMP does not incorporate sufficient monitoring for the long-term evaluation of the effectiveness of the barrier wall. Results of the initial monitoring events conducted upon the completion of the barrier wall indicate a positive difference in hydraulic head between the up- and down-gradient monitoring locations along the barrier wall and that the barrier wall is effective in mitigating flow to Red Cove/Plow Shop Pond. Consequently, a long-term monitoring program in the area of the barrier wall will be implemented, and select wells located on both the up- and down-gradient side of the barrier wall will be added to the LTM well network to monitor the long-term effectiveness of the wall.

3.0 UPDATED LTMMP PROGRAM

This LTMMP Update modifies the current monitoring well network at SHL to enhance the ability to evaluate the effectiveness of the individual remedial components underway at SHL that together encompass the remedy. To this end, this LTMMP update addresses five remedial program elements with the overall goal and strategy of providing sufficient data to proceed forward along the groundwater decision framework and monitor the remedy performance for SHL. These five elements include:

1. Continued maintenance of the landfill cap;
2. On-going monitoring and performance evaluation of the ATP remedy;
3. Hydraulic and geochemical performance monitoring of the barrier wall remedy;
4. Performance monitoring of the LUCs for the NIA; and
5. An update to the groundwater monitoring well network at SHL encompassing select monitoring locations installed between 2010 and 2014 and on-going maintenance of institutional controls institutional controls in the NIA.

Concerning the fourth and fifth elements and the completion of additional assessment activities between 2010 and 2014 in the area of impacted groundwater north of Sculley Road and the railroad right of way (referred to as the NIA), it is anticipated that long term monitoring will become a component of the remedy that will address groundwater in the NIA and will be formalized into the ROD through a future ESD. Whereas natural subsurface processes such as dispersion, volatilization, biodegradation, adsorption, and chemical reactions with subsurface materials can reduce COC concentrations, the extent and rate of attenuation depends on a variety of parameters such as COC types and concentration, temperature, moisture, and redox state. For an inorganic COC such as arsenic, fate and transport of the COC is the primary factor monitored as well as the nature and extent of reducing waters (aquifer geochemistry) present in the areas of attainment. The implementation of LUCs in the NIA in 2014 (see **Figure 4** for the area of LUCs) supplemented the LTM in the NIA by eliminating future potential for direct exposure to groundwater in the NIA through prohibiting the use or installation of drinking water or irrigation wells in the impacted area. The data collected in the completion of these elements will provide the basis for evaluating progress toward achieving the RAOs at SHL.

3.1 Data Quality Objectives for the Updated LTMMP Program

The data quality objectives (DQOs) of the updated LTMMP in the most general sense are to collect data of sufficient quality and quantity to enable monitoring of groundwater, landfill gas, and performance of the SHL remedy components such that the Army, regulatory agencies, and other stakeholders may regularly evaluate the protectiveness of the groundwater remedy and its ability to meet the RAOs outlined in the ROD. Furthermore and as stated in the May 2014 USEPA guidance document *Groundwater Remedy Completion Strategy* (OSWER 9200.2-144), "the DQO process is designed to refine project information needs and focus monitoring efforts on collecting the appropriate type and amount of data so that data support key decisions. This strategy is intended to provide a technical and scientific process for evaluating when sufficient data have been obtained to assess the likelihood that a groundwater remedy has or will achieve the RAOs and associated cleanup levels in a reasonable timeframe."

Per the *Data Quality Objective Process for Hazardous Waste Site Investigations* (EPA QA/G-4HW)(USEPA, 2000), a seven-step process is used to specify DQOs for the collection of environmental data. These steps include:

- State the Problem;
- Identify the Decision;
- Identify Inputs to the Decision;
- Define the Study Boundaries;
- Develop a Decision Rule;
- Specify Limits of Decision Errors; and,
- Optimize the Design for Obtaining Data.

By using the DQO Process, stakeholders can assure that the type, quantity, and quality of environmental data used in decision making will be appropriate for the intended application. For SHL, DQOs vary in terms of study boundaries, decision rules, and optimization. However, in general terms as applied to SHL, the goals in defining the DQOs for the various remedy components at SHL include:

- Routine evaluation to determine if each remedy component is working effectively toward meeting the RAOs in the ROD in a reasonable timeframe;
- Determination if existing data are sufficient to determine if each remedy component is working toward meeting the RAOs;
- If there are insufficient data to determine if a remedy component is successful, determining both the quantity, quality, and necessary duration of data gathering needs to make an evaluation of each component;
- If the data indicate the remedy component will not meet the RAOs in the ROD, then alternatives need to be evaluated.

Many of the DQOs detailed below involve the collection of groundwater samples over an extended period of time in various sub-areas of SHL to be used to evaluate the long term effectiveness of the combined remedy components. The approximate remedy life cycle time frames detailed below are used to measure progress towards meeting the goals in the ROD to determine if the remedy is performing as expected.

The LTMMP groundwater monitoring wells have been selected for assessment of remediation effectiveness from existing wells based on historical analytical results and both hydrologic and geochemical monitoring and modeling to provide representative samples in key sub-areas of the SHL remedy, including:

- Upgradient Areas – these are groundwater bearing zones discharging into the saturated overburden beneath the SHL footprint that encompass groundwater migrating in overburden toward SHL from the south and west and groundwater discharging from bedrock into the overburden beneath the SHL footprint or into the NIA. Monitoring of these upgradient groundwater zones is useful in understanding the levels of dissolved arsenic and dissolved oxygen entering the aquifer at the SHL and ultimately migrating to the north. These areas will be monitored to meet the DQO's requirement for overall remedy component evaluations.

- Landfill Area – these are wells located in the SHL landfill footprint and historically contain some of the highest dissolved arsenic concentrations. Monitoring of the landfill area wells is critical in determining the rate of reduction in arsenic and changes in geochemical parameters at the landfill area which provides insight into the overall performance of remedy components.

- Barrier Wall Area – these are wells located on the eastern and western side of the barrier wall and can be used to monitor the hydraulic effect of the barrier wall in diverting groundwater flow to the north and thereby mitigating arsenic input to Red Cove.

- Nearfield Area – these are wells located in the vicinity of the ATP extraction wells near the northern toe of the landfill. Monitoring of these locations is key to evaluating the 3-dimensional nature of the hydraulic capture of the ATP remedy as well as tracking changes in both arsenic concentrations and changes in redox conditions north of the extraction system.

- North Impact Area – these wells are located beyond the downgradient capture zone of the ATP and will be used 1) for the LTM program in the NIA and 2) to monitor the performance of the ATP remedy in achieving the RAOs in the area of attainment. Data from the NIA wells will also be used to assess redox changes as well as arsenic concentrations in groundwater over time.

Annual reviews and periodic 5 year reviews built into the LTM process are the vehicles used to optimize the data collection moving forward. DQOs related to the specific remedy components in place are detailed in the subsections below. The first five steps of the DQO process are addressed in the rest of this subsection. The last two steps of the DQO process are addressed in **Section 3.2**.

3.1.1 DQOs for the Landfill Cap/Containment Remedy Monitoring, Maintenance and Performance Evaluation

DQO Step 1: The specific DQO framework for the evaluation of the effectiveness of the long term monitoring of the landfill cap is designed to answer the following question:

Does the landfill cap continue to meet all landfill closure requirements in accordance with the SHL ROD?

DQO Step 2: The decision statements that will require continued data collection are as follows:

- Determine that the existing cap remedy is performing as designed to preserve the integrity of the final cover system; and
- Determine that long term trends in landfill gas production are consistent with the established life cycle of the landfill.

DQO Step 3: Information needed to support the decision statements is as follows:

- Visual inspection of the landfill cap on an annual basis to identify potential problems including settling, erosion, problematic vegetative growth, etc.; and
- Annual collection of landfill gas monitoring data.

DQO Step 4: Define the Study Boundaries:

The study boundary for this remedy assessment is the area within and adjacent to the landfill footprint. The timeframe for the collection of data in monitoring the effectiveness of a landfill cap is generally 30 years, consistent with the 30-year monitoring required under landfill management procedures.

The landfill cap was installed in 1993 and has been in place for 22 years. Therefore it can be expected that landfill cap inspections and landfill gas monitoring will continue for the next 8 years (through 2023) after which continued monitoring/inspection may become unnecessary.

DQO Step 5: Combining the Outputs from the Previous DQO Steps, a Decision Rule is developed as follows:

- If the integrity of the final cover system is maintained and long term trends in landfill gas production are consistent with the established life cycle of the landfill, then the landfill cap is operating as designed.

This LTMMP Update does not change or modify the remedy performance objectives and/or monitoring requirements of the landfill cap from the previous LTMMP. Annual landfill inspections will continue per the existing plan. Components of the landfill cap monitoring such as landfill gas screening at wellheads that have exhibited no landfill gas production consistently for several years will be evaluated for future exclusion and/or decommissioning as part of the annual reporting process and/or 5-year review process.

Should the annual inspections reveal evidence of unacceptable gas building beneath the landfill or failure of the cap integrity, significant modification to the cap remedy in terms of repair, re-engineering, or re-design may need to be evaluated.

3.1.2 *DQOs for the Groundwater Remedy*

DQO Step 1: The specific DQO framework for the evaluation of the effectiveness of the Groundwater Remedy is designed to answer the following questions:

Will the ATP remedy component meet the overall SHL remedy objectives including the protection of potential residential receptors from exposure to arsenic-impacted groundwater through the effective control and management of arsenic-impacted groundwater beneath the landfill and sufficiently change downgradient groundwater redox chemistry such that the NIA can achieve groundwater restoration goals within a reasonable timeframe?

Is arsenic-impacted groundwater discharging to Nonacoicus Brook surface water or sediment at concentrations that could pose a risk to human or environmental receptors.

Are the specified NIA Land Use Controls that prevent access to groundwater effective?

DQO Step 2: The decision statements that will require continued data collection are as follows:

- Determine if the ATP is having a beneficial impact sufficient to meet MCLs throughout the NIA area of attainment within a reasonable timeframe, protect residential receptors from exposure to arsenic-impacted groundwater, ***and*** reduce levels of arsenic-impacted groundwater concentrations within the ATP capture zone (i.e., the landfill area) such that groundwater concentrations would not further degrade or impact the downgradient aquifer, as demonstrated through some or all of the following lines of evidence:
  - Statistically significant decreases, as calculated using the latest version of ProUCL software, in dissolved arsenic-impacted groundwater concentrations down-gradient of the ATP capture zone (i.e., NIA and the northern portion of the nearfield areas);
  - Statistically significant changes, as calculated using the latest version of ProUCL software, in geochemical parameters including those identified on **Table 3** down-gradient of the ATP capture zone (i.e., nearfield and NIA) that indicate a shift in overall redox conditions necessary to decrease arsenic-impacted groundwater concentrations;
  - Statistically significant decreases, as calculated using the latest version of ProUCL software, in arsenic-impacted groundwater concentrations within the ATP capture zone (i.e., the landfill and the southern portion of the nearfield areas);
  - Statistically significant changes, as calculated using the latest version of ProUCL software, in the geochemical parameters including those identified on **Table 3** within the capture zone (i.e., the landfill area) that indicate a shift in overall redox conditions necessary to decrease arsenic concentrations; and,
  - Statistically significant decreases, as calculated using the latest version of ProUCL software, in dissolved arsenic influent concentrations to the ATP.

- Determine that ATP operation continues to capture groundwater migrating from beneath the landfill to off-site areas;

- Determine that the ATP operation continues to meet all established O&M requirements including the discharge permit criteria.

- Determine if shallow arsenic-impacted groundwater within 10 to 20 feet of the surface water elevation of Nonacoicus Brook has the potential to discharge to surface water or sediments within the Brook at concentrations which may pose a risk to human or ecological receptors.

- Determine that remedy LUCs are being effectively implemented as per the LUCIP.

DQO Step 3: Information needed to support the decision statements is as follows:

- Collection of arsenic-impacted groundwater from monitoring wells within the capture zone (landfill and nearfield wells located at the northern end of the landfill), within the area immediately downgradient of the capture zone (the remaining nearfield wells), and within the NIA followed by statistical data reduction for the evaluation of arsenic and geochemical parameter trends;

- Continued collection of hydraulic data to allow for periodic hydraulic capture assessments including updates to the overall SHL groundwater flow model using hydraulic data collected during future monitoring to verify groundwater particle flow paths showing capture of groundwater particles originating at the landfill;

- Collection of influent and effluent data from the ATP to meet system discharge permits and to document decreases in dissolved arsenic influent concentrations over time; and

- Collection of LUCIP specified monitoring and survey data.

DQO Step 4: Define the Study Boundaries:

The study boundary for this set of DQOs is defined by monitoring wells located upgradient of the ATP (landfill area), in the area surrounding the ATP (Nearfield Area), and the impacted aquifer area downgradient of the ATP in the NIA (the area of arsenic impacts that trends roughly north from the ATP towards Nonacoicus Brook).

Long term monitoring should continue to allow the collection of data from the landfill, nearfield, and NIA area wells sufficient to prepare a statistical analysis to document both the stability of arsenic concentrations and confirm that arsenic-impacted groundwater is not impacting the Nonacoicus Brook. In addition to statistical analyzing the data from each well, trend analysis will also be conducted on all wells located in the landfill, nearfield, and NIA as part of the annual reporting process and the next 5-year review. During and after statistical analysis of the data collected from each area, monitoring may continue to confirm that arsenic-impacted groundwater is stable and not impacting the Nonacoicus Brook.

DQO Step 5: Combining the Outputs from the Previous DQO Steps, the Decision Rule is developed as follows:

- If it is determined that the ATP remedy component is not having a statistically significant effect on the aquifer or the system has reached a point of diminished returns as determined through the performance metrics specified below, then the effectiveness of the ATP remedy component should be re-evaluated.

- The long-term monitoring of the NIA is determined to be adequate, if groundwater quality data indicate that:
    - the NIA arsenic-impacted groundwater concentrations are decreasing and not appearing in other areas of the NIA which have not been impacted to date;
    - the groundwater within 10 to 20 feet of the surface water of Nonacoicus Brook does not pose a potential risk to human or environmental receptors; and,
    - the LUCs to prevent access to groundwater are effective.

Long term groundwater monitoring within the landfill, nearfield and NIA areas is necessary to measure dissolved arsenic and other geochemical parameter trends in the aquifer both beneath the landfill and in groundwater migrating north from the northern toe of the landfill, to ensure that the impacted area remains limited to its present locale, and to continue to demonstrate that arsenic-impacted groundwater is not discharging to Nonacoicus Brook at concentrations posing either a human or ecological risk. Based on the site conditions and high uncertainty that aquifer restoration goals can be achieved, the remedial duration or "reasonable timeframe" is estimated to be 100 years and is the basis for determining the performance metrics. The remedy performance metric is the statistically significant reduction in arsenic concentrations in groundwater, potentially coupled with a shift in geochemical parameters (e.g. increases in dissolved oxygen and oxidation-reduction potential in the aquifer), as determined by sampling data from the landfill, nearfield and NIA area monitoring wells.

The performance metrics for the groundwater remedy are statistically significant decreases or changes, as calculated using the Mann-Kendall Test within the latest version of ProUCL software, in dissolved arsenic and geochemical concentrations in groundwater within and downgradient of the ATP capture zone and with respect to cleanup levels and MCLs established in the ROD and as detailed in DQO Step 2. If landfill, nearfield or NIA area wells do not show statistically significant decreases or changes in arsenic and geochemical concentrations over that time period, then the effectiveness of the ATP remedy should be re-evaluated. However, if arsenic concentrations decrease and/or beneficial changes in geochemistry are documented in a majority of key wells in the landfill, nearfield area and NIA, and data trends and modeling indicate that the system has not reached a point of diminished returns, then the ATP should continue to operate until that point of diminished returns is met at which time the effectiveness of the ATP remedy should be re-evaluated.

Monitoring wells proposed for statistical evaluation of dissolved arsenic trends include the following:

Landfill Area Wells	
Annual Sampling	
N5-P1	SHP-99-29X
SHM-10-07	SHM-10-11
SHM-10-13	SHM-10-12
SHM-10-15	SHM-10-14
Nearfield Area Wells	
Semi-Annual Sampling	**5 Year Sample Cycle**
SHM-93-22B	SHL-23
SHL-96-5B	
Annual Sampling	
SHL-5	SHM-96-5C
SHL-8S	
SHL-8D	
SHL-9	
SHL-22	SHM-10-06
SHM-93-22C	SHM-10-06A
EPA-PZ-2012-1A/B	
EPA-PZ-2012-3A/B	EPA-PZ-2012-2A/B
EPA-PZ-2012-5A/B	EPA-PZ-2012-4A/B
EPA-PZ-2012-7A/B	EPA-PZ-2012-6A/B
NIA Wells	
Semi-Annual Sampling	**Annual Sampling**
SHM-05-41B	SHM-05-40X
SHM-05-41C	SHM-99-31C
SHM-10-16	SHM-99-32X
SHM-13-03	SHM-05-41A
SHM-13-04	SHM-05-42A
SHM-13-06	SHM-05-42B
SHM-13-07	SHM-10-10
SHM-13-08	SHM-13-02
	SHM-13-05
	SHM-13-14S/D
	SHM-13-15
	SHP-13-03
5 Year Sample Cycle	
SHM-13-01	SHM-07-03
SHM-10-02	SHM-10-05A
SHM-10-03	SHM-10-08
SHM-10-04	

Monitoring of upgradient groundwater is also necessary to determine the overall quality of groundwater entering the SHL aquifer from the south and west. Data to date suggests that groundwater entering SHL from the south generally has little dissolved arsenic. The decision rule for the monitoring of upgradient groundwater is the on-going long term statistical stability of dissolved arsenic and key geochemical parameters in upgradient monitoring wells. If long term monitoring of upgradient locations continues to show stability, then the remaining data can be adequately assessed toward remedy evaluation. If the data show instability, then a re-evaluation of the CSM may be necessary. Key wells that are proposed for statistical evaluation are as follows:

- SHL-12, SHL-15, and SHL-24

Based on the historical stability of these data points, the proposed frequency of sampling for these upgradient locations is a 5-year cycle (to be sampled as part of the fall sampling event of the designated year), considering the long term potential monitoring timeframe in this area (100 years).

3.1.3 DQOs for Barrier Wall Monitoring

DQO Step 1: The specific DQO framework for the evaluation of the effective performance of the Barrier Wall is designed to answer the following question:

Will the SHL Barrier Wall meet the SHL remedy objective to prevent contaminated groundwater from contributing to the contamination of Plow Shop Pond sediments in excess of human health and ecological risk-based concentrations?

DQO Step 2: The decision statements that will require continued data collection are as follows:

- Determine that the barrier wall is preventing arsenic-impacted groundwater from the landfill area to the west from migrating east and discharging to surface water in Plow Shop Pond; and,

- Determine that over time arsenic flux to Red Cove is mitigated.

DQO Step 3: Information needed to support the decision statements is as follows:

- Collection of hydraulic head data on either side of the barrier wall on a periodic basis to confirm a hydraulic head differential across the wall and to calculate the hydraulic gradient on the west and east sides of the barrier wall as the primary indicator of barrier wall effectiveness; and,

- Collection of dissolved arsenic data from groundwater monitoring wells on the up-gradient and down-gradient sides of the barrier wall to document a reduction in arsenic concentration across the wall and ultimately a decrease in arsenic concentrations entering Red Cove based on data primarily from the east side of the wall to document the reduction in flux through time.

DQO Step 4: Define the Study Boundaries:

The study boundary for this set of DQOs is the area immediately up-gradient and down-gradient (west and east, respectively) of the barrier wall. The barrier wall was installed in 2012 with an approximate life cycle of 100 years. Based on the recent implementation date of the remedy, long term hydraulic monitoring will be required for the foreseeable future.

DQO Step 5: Combining the Outputs from the Previous DQO Steps, the Decision Rule is developed as follows:

- If there is a hydraulic head differential and a statistically significant decrease in arsenic concentration across the barrier wall from west (upgradient) to east (downgradient), a difference in hydraulic gradients west and east of the wall, and a reduction in arsenic flux east of the wall, then the barrier wall is having a beneficial impact.

Long term monitoring of the barrier wall area is designed to collect hydraulic head data on either side of the barrier wall to verify the effectiveness of the barrier wall in diverting groundwater flow from Red Cove supplemented with periodic groundwater sampling of key indicator wells to verify a reduction in arsenic flux to Red Cove. Periodic updates to the SHL groundwater flow model can provide estimates of groundwater flow reductions across the barrier wall to supplement these data.

Previous modeling suggests that existing arsenic-impacted groundwater on the eastern side of the wall may require several years to flush from the aquifer; therefore, the statistically significant decrease in arsenic concentration on the eastern side of the wall is not expected to occur until after 5 years of operational life. Future data collection optimization including the collection of additional sediment and surface water samples from Red Cove may be recommended in this area considering the long term life cycle of the barrier wall.

Key piezometers for monitoring hydraulic head differential are the barrier wall piezometers PZ-12-01 through PZ-12-10. Hydraulic heads will be monitored on a semi-annual basis at these locations to monitor the head differential. Monitoring wells in the barrier wall area proposed for the hydraulic head monitoring and groundwater sampling to evaluate arsenic concentration and other geochemical parameter trends include the following:

Semi-Annual Sampling	Annual Sampling
SHL-11	SHL-4
SHL-20	SHL-10
SHM-11-02	SHL-19
	SHM-11-06
	SHP-01-36X
	SHP-01-37X
	SHP-01-38A

The results of the hydraulic monitoring will be evaluated and compared to the design model predictions to demonstrate that the flow of groundwater beneath SHL is being diverted to the north, as expected. Should groundwater head differentials across the wall become negligible and/or arsenic flux to Red Cove is calculated, as detailed in **Section 3.5.2**, to increase in future years, engineered corrective measures will be considered to evaluate the potential cause and implement repairs, modifications and/or alternate remedy components considered to meet this RAO.

3.2 Sampling Design

3.2.1 Limits of Decision Errors

DQO Step 6: Specify the limits of decision errors:

The tolerable limits on decision errors, which will be used to establish performance goals for limiting uncertainty in the data, will be minimized through the evaluation and validation of all data prior to decision-making. For each remedy, data or information collection efforts will be designed such that, when implemented, they will generate newly-collected data that are of sufficient quality and quantity to address the project's goals (determined from Step 2). The adequacy of one or more existing sources of information or data may then be evaluated using a Type 1/ Type 2 error analysis if needed to determine the acceptability of the data to support the project's intended use.

At minimum, data validation will be performed for each sample delivery group after each sampling event using the ADR.net (Automated Data Review) software along with a chemist review of the ADR results. The ADR output will be adjusted by the chemist based on professional judgment to complete the validation process. The laboratory's analytical data packages will be reviewed to assess adherence to acceptable laboratory practices and the data validation requirements specified in Massachusetts Department of Environmental Protection Massachusetts Contingency Plan (MCP) Compendium of Analytical Methods, EM-200-1-10, and the Department of Defense Quality Systems Manual (QSM) for Environmental Laboratories, and applicable analytical methods. The level of data validation will be performed with reference to the project QAPP (Sovereign, 2013a) and EPA Region I Tier II Guidance. For Tier II data review, data quality objectives will be assessed by review of the Contract Laboratory Program-like summary forms, with no review of the associated raw data.

3.2.2 Data Acquisition

DQO Step 7: Optimize the design for obtaining data:

Table 1 and **Table 2** list the wells selected for long-term monitoring and whether they are shallow, mid-depth, deep overburden/till, or bedrock wells. **Figure 5** depicts the location of these long-term monitoring locations. This list includes wells to monitor groundwater as it travels near the eastern edge of the landfill and as it moves away from the landfill at its northern extreme. **Appendix B** presents baseline data for each existing monitoring well.

Since 2010, additional wells have been installed within the landfill, throughout the NIA, and along the barrier wall to further enhance the monitoring network. Data from these newly installed wells were evaluated with the purpose of updating the LTM network. Based on data collected from SHL and the NIA since 2010, wells were added or removed from the list of LTM wells with the goal to monitor and assess conditions throughout the study area as the SHL remedy affects aquifer conditions at SHL and the NIA.

The network will be continuously assessed and optimized in future years through annual reports. Recommendations made in the annual reports to increase or reduce the numbers of wells or to change analytes will be formally incorporated into revisions of the LTMMP during the next five-year review.

Groundwater sampling will be conducted in accordance with the *Site Specific Quality Assurance Project Plan* (QAPP) *for Shepley's Hill Landfill Supplemental Investigations, Long-Term Monitoring and Treatment System O&M Services* (Sovereign, 2013a). This document is included as **Appendix C** and will be amended, as needed, annually. Groundwater sampling and hydraulic monitoring frequencies, provided in **Tables 1** and **2**, may be summarized as follows:

- Groundwater Sampling Semiannual Events: The spring event will be focused on the arsenic-impacted area, where key wells are located for assessing the performance of the various remedy components as detailed above. The semiannual events will be conducted for a minimum of three years (through 2018) to document seasonal fluctuations. Thereafter, the semiannual events will be discontinued, and the former semiannual wells will be sampled annually during the fall sampling event.

- Groundwater Sampling Annual Events: During the fall, a synoptic groundwater chemistry event will be conducted involving the landfill area, barrier wall area, extraction well areas, and NIA monitoring areas. During the next five year review process, the current LTM wells that are monitored annually will be evaluated, and select wells will be designated for 5-year sampling events.

- Groundwater Sampling 5-Year Monitoring Events: Selected wells, considered less critical to performance evaluation but still of interest, will be included in the fall chemistry event every 5 years. This 5-year event will be designed to provide a larger scale snapshot of groundwater chemistry in all study areas including upgradient areas, landfill areas, barrier wall areas, extraction well area, and the NIA.

- Hydraulic Monitoring Annual Events: A comprehensive synoptic water-level data-set of the entire network of Upgradient, Landfill, Barrier Wall Performance, nearfield, and NIA wells will be completed in conjunction with the fall annual sampling event. These hydraulic monitoring events will include those wells scheduled for semi-annual and annual sampling as well as those wells scheduled for hydraulic monitoring only.

Spring events will be conducted in April/May and fall events in October/November timeframes. All groundwater samples will be collected in accordance with the USEPA Low Stress Purging and Sampling Procedures, Revision 3 (USEPA, 2010), and all samples to be analyzed for dissolved metals, including arsenic, iron, and manganese, and dissolved organic carbon will be field filtered using a 0.45-µm filter. Sampling will include the use of field instruments for measuring ORP, DO, pH, conductivity, temperature, and turbidity, and groundwater samples will be submitted for laboratory analysis of dissolved (field filtered) arsenic, sulfate, total alkalinity, dissolved manganese, dissolved iron, dissolved organic carbon, and chloride as detailed with laboratory methods on **Table 3**. Analyses will be performed by labs accredited in accordance with the National Environmental Laboratory Accreditation Conference (NELAC) and certified in Massachusetts. The laboratory will be certified by the Environmental Laboratory Accreditation Program (ELAP) and will follow the DOD QSM latest version.

Previously, groundwater samples were analyzed for several additional water quality analytes, nitrate/nitrite, sulfide, ammonia, calcium, magnesium, sodium and potassium. However, due to the rationale presented below, the testing for these analytes will be discontinued.

- <u>Nitrate/nitrite</u>: This redox couple was originally analyzed in order to estimate redox potential in the groundwater using the Nernst equation. Unfortunately, most samples yielded non-detectable concentrations for either nitrate or nitrite rendering the calculation useless. There is no reason to further analyze for this redox couple.
- <u>Sulfide</u>: This part of the sulfate/sulfide redox couple was originally analyzed in order to estimate redox potential in the groundwater using the Nernst equation similar to the nitrate/nitrite couple. Unfortunately, most samples yielded non-detectable sulfide concentrations due to rapid precipitation of metal sulfides rendering the calculation useless. There is no reason to further analyze for this part of the sulfate/sulfide redox couple.
- <u>Ammonia</u>: While ammonia is a good indicator of reducing conditions, it is difficult to determine reliably and does not provide any more information than bicarbonate or manganese do for identifying the extent of reducing conditions in the landfill. It therefore can be eliminated without sacrificing reliable redox information.
- <u>Calcium, Magnesium, Sodium and Potassium</u>: These elements have primarily been determined in water samples to provide a complete major cation and anion balance profile for the samples. The data were used to determine charge imbalance to ensure that no major chemical parameters had been neglected as part of the analytical program. It has been established over the years that charge balance occurs regularly in the samples indicating that both the sampling protocol and laboratory protocol have produced an accurate depiction of water quality in the samples. Any significant deviation in sulfate or chloride in future samples would suggest that these analytes again be checked.

The location and frequency of monitoring presented here will be optimized as data are collected and evaluated through the annual reporting process. Any modifications will be made through Annual Report recommendations and future revisions to the LTMMP. Any changes to this sampling protocol must be agreed upon mutually by the Army and the appropriate regulatory agencies.

The remaining SHL and NIA groundwater wells and piezometers not designated for long-term sampling or hydraulic monitoring were evaluated for future use, and those wells and piezometers which were determined to be of no future value were selected for abandonment.

The proposed list of wells and piezometers to be abandoned and the rationale for abandonment are included as **Table 4**.

3.3 Landfill Monitoring and Maintenance

Long term monitoring and maintenance of the landfill final cover system is required for a period of 30 years from landfill closure to preserve the integrity of the cover system and identify potential problems for timely repair. The basis for this section of the plan is found in the Feasibility Study and Proposed Plan (ABB, 1995).

3.3.1 Annual Inspections

Annual inspections shall be conducted by individuals knowledgeable in landfills, as well as plant growth concerns, in order to detect and identify problems such as erosion, settlement or movement of soil on the cap, etc. Annual inspections will include the following:

<u>Monitoring wells</u>: Inspect the landfill monitoring wells for damage to the protective casing and cap, if present. Ensure locks are in working condition.

<u>Piezometers</u>: Inspect the piezometers for damage to the protective casing and cap, if present. Ensure locks are in working condition.

<u>Cover surface</u>: Inspect for bare spots greater than 100 ft., and note locations for future monitoring. Inspect the surface for evidence of disruption due to frost heaves.

<u>Vegetative Growth</u>: Inspect the overall condition (healthy or distressed), the need for water and the need to mow. Also look for unwanted vegetation such as purple loosestrife and overgrown vegetation in drainage swales.

<u>Landfill Gas vents</u>: Inspect for damage, observe if gas is being vented.

<u>Drainage Swales</u>: Inspect for any repairs needed for run-off drainage control structures and for erosion of the banks or adjacent areas.

<u>Culverts</u>: Inspect for silting, debris build up, and need for repair or clean out.

<u>Catch basins</u>: Inspect for silting of the basins, the need for clean out, loose rims, and proper grading around the rims.

<u>Settlement</u>: Inspect for slopes flatter than 2 %, development of depressions or ponding of water. Inspect existing depression at northern end of landfill for additional settlement.

<u>Erosion and Sedimentation</u>: Inspect the landfill surface for cracks or erosion gullies. Check swales, embankments, hillsides for erosion and sedimentation of surrounding areas.

<u>Access Roads</u>: Inspect the access roads around and to the landfill for needed repairs.

<u>Security Fencing</u>: Inspect for damage to, or breeches in, the fencing.

<u>Wetlands Encroachment</u>: Inspect the entire landfill perimeter for encroachment of wetlands species.

3.3.1.1 Landfill Inspection Checklist

The Landfill Inspection Checklist is presented in **Appendix D**. Annual inspections will be performed visually using the checklist, and the completed checklists shall be retained until monitoring is no longer required.

3.3.1.2 Corrective Action

The completed checklist will be reviewed for an overall condition assessment. If the integrity of the landfill cap and associated systems are deemed to be compromised in any way, it shall be documented on the checklist and reported to the Army who will determine the required corrective actions.

3.3.2 Vegetative Maintenance

To preserve the integrity of the final cover system, the maintenance of the vegetative layer is critical, as erosion can be minimized through the promotion of good vegetative growth. The vegetative layer shall be inspected and maintained annually, which will induce the propagation of acceptable vegetation, prohibit growth of small trees, brush, unwanted vegetation and associated root structure, and allow easy access for inspection of the landfill cover. The inspection and maintenance shall be undertaken by individuals who have a thorough knowledge of types of vegetation that are to be encouraged to propagate and the types that are to be eliminated. The vegetative layer shall be cut in early fall to a manageable height, but not less than eight inches. This vegetative maintenance will also help when performing the visual surveys for the other items to be inspected.

3.3.3 Settlement Monitoring

Any existing depressions will be monitored for additional settlement and if detected will be corrected, as required. Surveying of the landfill cap may be performed if visual inspection of the cap indicates slopes of less than 2% or if the development of additional depressions or ponding of water is observed. If the slopes of the landfill decrease to less than a 2% due to settlement, the impacted area may be analyzed by the Army to determine the proper course of action. Actions could involve placing additional cover material on the landfill to re-establish the required slope, regrading, or providing additional drainage swale area.

3.3.4 Landfill Gas Monitoring

A passive gas vent system has been installed consisting of 18 gas vents. Drawing 833-90-01 Sheets 1 - 5, on file with the New England Division of the Army Corp of Engineers, shows the grid plan with the vent locations and identifications. Gas sampling of these vents will be used to establish long-term trends with regards to gas production and venting. The combustible gas survey will determine whether methane, hydrogen sulfide or VOCs have accumulated in the subsurface of the landfill site. Additionally, 25 perimeter soil gas probes have been installed along the northwest and southern edges of the landfill.

3.3.4.1 Frequency and Parameters

Landfill gas field sampling from the gas vents and perimeter soil gas probes shall be performed annually. Gas samples will be field analyzed for the following parameters: Total VOC concentration, percent Oxygen (O_2), Hydrogen Sulfide (H_2S) concentration, Percent Lower Explosive Limit (LEL), Carbon Monoxide (CO) concentration, percent Carbon Dioxide (CO_2), and percent Methane (CH_4). If no gas has been detected at a vent for five consecutive years, then the vent shall be pressure tested to determine if it is working properly. If the vent is found to be clogged it shall be repaired as required.

3.3.4.2 Monitoring Equipment and Sample Analysis

The soil gas samples obtained from the permanent gas vents and perimeter soil gas probes shall be analyzed with field analytical equipment including a portable landfill gas analyzer, combustible gas indicator, and a photoionization detector (PID). The monitoring is conducted by first capping off vents and connecting an adjustable flow rate sampling pump to sample port (barbs) on the cap. Prior to sampling, two vent volumes will be purged from the soil gas vent using the adjustable flow rate sampling pump. The analytical devices are in turn connected to the sampling port following purging of the vents. All analytical devices are equipped with internal pumps. The perimeter soil gas probes are constructed with ports for sampling and are also purged prior to sampling.

A portable landfill gas analyzer shall be used to measure percent LEL, percent CO_2, and percent CH_4. A combustible gas indicator shall be used to measure percent O_2, H_2S concentration, and CO concentration. A PID will be used to screen for total VOCs concentration.

All instruments shall be calibrated according to manufacture instructions prior the start of the sampling. The portable landfill gas analyzer and combustible gas indicator shall be calibrated using mixed gases supplied by the instrument manufacture. The PID shall be calibrated to 100 ppm isobutylene and a zero gas. Calibration of all instruments will be checked at the end of the day. Results will be recorded on a form similar to the Landfill Gas Monitoring form in **Appendix E**.

3.4 ATP Operation and Monitoring

3.4.1 System Description, Operations, and Maintenance

The arsenic treatment system is designed to remove arsenic from extracted groundwater through co-precipitation with iron followed by microfiltration. The treatment system is housed in a 40-foot by 40-foot steel building and consists of the following components:

- Extraction system (two extraction wells);
- Chlorine dioxide (ClO_2) generation and addition;
- Coagulation via a contact tank with a direct drive batch tank mixer;

- MF of oxidized solids;
- Solids removal via an IPC;
- Bag filtration and discharge of the IPC decant water;
- Polymer aided flocculation of sludge using a FBRO; and,
- Discharge to the Devens POTW.

The extraction system consists of two extraction wells (EW) located at the northwestern portion of the landfill cap. These extraction wells, EW-1 and EW-4, are capable of achieving the required combined extraction rate of 50 gpm by either operating simultaneously or independently of one another to maximize plant influent flow. Subsequently, groundwater enters the ATP influent stream, and then is dosed with chlorine dioxide which oxidizes and precipitates the inorganic metals, arsenic, iron, and manganese. These precipitates are then filtered by a microfiltration system and the effluent or treated water is discharged to the Devens POTW collection system. Every 15 minutes, the MF control unit backwashes the filtered precipitates from the membranes. These solids are fed to the IPC and allowed to settle out of suspension and form a residual sludge. The backwash effluent supernatant is fed through two bag filters configured in parallel and discharged to the plant effluent sump. The sludge is then pumped out of the IPC, dosed with polymer to increase flocculation, and carried over to the FBRO. The accumulated sludge is removed from the plant approximately once every two weeks for disposal.

A licensed plant operator will be on site at least two times a week, to monitor and maintain the system's efficiency of removing arsenic from the groundwater to meet the effluent discharge arsenic concentration standard of 75 µg/L as well as the other requirements stated in the discharge permit (**Appendix F).** During these visits, the operator will perform all necessary system repairs and routine maintenance tasks, and if specific repairs are beyond the operator's capability, the operator will supervise over a qualified subcontractor. These procedures are designed to ensure proper system operation and to meet discharge requirements.

3.4.2 Influent/Effluent Monitoring

To verify that the system is meeting discharge requirements, system sampling will be performed at the sample locations/frequencies for selected analytes in accordance with the discharge permit requirements established with the MassDevelopment Wastewater Treatment Facility. This permit was initially established with MassDevelopment on July 14, 2003 and was subsequently amended prior to system start-up in August 2005. The current discharge permit became effective on June 28, 2013 and expires on June 28, 2016. Current permit effluent limitations and monitoring (type and frequency) and reporting requirements are outlined within the permit and summarized below:

LOCAL EFFLUENT LIMITATIONS REQURIED SAMPLING

Parameter	Sampling Frequency	Limitation
Arsenic	Monthly	0.20 mg/l
Chromium (total)	Annually	0.40 mg/l
Cadmium	Annually	0.045 mg/l

Parameter	Sampling Frequency	Limitation
Copper	Annually	0.75 mg/l
Lead	Annually	0.20 mg/l
Silver	Annually	0.30 mg/l
Selenium	Annually	0.03 mg/l
Mercury	Annually	0.001 mg/l
Total Toxic Organics (TTO)	Annually	5.0 mg/l
Total Petroleum Hydrocarbons (TPH)	Annually	100 mg/l
pH (units)	Continuous	5.5-9.5

As noted in the table above, arsenic is sampled monthly, and other parameters are sampled quarterly or annually. The permit requires that the daily load for arsenic not exceed 0.10 pounds per day. In addition, the permit includes a "Special Condition" requiring weekly sampling of the effluent arsenic concentration in the event that the arsenic concentration exceeds 75 µg/L in a permit required monthly sampling. The Contingency Remedy was modified to include treatment to the process to ensure that neither the concentration nor the mass-related limitations are exceeded.

In addition, a continuous pH meter with chart recorder has been installed on the effluent discharge line of the system. The permit requires that:

…a pH meter shall be used continuously to measure the pH of the discharge. The pH meter shall be a continuous monitoring instrument with a chart recorder. All charts shall be maintained on file onsite for a minimum of 3 years. At a minimum, the pH meter shall be calibrated weekly and a calibration log maintained on file onsite for a minimum of 3 years.

In addition to those parameters with effluent limitations noted on the table above, the following additional parameters are currently monitored quarterly: Flow (MGD), barium, manganese, magnesium, chloride, nitrate, and sulfate. Based on discussions with the MassDevelopment Utilities Supervisor, further monitoring of these parameters in the effluent are no longer necessary for compliance with the permit. Consequently, they will be removed under a permit revision.

In accordance with the permit, monthly and quarterly monitoring reports are to be submitted to the MassDevelopment Utilities Supervisor and the United Water Industrial Pretreatment Coordinator. Copy of the current discharge permit is included as **Appendix F**.

VOC analysis (EPA Method 8260) will be conducted on the system influent annually, concurrently with the discharge permit required annual effluent sampling. Annual dissolved methane and ethane sampling of the system influent will also be conducted at this time.

During the ATP start-up testing operations, the process influent and effluent was sampled extensively for arsenic, iron, and manganese, to evaluate influent and effluent concentrations of these constituents. This was conducted such that chemical additions needed to coagulate these species could be evaluated, and the dosage could be optimized. Influent inorganic loading characteristics shall be assessed quarterly throughout the year to gauge system loading and to ensure that a sufficient iron concentration is maintained to promote iron and arsenic precipitant coagulation.

3.5 Barrier Wall Monitoring

The installation of the SHL/Red Cove barrier wall in the summer 2012 has altered the hydrogeology of the aquifer in this area. Prior to installation, a portion of the groundwater flowing beneath SHL discharged to Red Cove in Plow Shop Pond. Monitoring of these conditions documented that a remedy was required to achieve the RAO of preventing contaminated groundwater from impacting Red Cove. The barrier wall was therefore designed to limit the flux of arsenic in groundwater to Red Cove by limiting the amount of groundwater which would flow and discharge from SHL to Red Cove.

3.5.1 Hydraulic Head Monitoring

During the construction of the barrier wall during summer and fall 2012 at the SHL, a series of overburden groundwater piezometers were installed along the barrier wall alignment to provide hydraulic performance monitoring of the barrier wall. Well screens for each of the piezometers were set at similar depths across the length of the wall to the extent possible considering the saturated overburden thickness. The piezometers consist of five (5) sets of wells (two wells per set), with one point per set located up-gradient of the barrier wall (westerly side) and the other down-gradient (easterly side) of the barrier wall. **Figure 2** displays the locations of the piezometers. The spatial orientation of the piezometers was determined based on both a review of the depth to rock observations documented during the barrier wall construction and based on lateral spacing considerations to allow for a pair at the barrier wall hinge point closest to Red Cove. The piezometers were off-set approximately eight to ten feet from each side (or the edge) of the barrier wall.

Weekly hydraulic monitoring events were conducted in November 2012 followed by monthly hydraulic monitoring events from December 2012 through April 2013. During each monitoring event, an electronic water level meter was used to measure depth to water (DTW) with an accuracy of ± 0.01 feet from the top of casing of each piezometer. Results of the monitoring events demonstrated a positive difference in hydraulic head at each piezometer couplet location along the barrier wall. The maximum hydraulic head differential observed in paired piezometers during the six month period was 1.83 ft. (PZ-12-09 and PZ-12-10), towards the southern end of the wall. The minimum head differential observed in paired piezometers was during the six month period was 0.27 ft. (PZ-12-01 and PZ-10-02) at the northern end of the wall. It is presumed that the greater head differential to the south is due to a combination of a less saturated thickness in the southern portion of the barrier wall as compared to the northern portion and the expected increase in velocity (and corresponding lowering of hydraulic head) of the groundwater as it flows north.

A summary of historic barrier wall piezometer hydraulic monitoring data collected from November 2012 to April 2013 is detailed in **Table 5**, which provides detailed water table elevations measured at each piezometer pair during each monitoring event. Additionally,

Table 5 tallies the current head differential between each pair along with the change in head differential from one monitoring event to the next.

As presented on **Table 2,** continued hydraulic monitoring of the piezometers located along the barrier wall will be conducted as part of the semiannual LTM gauging events. In addition, the existing well network associated with the SHL monitoring program will be used, as necessary, to compliment the hydraulic information obtained from the piezometers to adequately assess the hydraulic gradient in the area of the wall.

3.5.2 Arsenic Flux to Red Cove

Arsenic flux calculations will utilize hydraulic head differential data across the barrier wall and will provide a range of potential flux based on the input of a range of arsenic concentrations to the formula. Specifically, flux will be calculated by multiplying the yield (gallons per minute) using Darcy's Law of aquifer flowing around the southern end of the wall and across the wall by the concentration (ug/L) of arsenic in the water from wells located adjacent to Red Cove, and multiplying by conversion factors to obtain the flux estimate in grams per day. Those wells designated for barrier wall performance monitoring and from which the data for flux calculations will be obtained are presented on **Tables 1** and **2**.

Previous modeling suggests that existing arsenic-impacted groundwater on the eastern side of the wall may require several years to flush from the aquifer; therefore, the statistically significant decrease in arsenic concentration on the eastern side of the wall is not expected to occur until after 5 years of operational life. Consequently, calculation of arsenic flux will be conducted at the end of the next 5-year review period.

4.0 SAMPLING PROCEDURES

The following sections detail all the appropriate methods, Standard Operating Procedures (SOPs), activities, and equipment necessary for a LTM sampling event. All the information presented references the Standard Army Procedures and most recent EPA low flow sampling SOP (EQASOP-GW001 – **Appendix G**).

4.1 Environmental Media Monitoring

The long term monitoring program for groundwater will include the following sample location points listed in **Tables 1** and **2**. Refer to **Section 3.1** for descriptions of the sampling point selection, frequency, and analysis.

4.2 Pre-sampling Activities

Prior to conducting the sampling event, the appropriate equipment and supplies shall be obtained, and the laboratory shall be contacted (approximately two weeks prior to commencement of event) to communicate and coordinate the sampling event. Arrangements will be made with the laboratory to prepare and deliver sampling kits to a specified location.

4.2.1 *Equipment and Supplies*

Equipment required for sampling the monitoring wells includes but is not limited to: laboratory sampling kits (sample containers, caps, labels, coolers, custody seals, etc.); peristaltic or submersible pumps; Teflon lined polyethylene, PVC, Tygon or stainless steel tubing; safety glasses and gloves; water level indicator; pH/DO/ORP/Conductivity/Temp meters; turbidity meters; flow through cells; PID; deionized water decontamination supplies; graduated purge water container (minimum 5 gallons); keys to well locks; ice or blue ice packs; field analysis forms; and chain-of-custody forms. All purging, sampling and decontamination equipment and procedures will be in accordance with Standard Army Procedures and up to date EPA low-flow purging and sampling procedures (EQASOP-GW001 – **Appendix G**). Samples will be collected directly from tubing connected to the pump discharge. Tubing will be preferably well dedicated. If tubing is not well-dedicated, fresh (unused) tubing will be used at each sampling location.

4.2.2 *Equipment Calibration*

All field equipment shall be calibrated at the beginning of each day of use. Standard equipment will include pH/DO/ORP/Conductivity/Temperature/Turbidity meter and a PID. Calibration samples will be collected exclusively for field analysis and not submitted for laboratory analysis. Probes used to measure field parameters shall be rinsed with distilled water between each sample points.

4.2.3 *Site Location, Security and Access*

Monitoring well locations are shown on the site map found in **Figure 2**. Most wells are located within a secured area and arrangements must be made for access. A key must be obtained from the Army for entry to the site.

4.2.4 *Initial Well Opening and Inspection*

Upon removing the locking cap and the well casing protective cap, any odors noted will be recorded in the Monitoring Well Sampling Log Form (**Appendix H)**. The headspace of the well casings shall be checked for total VOCs immediately upon removing the well cover using a PID. Any damage or evidence of tampering will be recorded in the logbook.

4.2.5 *Water Level Measurements*

Prior to well purging or sampling, groundwater measurements will be made using an electronic water level indicator. Water levels will be recorded from the top of the well plastic casing and will be recorded to the nearest 0.01 foot. The probe will be rinsed following the appropriate decontamination procedures detailed in **Section 4.5.3** between sample points. The depth to water will be measured in each well using the decontaminated water level indicator, taking care not to lower the probe below the water surface any further than necessary. Depth to water will be determined with as little physical disturbance of the water in the wells as possible. Note that dedicated tubing may be suspended in the well during water-level measurements. All water level measurements shall be taken on the same day as sample collection. Water level measurements shall be recorded on the Monitoring Well Sampling Log Form located in **Appendix H**.

4.3 Sampling Activities

All activities to be completed prior to sample collection are presenting in the following sections.

4.3.1 Well Purging

Prior to sampling or performing field analyses, each well will be purged in accordance with EPA's most up to date low-flow purging and sampling procedures (EQASOP-GW001 – **Appendix G**). This will be done to ensure that representative samples may be obtained. Water drawdown during purging shall be less than 0.3 feet.

Wells will be purged using an adjustable rate, low-flow submersible or peristaltic pump. This will be accomplished by lowering a section of plastic tubing into the well so that the lower (intake) end of the tubing is approximately midpoint of the well screen. Purging shall continue until field parameter measurements meet stabilization criteria; yet, if after two hours of purging the field parameters have not stabilized, sample collection may commence. Tubing which comes into contact with well water must be constructed of a material which will not contaminate samples. If sampling for VOCs only tubing of Teflon® construction may be reused and must be decontaminated between sample points. If PVC tubing is used, it must be dedicated to the well. The field measured parameters are: pH, temperature, DO, ORP, conductivity and turbidity. Purging data shall be recorded on the Monitoring Well Sampling Log Form in **Appendix H**.

4.3.2 Sample Containers and Preservatives

Containers: Sample containers will be obtained from the laboratory and shall not be reused. Ground water samples will only be collected in laboratory indicated containers depending on the specific analyte and method of analysis.

Preservatives: If preservatives are necessary, the laboratory will provide sample containers with preservatives added. The appropriate personal protective equipment (PPE) and safe handling measures should be taken when handling sample containers with preservatives, as some preservatives may cause harm if not handled correctly. All samples will be kept in an ice chest until delivery to the laboratory. The laboratory will recheck the pH prior to analysis to insure that the lab-prepared preservatives were not compromised.

Holding Times: The time between sample collection and initiation of laboratory analyses will be determined by the specific test analysis and applicable EPA reference. Any analysis of samples after the prescribed holding time will be flagged during data validation and evaluated for data usability.

4.4 Sample Collection

After purging and stabilization, water samples will be field filtered using a 0.45-µm filter and collected by allowing the pump discharge to flow gently down the inside of the sample container with minimal turbulence to prevent aeration and agitation.

4.4.1 Sample Identification

The system for identifying and tracking the samples, associated field data, and the method of relating the data to the proper samples will be recorded in permanently bound and weatherproof logbook and/or field data sheets maintained by the field team. Team members will record all information related to sampling procedures, time, field and weather conditions, unusual events, sample descriptions (including sample depth), instrument readings, and Chain-of-Custody data. Field documentation will be written in indelible ink. Additional sample types, areas of origin, and sub sample types will be allocated as necessary.

Site-specific sample identification numbers will be assigned prior to sample collection. Each sample will be identified in the field notebook and field sampling form by an alpha-numeric code following the identification scheme outline below. The site-specific sample number will consist of the following:

Groundwater Samples

Notation: SHM-XX-XX-MMDDYY

Where: SHM indicates Groundwater Sample,
-XX-XX indicates year and well location identifier, and
-MMDDYY is the 6-digit date on which the sample was collected.

Ex: SHM-10-01-102212; Groundwater sample from well location SHM-10-01 collected on October 22, 2012.

Duplicate Samples

Notation: DUP- MMDDYY

Where: DUP indicates blind duplicate sample, and
-MMDDYY is the 6-digit date on which sample was collected.

Ex: DUP-102212; Duplicate sample collected on October 22, 2012.

Field Rinsate Blank Samples

Notation: RB- MMDDYY

Where: RB indicates field Rinsate Blank sample, and
-MMDDYY is the 6-digit date on which sample was collected.

Ex: RB-102212; Field Rinsate Blank sample collected on October 22, 2012.

4.4.2 *Quality Assurance/Quality Control Samples*

During each sampling event field QA/QC samples shall be collected in accordance with the project QAPP. All field QA/QC samples shall be preserved, shipped and analyzed with the other samples from the sampling event. A summary of required field QA/QC samples is presented below:

Field Duplicate	Matrix Spike (MS)	Matrix Spike Duplicate (MSD)	Equipment Rinsate Blank
1 per 10 field samples	1 per 20 field samples	1 per 20 field samples	1 per each day decontamination of sampling equipment is completed

4.4.2.1 Field Duplicate Sample

Field duplicate samples shall be taken immediately following the preparation of the field sample collected from the sampling location. Field duplicate samples shall be prepared in the same way as the field samples and shall be identified as a duplicate on the sample container label. The specific sampling location of field duplicate samples shall be selected using random method. Field duplicate samples will be collected at a frequency of one per ten field samples.

4.4.2.2 Rinsate Blank

A rinsate blank is collected during each day of sampling that sampling equipment decontamination is conducted to check for potential contamination due to sample equipment construction or improper decontamination procedures. The rinsate blank shall be prepared as follows:

a) The sampling equipment sample will be decontaminated following standard applicable decontamination SOPs;
b) De-ionized shall be rinsed over the decontaminated sampling equipment and collected in the appropriate sample container; and
c) The sample container shall be labeled as a rinsate blank.

4.4.2.3 Matrix Spike/Matrix Spike Duplicates

Matrix spike (MS) and matrix spike duplicate (MSD) samples shall be taken immediately following the preparation of the regular sample collected from the sampling location. The MS/MSD samples shall be prepared and identified on the sample container label in the same manner as the regular sample and noted on the Chain of Custody. A MS/MSD sample set is to be collected for every 20 regular field samples collected. The specific sampling location of MS/MSD samples shall be selected using random method.

4.5 Post-Sampling Activities

All post-sampling activities are presented in the sections below.

4.5.1 Chain-of-custody

Chain-of-Custody records provide documentation of the handling of each sample from the time of its collection to its destruction. Sovereign will initiate sample custody upon collection of samples. The Chain-of-Custody forms will be placed in weatherproof plastic bags and taped to the inside lid of the cooler. The cooler will be sealed with a minimum of two custody seals, one on either side of the cooler lid. The Chain-of-Custody forms will be used for recording pertinent information about the types and numbers of samples collected and shipped for analysis. Sample identification numbers will be included on the Chain-of-Custody form to ensure that no error in identification is made during shipment. The Chain-of-Custody procedures shall be performed in accordance with Appendix F of EM-200-1-3 (USACE, 2001).

A sample is considered “in custody” if it:

- Is in a person’s actual possession.
- Is in view after being in physical possession.
- Is locked so that no one can tamper with it after having been in physical custody.
- Is in a secured area, restricted to authorized site personnel only.

Per this definition, samples that are secured within sample refrigerators and/or freezers in locked, secured location awaiting laboratory pickup are considered “in custody”.

4.5.2 Sample Delivery/Shipment to Laboratory

If samples are to be transported to by way of Federal Express or a similar shipping method, each sealed container will need to comply with the following shipping requirements. Sample jars will be packed in bubble wrap and then placed in leak-proof plastic bags and placed in containers compatible with the intended analysis and properly preserved prior to relinquishment/shipment to the laboratory. Thermal ice chests/coolers will be packed with foam padding to cushion the sample containers. Ice will be placed inside sealed plastic bags and packed in the cooler surrounding and atop the packed samples. A Chain-of-Custody form will be placed in a waterproof plastic bag and taped to the inside lid of the cooler. Ice chests will be taped shut with strapping tape, and wrapped around the cooler in at least two places. Tape will also be put over the drain plug (if present) to prevent leaking. Ice chests will be sealed with numbered and signed custody seals that are signed and dated. Custody seal numbers should be included on the Chain-of-Custody and logged in the field team sample logbook. This packaging and shipment is in accordance with Region 1 EPA protocol. Prior to shipment, a QC check will be performed to ensure samples have been properly identified and packaged, and that appropriate documentation (Chain-of-Custody) will accompany them.

Samples that are delivered to the off-site laboratory or relinquished to a laboratory courier shall be placed in appropriate transportation containers and preserved as required. Samples should be packed in such a manner as to minimize the possibility of sample container breakage.

Samples provided to an off-site laboratory courier must be sealed inside a cooler secured with a minimum of two numbered and signed custody seals. Custody seal numbers should be included on the Chain-of-Custody and logged in the field team sample logbook. The Chain-of-Custodies should be transferred to the laboratory using the appropriate relinquishment procedures, but do not need to be placed in the transportation container. Prior to shipment, a QC check will be performed to ensure samples have been properly identified and packaged, and that appropriate documentation (Chain-of-Custody) will accompany them.

4.5.3 Equipment Decontamination

All sampling equipment must be properly decontaminated prior to sample collection, between sampling locations, and following a sampling event. Decontamination of equipment is necessary to prevent cross-contamination between samples. In addition, rust should be removed from any part of the sampling equipment that may contact the sample. All equipment such as pumps, water level meters, water quality meters, and miscellaneous tools and equipment which contact the sample will be decontaminated. Decontamination will occur between individual sampling locations. USEPA Region 1 Decontamination SOP No. 2000 is used as a guideline for this procedure. Decontamination chemicals (i.e. nitric acid or methanol) will be collected and containerized for off-site disposal.

4.5.4 Investigation-Derived Waste

Decontamination fluids containing methanol or nitric acid will be containerized, labeled, sealed with a custody seal, and removed for disposal per applicable hazardous and/or non-hazardous waste generation procedures. All other potential wastes generated during sampling activities will be returned to the ground at the point of collection, consistent with USEPA and MassDEP requirements.

4.5.5 Data Validation

Data validation will be performed for each SDG from each sampling event using the ADR.net (Automated Data Review) software along with a chemist review of the ADR results. The ADR output will be adjusted by the project chemist based on professional judgment to complete the validation process. The laboratory's analytical data packages will be reviewed to assess adherence to acceptable laboratory practices and the data validation requirements specified in MCP Compendium of Analytical Methods, EM-200-1-10, and the Department of Defense QSM for Environmental Laboratories, and applicable analytical methods. The level of data validation will be performed with reference to the project QAPP and EPA Region I Tier II Guidance. For Tier II data review, data quality objectives will be assessed by review of the Contract Laboratory Program-like summary forms, with no review of the associated raw data.

4.6 Field Documentation

This section documents Chain-of-Custody, sample, and field observation documentation procedures.

4.6.1 *Field Log Books*

The field logbook along with supplemental field data sheets will enable the sampling activity to be reconstructed without relying on the collector's memory. Logbooks will be kept in the possession of the field member responsible for sampling activities or in a secure place during fieldwork. The following information will be recorded in the field logbook:

- Name and title of author, and date and time of entry.
- Name and address of field contact.
- Names and responsibilities of field crewmembers.
- Names and titles of any site visitors.
- Sample collection method (s).
- Number and volume of sample(s) taken.
- Information concerning sampling changes, scheduling modifications, and change orders.
- Details/Sketch of sampling location(s), including depth.
- Date and time of sample collection.
- Weather conditions.
- Field observations.
- Any field measurements made.
- Sample identification number(s).
- Information from containers, labels of reagents used, water type (e.g.., deionized) used for blanks, etc.
- Sampling methodology.
- Sample preservation.
- Analytical method(s) to be performed.
- Sample distribution and transportation.
- Sample documentation (i.e.., Chain-of-Custody record numbers).
- Decontamination procedures.
- Documentation for investigation-derived wastes (IDW) (i.e., contents and approximate volume of waste, disposal method).
- Documentation of any scope of work changes required by field conditions.
- Signature and date (entered by personnel responsible for observations).

4.6.2 *Field Sample Collection Sheets*

Field sample collection sheets enable the sampling activity to be reconstructed without relying on the collector's memory. These sheets will include:

- Names and responsibilities of field crewmembers.
- Sampling point location identification; including construction and integrity descriptions.
- Sampling point hydraulic data if applicable.
- All field measurements (e.g. water quality data, weather conditions, etc).
- Decontamination procedures.
- Any in-situ filtering processes.
- Sampling equipment and field parameter monitoring equipment descriptions, such as type, model, and serial number.

- Documentation of any changes in field conditions or observations during the sampling process.
- Signature and date (entered by personnel responsible for observations).

Copies of applicable field sample collection sheets can be found in **Appendix H**.

4.6.3 Photographic Documentation

Photographs of field activities will be logged as part of all field efforts and will be maintained within the project file.

4.6.4 Project File

Completed project file records shall be maintained by the Army and shall be updated regularly by project administrators as needed. Project records shall be maintained during the regulatory lifespan of the site.

5.0 INSTITUTIONAL CONTROL MONITORING PLAN

One of the SHL project RAOs is to protect potential residents from exposure to contaminated groundwater migrating from the landfill at levels that pose a risk to human health and the environment. The current ROD does not specifically address implementation of LUCs for any non-Army property located north of the landfill (i.e., the groundwater impacted off-site or the "north impacted area" or NIA), because the extent of the impact was not defined at the time. Post-ROD investigations have established that the SHL has impacted groundwater north and downgradient of SHL within the NIA.

The NIA LUCs were documented in the December 2013 *ESD for Land Use Controls to Restrict Groundwater Use* (Sovereign, 2013g), and the area of LUCs are presented on **Figure 4**. Upon submittal of the ESD, a LUCIP for the LUCs in the NIA was submitted in August 2014 to describe the procedures for implementing the LUCs in the NIA (Sovereign, 2014b).

5.1 Land Use Control Objectives

Groundwater in the NIA would pose an unacceptable risk to human health if used for drinking water and may cause unacceptable risk to human health if used for irrigation purposes. Therefore, administrative and/or legal LUCs are being incorporated as a component of the selected groundwater remedy for the site as part of an ESD. The performance objectives of the LUCs shall be to:

- Restrict access to groundwater so the potential exposure pathway to the contaminants would remain incomplete;

- Prohibit the withdrawal and/or future use of water, except for monitoring, from the aquifer within the identified groundwater LUC boundary; and

- Maintain the integrity of any current or future monitoring system.

5.2 Institutional Controls

To meet the LUC performance objectives, the following institutional controls in the form of governmental permitting, zoning, public advisories, prohibitive directives (e.g., no drilling of drinking water wells) and other legal restrictions are utilized within the NIA.

- The Ayer Board of Health (BOH) Well Regulations (Adopted January 10, 2001) – Town of Ayer permitting requirements for the installation and use of new drinking water wells.

- Moratorium on Groundwater Use within the Area of Land Use Controls - The Ayer BOH has issued a Moratorium on Groundwater Use, as adopted and amended by the Town of Ayer on May 6, 2013 and May 20, 2013, respectively.

- The Zoning By-Laws of the Town of Ayer (Adopted March 3, 1973 and Updated May 2001; Subdivision Control Regulations Updated 1987); Town of Ayer Building Department Permitting Requirements. Specifically, any new homes located in areas serviced by public utilities are required to obtain connection permits from the town's Department of Public Works.

- The Massachusetts Drinking Water Regulation 310 CMR 22.00 – the state regulatory permitting and approval process for any new drinking water supply wells in Massachusetts that propose to service more than 25 customers or exceed a withdrawal rate of 100,000 gallons per day.

5.3 Land Use Control Maintenance and Inspection

The Army intends to implement the following affirmative measures to further ensure that the LUC performance objectives are being met.

- Public education and outreach via ongoing periodic distribution of educational materials and groundwater use surveys to be distributed to all property owners and residents with the stated goal of confirming that no groundwater wells are in use within the entire Area of LUCs.

- Meet with the Ayer BOH on an annual basis, or more frequently if needed, to discuss the implementation of LUCs and provide an updated Area of Land Use Control map(s) that document the current and projected location of groundwater contamination within the Town of Ayer.

All LUCs will be maintained until either (1) the concentrations of COCs in the groundwater are at such levels as to allow unrestricted use and exposure, or (2) the Army, with the prior concurrence of the EPA and MassDEP, modifies or terminates the LUC in question. Specific details regarding the LUCs including timing of public education and outreach and on-going public involvement are detailed in the ESD and LUCIP for the LUCs (Sovereign, 2013g and 2014b).

6.0 REPORTING REQUIREMENTS

A summary of site activities and frequencies and associated reporting requirements is provided in the table below:

Activity	Frequency	Reporting Requirement
Groundwater Monitoring	Semi-annual	Included within Annual Report
Groundwater Analytical Data Validation	Within 60 days of sampling	Electronic Data Deliverable
Landfill Gas Monitoring	Annual	Included within Annual Report
Landfill Maintenance and Inspection	Annual	Included within Annual Report
LUC Performance	Annual	Included within Annual Report

Groundwater monitoring raw analytical data will be submitted to the USEPA and the MassDEP within 60 days of completion of the monitoring events. A summary of the completed groundwater monitoring activities and data analysis will be included with the Annual report.

Annual reports shall include a description of sites activities and a summary of the environmental monitoring programs conducted during the past year associated with the SHL, including landfill maintenance and inspection, landfill gas monitoring, ATP operation, maintenance and monitoring, groundwater monitoring, and LUC maintenance. As part of annual reporting, performance of all the remedy components shall be evaluated to ascertain if the selected remedy is anticipated to meet the RAOs. Annual reports shall be submitted to the Army, USEPA and the MassDEP.

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Figures

Replacement Pages

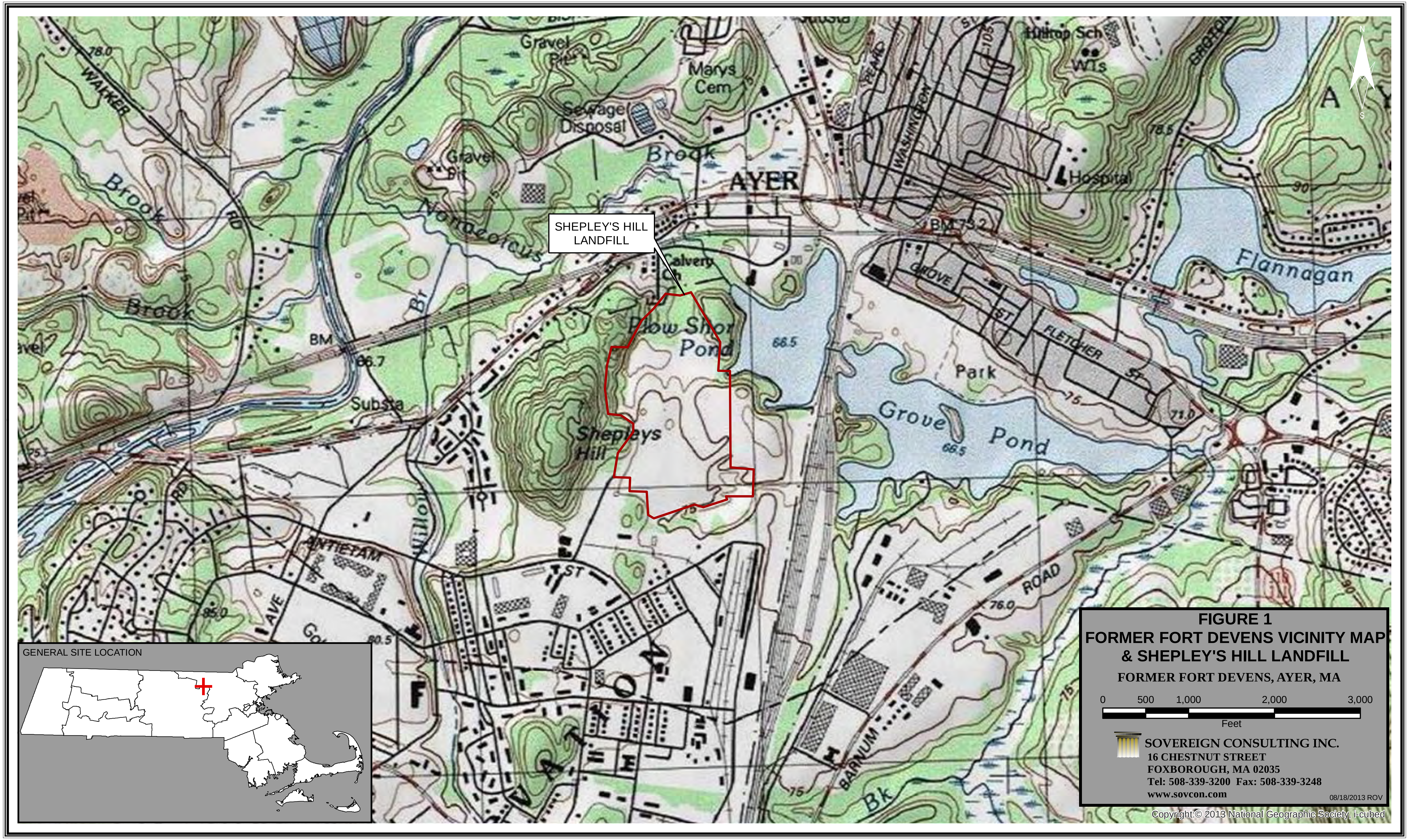

FIGURE 1
FORMER FORT DEVENS VICINITY MAP & SHEPLEY'S HILL LANDFILL
FORMER FORT DEVENS, AYER, MA

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16 CHESTNUT STREET
FOXBOROUGH, MA 02035
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08/18/2013 ROV


FIGURE 2 - NORTHERN IMAPCT AREA AND SHEPLEY'S HILL LANDFILL SITE PLAN
FORMER FORT DEVENS, AYER, MA
0 150 300 600 900
Feet
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Legend
OVERBURDEN MONITORING WELL/PIEZOMETER
MONITORING WELL - DESTROYED
GROUNDWATER PROFILING LOCATION/MONITORING WELL
GROUNDWATER PROFILING LOCATION
BEDROCK MONITORING WELL
EXTRACTION WELL
SOIL BORING
STREAM GAUGE
BARRIER WALL
Source: Esri, DigitalGlobe, GeoEye, i-cubed, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community
N
S
AOC 32
SHM-10-04
DEP-08-03
SHSG-13-03G
SHM-13-15
SHM-13-24
SHM-10-17
SHM-10-18
SHM-13-03
SHM-10-23
SHSG-13-02G
SHP-07-01A
DEP-08-07
SHM-13-14S
SHM-13-14D
SHP-13-03
SHM-10-25
SHM-10-20
SHM-10-21
SHX-01-06X
SHX-01-07X
SHM-10-03
SHX-01-08X
SHM-13-10
SHX-01-14X
SHM-10-05A
SHM-10-05
DEP-08-08
SHM-10-10
SHM-10-27
SHM-10-22
SHM-13-09
SHX-01-12BX
SHX-01-12AX
SHM-13-05
SHM-10-26
SHP-07-01BD
SHP-07-01CD/CS
SHM-13-08
SHX-01-09X
SHM-05-39A
SHM-05-39B
SHM-13-07
SHM-99-33A/B
SHM-99-33C
SHM-13-02
SHM-10-02
SHM-13-06
SHX-01-10X
SHP-07-01DD/DS
SHP-07-01D
SHP-05-49A/B
SHX-01-13X
SHP-07-03A
SHM-10-01
SHM-13-12
SHM-13-04
SHM-10-08
SHX-01-11X
SHM-99-32X
SHM-10-19
SHP-05-48A/B
SHP-99-34B\ SHP-99-34A
SHM-13-13
SHM-05-40X
SHP-07-01BS
SHM-07-05X
SHP-07-03B
SB-3
SHM-99-31C
SHP-07-03E
SHM-10-09
SHM-13-11
SHM-99-31B
SHSG-13-01G
SHM-07-03 / SB-07-03
SHM-99-31A
EPA-PZ-2012-5A/B
SHP-07-03C
SB-07-02
SHM-05-42A/B
SHM-96-5B
DEP-08-05
SHP-07-03D
SHM-10-16
SHL-22
SHL-5
SHM-13-01
SHM-05-41A
SHM-05-41B
SHM-93-22B
SB-07-01
SHM-05-41C
SHP-05-47A/B
SHSG-14-01G
SHM-93-22C
SHL-9
PSP-01
SHL-8D/8S
SHL-13
EPA-PZ-2012-7A/B
EPA-PZ-2012-2A/B
SHM-96-5C
EPA-PZ-2012-6A/B
EW-04
SHP-05-45A/B
EPA-PZ-2012-1A/B
EPA-PZ-2012-3A/B
EW-01
SHP-05-46A/B
SHM-10-06A
SHL-23
SHL-21
SHM-10-06
N1-P1
N1-P2
N1-P3
EPA-PZ-2012-4A/B
SHP-05-43
SHP-01-36X
SHM-11-06
SHP-05-44
RSK-30
RSK-35
SHP-01-37X
N2-P1, N2-P2
RSK-34
RSK-33
SHM-11-01
PZ-12-02
PZ-12-01
PZ-12-03
SHM-10-14
SHL-20
SHL-11
RSK-1-7
RSK-16-21
SHM-11-04
SHP-01-38A/B
RSK-49
RSK-32
PZ-12-04
RSK- 8-12,48
N5-P1/N5-P2
RSK-29
N3-P1, N3-P2
SHP-99-29X
SHM-10-13
SHM-11-07
RSK-36-43, 47
RSK-28
RSK-23
SHM-10-15
SHM-11-02
RSK-13-15
PZ-12-06
SHL-4
RSK-27
PZ-12-05
SHM-11-05
RSK-25
RSK-26
SHL-19
SHM-10-07
SHL-10
PZ-12-07
SHM-93-10C
SHM-11-08
SHM-11-03
SHM-93-10D
RSK-24
PZ-12-09
SHM-93-10E
PZ-12-08
PZ-12-10
SHL-14
SHM-10-12
UNKNOWN WELL
SHM-93-01A
SHL-3
N4-P1
N4-P2
N4-P3
SHP-99-01C
SHL-1
SHP-99-35X
SHP-99-01B
SHL-18
SHM-93-18B
N6-P1
SHL-7
SHM-95-27X
SHM-10-11
SHL-15
32M-92-01X
32Z-01-07X
SHM-93-24A
32M-01-13X
N7-P1
N7-P2
SHL-24
SHL-16
32M-01-15X
32Z-01-06X
32M-99-11X
32Z-01-08X
32Z-01-11X
32M-01-14XBR
SHL-17
32M-92-04X
32M-01-14XOB
B204-01
SHL-12
32-4
32M-92-06X
SHL-25
32M-99-09X
32M-01-17X
32-3
32M-01-18X
32M-99-08X
32M-99-10X
POL-1
32Z-01-16X
32M-92-05X
32M-92-07X
B204-02
32Z-01-10X
32Z-99-02X

Legend

- OVERBURDEN MONITORING WELL/PIEZOMETER
- MONITORING WELL - DESTROYED
- GROUNDWATER PROFILING LOCATION/MONITORING WELL
- GROUNDWATER PROFILING LOCATION
- BEDROCK MONITORING WELL
- EXTRACTION WELL
- SOIL BORING
- STREAM GAUGE
- BARRIER WALL
- DISSOLVED ARSENIC >100 (PPB)

NOTE:
1. ARSENIC VALUE SHOWN IN PARENTHESES AFTER MONITORING WELL IDENTIFICATION LABEL (WHERE APPLICABLE).
2. THE MOST CURRENT ARSENIC DATA WAS USED FOR EACH SAMPLING LOCATION.

FIGURE 3 - DOWNGRADIENT ARSENIC LIMIT OF IMPACT PLAN

FORMER FORT DEVENS, AYER, MA

0 150 300 600 900
Feet

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N
S
TOWN OF
AYER
AREA OF LAND USE CONTROLS
PLOW SHOP
POND
SHEPLEY'S HILL
LANDFILL
Legend
Property Boundary (Approx.)
Area of Land Use Controls
FIGURE 4 - AREA OF LAND USE CONTROLS
FORMER FORT DEVENS, AYER, MA
0 150 300 600 900
Feet
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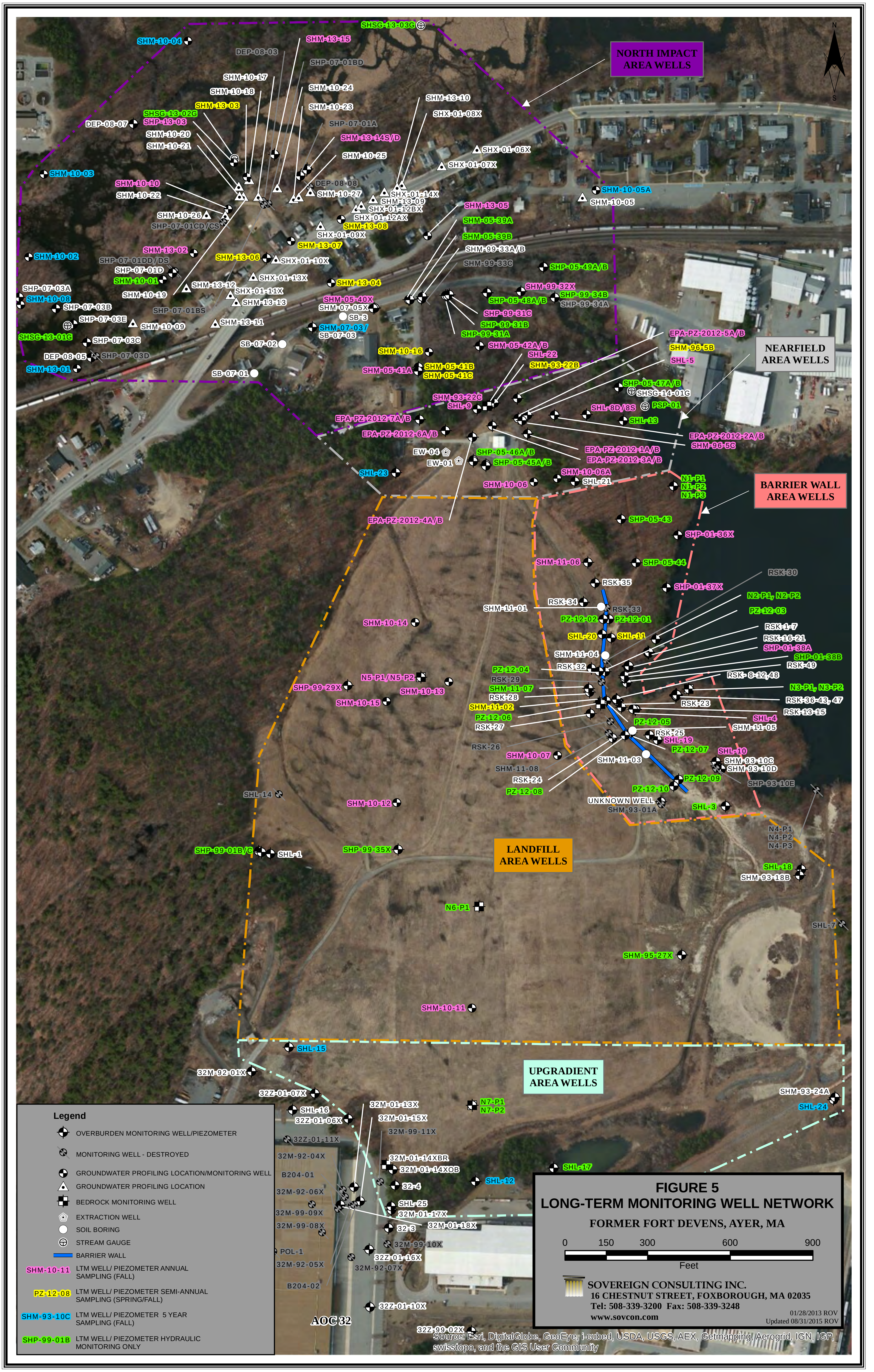

NORTH IMPACT AREA WELLS
NEARFIELD AREA WELLS
BARRIER WALL AREA WELLS
LANDFILL AREA WELLS
UPGRADIENT AREA WELLS
AOC 32
Legend
OVERBURDEN MONITORING WELL/PIEZOMETER
MONITORING WELL - DESTROYED
GROUNDWATER PROFILING LOCATION/MONITORING WELL
GROUNDWATER PROFILING LOCATION
BEDROCK MONITORING WELL
EXTRACTION WELL
SOIL BORING
STREAM GAUGE
BARRIER WALL
SHM-10-11 LTM WELL/ PIEZOMETER ANNUAL SAMPLING (FALL)
PZ-12-08 LTM WELL/ PIEZOMETER SEMI-ANNUAL SAMPLING (SPRING/FALL)
SHM-93-10C LTM WELL/ PIEZOMETER 5 YEAR SAMPLING (FALL)
SHP-99-01B LTM WELL/ PIEZOMETER HYDRAULIC MONITORING ONLY
FIGURE 5
LONG-TERM MONITORING WELL NETWORK
FORMER FORT DEVENS, AYER, MA
0 150 300 600 900
Feet
SOVEREIGN CONSULTING INC.
16 CHESTNUT STREET, FOXBOROUGH, MA 02035
Tel: 508-339-3200 Fax: 508-339-3248
www.sovcon.com
01/28/2013 ROV
Updated 08/31/2015 ROV
Source: Esri, DigitalGlobe, GeoEye, i-cubed, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Tables

Replacement Pages

TABLE 1
LTMMP SAMPLING AND HYDRAULIC MONITORING PROGRAM
Shepley's Hill Landfill, Devens, Massachusetts

Monitoring Interval	Well ID	TOC Elevation (ft msl)	Screen Interval (ft bgs)	Screen Elevation (ft msl)	Interval Description	DQO for Inclusion within the LTMMP
UPGRADIENT AREA						
Every 5 Years	SHL-12	248.67	--	--	Shallow Overburden/WT	Wells upgradient of source are necessary for determining groundwater parameters of what is entering the source zone
	SHL-15	259.93	--	--	Shallow Overburden/WT	Wells upgradient of source are necessary for determining groundwater parameters of what is entering the source zone
	SHL-24	239.6	110.0 - 120.0*	126.7 - 116.7	Deep Overburden	Wells upgradient of source are necessary for determining groundwater parameters of what is entering the source zone
LANDFILL AREA						
Annual	N5-P1	242.62	144.0 - 149.0*	96.39 - 91.39	Bedrock	Well provides the bedrock monitoring within the landfill source area. Sampled historically, use to chart trends in source zone chemistry.
	SHP-99-29X	243.32	19.0 - 29.0	222.38 - 212.38	Shallow Overburden/WT	Similar screen interval and close proximity to N5-P2, however much higher As concentrations. Sampled historically, use to chart trends in source zone chemistry.
	SHM-10-07	246.87	40.0 - 50.0	206.87 - 196.87	Mid-Depth Overburden	Provides an additional sampling point within the Landfill Area, east of historically sampled wells.
	SHM-10-11	263.2	50.0 - 60.0	210.86 - 200.86	Deep Overburden	Wells upgradient of source are necessary for determining groundwater parameters of what is entering the source zone
	SHM-10-12	254.6	45.0 - 55.0	207.02 - 197.02	Mid-Depth Overburden	Provides an additional sampling point within the Landfill Area, south of historically sampled wells.
	SHM-10-13	244.75	60.0 - 70.0	184.75 - 174.75	Deep Overburden	Provides an additional deep sampling point within the Landfill Area, east of historically sampled wells.
	SHM-10-14	237.61	60.0 - 80.0	177.61 - 157.61	Deep Overburden	Provides an additional deep sampling point within the Landfill Area, north of historically sampled wells.
	SHM-10-15	243.76	45.0 - 55.0	198.76 - 188.76	Mid-Depth Overburden	Provides an additional sampling point within the Landfill Area, south and east of historically sampled wells.
BARRIER WALL AREA						
Semi-Annual	SHL-11	235.48	12.0 - 27.0	221.97 - 206.97	Shallow Overburden/WT	Evaluates barrier wall contaminant removal performance. Sampled historically, use to chart trends in source zone chemistry.
	SHL-20	235.96	39.0 - 49.0	195.69 - 185.69	Deep Overburden/Till	Evaluates barrier wall contaminant removal performance. Sampled historically, use to chart trends in source zone chemistry.
	SHM-11-02	240.77	52.0 - 66.0	186.63 - 172.63	Bedrock	Monitors/evaluates possiblility of As migration through bedrock beneath the barrier wall.
Annual	SHL-4	227.54	3.0 - 13.0	222.50 - 212.50	Shallow Overburden/WT	Historically sampled annually, continued annual sampling to monitor As concentrations on downgradient side of barrier wall.
	SHL-10	247.95	24.0 - 39.0	222.58 - 212.58	Shallow Overburden/WT	Historically sampled bi-annually; remains part of LTM plan to monitor As concentrations on the downgradient/southern side of the barrier wall
	SHL-19	240.52	20.0 - 30.0	218.43 - 208.43	Shallow Overburden/WT	Historically sampled annually, continued annual sampling to monitor As concentrations on downgradient side of barrier wall.
	SHM-11-06	236.2	25.0 - 35.0	208.27 - 198-27	Shallow Overburden	Added to annual sampling to monitor As concentrations as groundwater migrates north along the barrier wall
	SHP-01-36X	224.84	3.0 - 8.0	217.10 - 212.10	Shallow Overburden/WT	Historically sampled annually, continued annual sampling to monitor As concentrations along Plow Shop Pond edge.
	SHP-01-37X	222.84	1.0 - 6.0	217.64 - 212.64	Shallow Overburden/WT	Historically sampled annually, continued annual sampling to monitor As concentrations along Plow Shop Pond edge.
	SHP-01-38A	220.9	1.5 - 6.5	217.27 - 212.27	Shallow Overburden/WT	Historically sampled annually, continued annual sampling to monitor As concentrations along Plow Shop Pond edge and downgradient of the barrier wall
NEARFIELD AREA						
Semi-Annual	SHM-93-22B	219.42	82.3 - 92.3	136.62 - 126.63	Mid-Depth Overburden	Sampled historically, to evaluate ATP effectiveness and trends.
	SHM-96-5B	218.95	80.0 - 90.0	137.43 - 127.43	Base of Sand/Till	Sampled historically, to evaluate ATP effectiveness and trends.
Annual	SHL-5	217.62	3.0 - 13.0	213.81 - 203.81	Shallow Overburden/WT	Historically sampled historically to evaluate ATP effectiveness and trends; relatively low detections (<50 ug/L since March 1993) so reduced sampling to annually.
	SHL-8S	220.99	52.0 - 54.0	166.95 - 164.95	Mid-Depth Overburden	Historically sampled semi-annually; no detections since October 2007, so reduced sampling to annually
	SHL-8D*	220.79	68.0 - 70.0	150.95 - 148.95	Deep Overburden	Historically sampled semi-annually; no detections since October 2007, so reduced sampling to annually
	SHL-9	221.99	15.0 - 25.0	205.88 - 195.88	Shallow Overburden/WT	Historically sampled historically to evaluate ATP effectiveness and trends; relatively low detections (<50 ug/L since October 2002) so reduced sampling to annually.
	SHL-22	219.59	105.0 - 115.0	114.06 - 104.06	Deep Overburden	Historically sampled historically to evaluate ATP effectiveness and trends; relatively low detections (<100 ug/L since October 2008) so reduced sampling to annually.
	SHM-93-22C	220.7	124.3 - 134.3	94.72 - 84.72	Bedrock	Historically sampled historically to evaluate ATP effectiveness and trends; relatively low detections (<100 ug/L since installation in 1993) so reduced sampling to annually.
	SHM-96-5C	218.4	50.0 - 60.0	167.41 - 157.41	Mid-Depth Overburden	Historically sampled historically to evaluate ATP effectiveness and trends; relatively low detections (<70 ug/L since October 2001) so reduced sampling to annually.
	SHM-10-06	232.91	69.5 - 79.5	160.49 - 150.49	Deep Overburden	Added to annual sampling to provide an additional monitoring point along the eastern edge of the landfill.
	SHM-10-06A	248.55	77.0 - 87.0	169.0 - 159.0	Deep Overburden	Added to annual sampling to replace SHL-21. SHM-10-06A has a deeper screen interval and higher As concentrations as compared to SHL-21.
	EPA-PZ-2012-1A/B	222.75 / 222.50	20.0 - 25.0 / 70.0 - 75.0	202.75 - 197.75 / 152.50 - 147.50	Shallow/Deep Overburden	Provides an additional shallow/deep sampling point in the nearfield area, east of the treatment plant.
	EPA-PZ-2012-2A/B	222.34 / 222.32	20.0 - 25.0 / 75.0 - 80.0	202.34 - 197.34 / 147.32 - 142.32	Shallow/Deep Overburden	Provides an additional shallow/deep sampling point in the nearfield area, northeast of the treatment plant.
	EPA-PZ-2012-3A/B	222.60 / 222.51	20.0 - 25.0 / 70.0 - 75.0	202.60 - 197.60 / 152.51 - 147.51	Shallow/Deep Overburden	Provides an additional shallow/deep sampling point in the nearfield area, north of the treatment plant.
	EPA-PZ-2012-4A/B	226.54 / 226.34	20.0 - 25.0 / 70.0 - 75.0	206.54 - 201.54 / 156.34 - 151.34	Shallow/Deep Overburden	Provides an additional shallow/deep sampling point in the nearfield area, north of the treatment plant.
	EPA-PZ-2012-5A/B	218.91 / 218.31	20.0 - 25.0 / 80.0 - 85.0	198.91 - 193.91 / 138.31 - 133.31	Shallow/Deep Overburden	Provides an additional shallow/deep sampling point in the nearfield area, west of the treatment plant.
	EPA-PZ-2012-6A/B	234.21 / 234.03	25.0 - 30.0 / 75.0 - 80.0	209.21 - 204.21 / 159.03 - 154.03	Shallow/Deep Overburden	Provides an additional shallow/deep sampling point in the nearfield area, west of the treatment plant.
	EPA-PZ-2012-7A/B	234.08 / 233.92	25.0 - 30.0 / 60.0 - 65.0	209.08 - 204.08 / 173.92 - 168.92	Shallow/Mid-Depth Overburden	Provides an additional shallow/deep sampling point in the nearfield area, west of the treatment plant.
Every 5 Years	SHL-23	241.26	23.0 - 33.0	216.36 - 206.36	Shallow Overburden/WT	Historically sampled bi-annually to monitor/evaluate possible western migration route downgradient of source area
NORTH IMPACT AREA						
Semi-Annual	SHM-05-41B	222.3	62.0 - 64.0	160.6 - 158.6	Mid-Depth Overburden	Sampled historically, to evaluate ATP effectiveness and trends.
	SHM-05-41C	222.56	88.0 - 93.0	134.94 - 129.94	Deep Overburden/Till	Sampled historically, to evaluate ATP effectiveness and trends.
	SHM-10-16	219.24	75.0 - 85.0	144.24 - 134.24	Deep Overburden	Added to annual sampling to provide an additional monitoring point northwest of the treatment plant.
	SHM-13-03	211.7	42.0 - 52.0	167.83 - 157.83	Deep Overburden	Monitors the leading/northern edge of the As impacted groundwater
	SHM-13-04	227.01	20.0 - 30.0	207.01 - 197.01	Shallow Overburden	Monitors As concentrations within the core of the As impacted groundwater
	SHM-13-06	223.89	36.0 - 46.0	188.23 - 178.23	Deep Overburden/Till	Monitors As concentrations within the core of the As impacted groundwater
	SHM-13-07	225.61	27.0 - 37.0	198.61 - 188.61	Mid-Depth Overburden	Monitors As concentrations within the core of the As impacted groundwater
	SHM-13-08	227.9	55.0 - 65.0	173.17 - 163.17	Mid-Depth Overburden/Till	Monitors As concentrations within the core of the As impacted groundwater
Annual	SHM-05-40X	223.34	32.0 - 34.0	191.55 - 189.99	Mid-Depth Overburden/Till	Sampled historically annually. Monitors As concentrations within the core of arsenic impacted groundwater.
	SHM-05-41A	222.45	42.0 - 44.0	180.78 - 178.78	Shallow Overburden	Historically sampled historically to evaluate ATP effectiveness and trends; relatively low detections (<50 ug/L since September 2006) so reduced sampling to
	SHM-05-42A	216.84	40.0 - 42.0	173.66 - 171.66	Shallow Overburden	Historically sampled historically to evaluate ATP effectiveness and trends; relatively low detections (<5 ug/L since installation in 2005) so reduced sampling
	SHM-05-42B	216.82	70.0 - 72.0	143.66 - 141.66	Deep Overburden	Historically sampled historically to evaluate ATP effectiveness and trends; relatively low detections (<300 ug/L since April 2008) so reduced sampling to
	SHP-99-31C	214.72	68.0 - 78.0	141.97 - 131.97	Deep Overburden	Sampled historically annually. Monitors As concentrations within the core of As impacted groundwater at depth.
	SHM-13-05	225.11	75.0 - 85.0	150.57 - 140.57	Deep Overburden	Monitors eastern boundary of As impacted groundwater
	SHM-99-32X	221.37	72.0 - 82.0	147.07 - 137.07	Deep Overburden	Sampled historically annually. Monitors As concentrations within the core of As impacted groundwater.
	SHM-10-10	217.12	56.0 - 66.0	159.43 - 149.43	Deep Overburden/Till	Monitors the northern edge of the As impacted groundwater.
	SHM-13-02	218.7	60.0 - 70.0	156.88 - 146.88	Deep Overburden	Monitors the northern edge of the As impacted groundwater.
	SHM-13-14S	211.02	5.0 - 15.0	203.01 - 193.01	Shallow Overburden	Monitors As concentrations within 10 to 20 feet of Nonacoicus Brook
	SHM-13-14D	210.7	45.0 - 55.0	162.94 - 152.94	Deep Overburden	Monitors the northern edge of the As impacted groundwater.
	SHM-13-15	210.55	50.0 - 60.0	157.67 - 147.67	Deep Overburden	Monitors the northern edge of the As impacted groundwater.
	SHP-13-03	--	4.0 - 6.0	--	Shallow Overburden	Monitors As concentrations within 10 to 20 feet of Nonacoicus Brook
Every 5 Years	SHM-07-03	227.86	25.0 - 35.0	203.01 - 193.01	Shallow Overburden	Added sample location to monitor/evaluate possible western migration route.
	SHM-10-05A	235.07	50.0 - 60.0	185.24 - 175.24	Mid-Depth Overburden	Added sample location to monitor/evaluate the eastern extent of the NIA.
	SHM-13-01	208.07	39.0 - 49.0	166.79 - 156.79	Deep Overburden	Added sample location to monitor/evaluate the western extent of the NIA.
	SHM-10-02	223.07	53.0 - 63.0	167.12 - 157.12	Mid-Depth Overburden	Added sample location to monitor/evaluate the western extent of the NIA.
	SHM-10-03	232.06	58.5 - 68.5	171.2 - 161.2	Mid-Depth Overburden	Added sample location to monitor/evaluate the northern extent of the NIA.
	SHM-10-04	212.63	55.0 - 65.0	154.73 - 144.73	Mid-Depth Overburden	Added sample location to monitor/evaluate the northern extent of the NIA.
	SHM-10-08	214.41	46.0 - 56.0	165.68 - 155.68	Deep Overburden/Till	Added sample location to monitor/evaluate the western extent of the NIA.

Semi-Annual Samping (Spring and Fall)
Annual Sampling (Fall)
Sampling Every 5 Years (Fall)

Notes:
ft bgs = feet below ground surface
ft msl = feet mean sea level
* Includes estimated values derived from Supplemental Groundwater Investigation (Harding ESE, 2003).
Adapted from Final Revised Long Term Monitoring and Maintenance Plan (CH2MHill, 2007).

TABLE 2
LTMMP HYDRAULIC MONITORING ONLY
Shepley's Hill Landfill, Devens, Massachusetts

Monitoring Interval	Well ID	TOC Elevation	Screen Interval	Screen Elevation	Interval Description	DQO for Inclusion within the LTMMP
Upgradient Area						
Annual	SHL-17	233.83	--	--	Shallow Overburden/WT	Provides an additional hydraulic monitoring point upgradient of the landfill
LANDFILL AREA						
Annual	N5-P2	242.67	20.0 - 25.0*	220.39 - 215.39	Shallow Overburden/WT	Historically sampled annually, reduced to hydraulic monitoring only due to close proximity to N5-P1, SHM-10-13, SHM-10-14, and SHM-10-15.
	N7-P1	255.6	65.0 - 69.0*	188.51 - 183.51	Bedrock	Historically used for hydraulic monitoring purposes.
	N7-P2	256.07	29.0 - 35.0*	224.51 - 218.51	Shallow Overburden/WT	Historically used for hydraulic monitoring purposes.
	SHP-95-27X	237.46	--	--	Shallow Overburden/WT	Historically used for hydraulic monitoring purposes.
	SHL-18	237.56	--	--	Shallow Overburden/WT	Historically used for hydraulic monitoring purposes.
	N6-P1	258.46	84.0 - 88.0*	171.78 - 167.78	Bedrock	Historically used for hydraulic monitoring purposes.
	SHP-99-01C	273.56	19.7 - 29.7	254.66 - 244.66	Bedrock	Provides an additional hydraulic monitoring point on the western side of the landfill
	SHP-99-35X	257.5	30.2 - 40.2	225.99 - 215.99	Shallow Overburden/WT	Historically used for hydraulic monitoring purposes.
BARRIER WALL AREA						
Semi-Annual	PZ-12-01	237.55	24.0 - 34.0	209.78 - 199.78	Shallow Overburden/WT	Hydraulic monitoring of groundwater east of the barrier wall
	PZ-12-02	237.81	24.0 - 34.0	209.68 - 199.68	Shallow Overburden/WT	Hydraulic monitoring of groundwater west of the barrier wall
	PZ-12-03	236.42	22.0 - 32.0	210.76 - 200.76	Shallow Overburden/WT	Hydraulic monitoring of groundwater east of the barrier wall
	PZ-12-04	238.22	22.0 - 32.0	212.97 - 202.97	Shallow Overburden/WT	Hydraulic monitoring of groundwater west of the barrier wall
	PZ-12-05	238.81	26.0 - 36.0	210.05 - 200.05	Mid-Depth Overburden	Hydraulic monitoring of groundwater east of the barrier wall
	PZ-12-06	242.24	26.0 - 36.0	212.35 - 202.35	Mid-Depth Overburden	Hydraulic monitoring of groundwater west of the barrier wall
	PZ-12-07	244.63	18.0 - 28.0	222.79 - 212.79	Mid-Depth Overburden	Hydraulic monitoring of groundwater east of the barrier wall
	PZ-12-08	244.88	18.0 - 28.0	223.70 - 213.70	Mid-Depth Overburden	Hydraulic monitoring of groundwater west of the barrier wall
	PZ-12-09	241.94	22.0 - 32.0	216.26 - 206.26	Shallow Overburden/WT	Hydraulic monitoring of groundwater east of the barrier wall
	PZ-12-10	242.29	22.0 - 32.0	216.83 - 206.84	Shallow Overburden/WT	Hydraulic monitoring of groundwater west of the barrier wall
Annual	N1-P1	230.01	--	--	Deep Overburden	Historically used for hydraulic monitoring purposes.
	N1-P2	230.03	--	--	Mid-Depth Overburden	Historically used for hydraulic monitoring purposes.
	N1-P3	230.18	--	--	Shallow Overburden/WT	Historically used for hydraulic monitoring purposes.
	N2-P1	222.16	--	--	Deep Overburden	Historically used for hydraulic monitoring purposes.
	N2-P2	222.0	--	--	Mid-Depth Overburden	Historically used for hydraulic monitoring purposes.
	N3-P1	220.86	33.0 - 35.0*	185.73 - 183.73	Bedrock	Historically used for hydraulic monitoring purposes.
	N3-P2	242.67	4.0 - 9.0*	214.73 - 209.73	Water Table	Historically used for hydraulic monitoring purposes.
	SHL-3	246.89	24 - 34	222.89 - 212.89	Mid-Depth Overburden	Historically used for hydraulic monitoring purposes.
	SHP-01-38B	221.06	18.0 - 23.0	200.87 - 195.87	Deep Overburden	Historically used for hydraulic monitoring purposes.
	SHP-05-43	260.66	50.5 - 60.5	207.83 - 197.83	Shallow Overburden	Historically used for hydraulic monitoring purposes.
	SHP-05-44	258.08	51.0 - 61.0	207.79 - 197.49	Mid-Depth Overburden	Historically used for hydraulic monitoring purposes.
	SHM-11-07	240.86	41.0 - 46.0	197.19	Mid-Depth Overburden/Till	Hydraulic monitoring of groundwater upgradient and slightly removed from the barrier wall
NEARFIELD AREA						
Annual	SHL-13	220.71	5.0 - 20.0	213.47 - 198.47	Shallow Overburden/WT	Historically sampled annually, reduced to hydraulic monitoring only due to As concentrations less than 5 ppb since sampling initiated in 2006. Also close proximity to SHL-8S/D, which is sampled annually and exhibited As concentrations below detection limits since October 2007
	SHP-05-45A	228.47	20.0 - 25.0	206.33 - 201.33	Shallow Overburden	Historically used for hydraulic monitoring purposes.
	SHP-05-45B	229.1	65.0 - 75.0	161.73 - 151.73	Mid-Depth Overburden	Historically used for hydraulic monitoring purposes.
	SHP-05-46A	227.63	20.0 - 25.0	206.1 - 201.1	Shallow Overburden	Historically used for hydraulic monitoring purposes.
	SHP-05-46B	228.22	65.0 - 75.0	161.35 - 151.35	Mid-Depth Overburden	Historically used for hydraulic monitoring purposes.
	SHP-05-47A	217.53	1.0 - 2.0	212.5 - 211.5	Water Table	Historically used for hydraulic monitoring purposes.
	SHP-05-47B	215.4	3.0 - 4.0	210.47 - 209.47	Water Table	Historically used for hydraulic monitoring purposes.
NORTH IMPACT AREA						
Annual	SHP-05-48A	217.3	1.0 - 2.0	212.09 - 211.09	Water Table	Historically used for hydraulic monitoring purposes.
	SHP-05-48B	215.93	2.0 - 3.0	211.03 - 210.03	Water Table	Historically used for hydraulic monitoring purposes.
	SHP-05-49A	216.67	1.0 - 2.0	211.26 - 210.26	Water Table	Historically used for hydraulic monitoring purposes.
	SHP-05-49B	215.15	2.5 - 3.5	210.66 - 209.66	Water Table	Historically used for hydraulic monitoring purposes.
	SHM-05-39A	221.54	37.0 - 39.0	184.79 - 182.79	Mid-Depth Overburden	Historically sampled annually, reduced to hydraulic monitoring only due to close proximity to SHM-05-40X and SHM-99-31C. Newly installed wells SHM-13-.05 are located downgradient of this sampling location have been added to the sampling plan
	SHM-05-39B	221.52	66.0 - 68.0	155.78 - 153.78	Deep Overburden	Historically sampled annually, reduced to hydraulic monitoring only due to close proximity to SHM-05-40X and SHM-99-31C. Newly installed wells SHM-13-05 are located downgradient of this sampling location have been added to the sampling plan
	SHP-99-31A	214.35	4.0 - 14.0	208.76 - 198.76	Shallow Overburden/WT	Historically sampled annually, reduced to hydraulic monitoring only due to shallow well construction. Higher As concentrations have been historically detected within the deepest well of the triplet (SHP-99-31C)
	SHP-99-31B	214.4	50.0 - 60.0	162.44 - 152.44	Mid-Depth Overburden	Historically sampled annually, reduced to hydraulic monitoring only due to mid-depth well construction. Higher As concentrations have been historically detected within the deepest well of the triplet (SHP-99-31C)
	SHP-99-34 B	224.58	74.5 - 79.5	148.0 - 143.0	Deep Overburden	Historically used for hydraulic monitoring purposes.
	SHM-10-01	209.52	60.5 - 70.5	146.14 - 136.14	Deep Overburden/Till	Added to provide an additional hydraulic monitoring point along the western portion of the NIA
SURFACE WATER						
Annual	PSP-01	218.16	--	--	Staff Gauge	Historically used for monitoring surface water elevations within Plow Shop Pond.
	SHSG-13-01G	208.29	--	--	Staff Gauge	Added to monitor surface water elevations within Nonacoicus Brook and to aid in hydraulic modeling
	SHSG-13-02G	211.67	--	--	Staff Gauge	Added to monitor surface water elevations within Nonacoicus Brook and to aid in hydraulic modeling
	SHSG-13-03G	211.07	--	--	Staff Gauge	Added to monitor surface water elevations within Nonacoicus Brook and to aid in hydraulic modeling

Semi-Annual Hydraulics Only
Annual Hydraulics Only

Notes:
ft bgl = feet below ground level
ft msl = feet mean sea level
All wells included in the SHL LTM sampling program are to be gauged at minimum annually in addition to those wells listed above.
* Includes estimated values derived from Supplemental Groundwater Investigation (Harding ESE, 2003).
Adapted from Final Revised Long Term Monitoring and Maintenance Plan (CH2MHill, 2007).
During five-year review periods, hydraulic monitoring will be preformed semi-annually for all wells.

TABLE 3
GROUNDWATER SAMPLE ANALYTICAL PROGRAM
Shepley's Hill Landfill, Devens, Massachusetts

Analytical Parameters	Analytical Method
Dissolved Arsenic	**EPA 6020A**
Dissolved Metals Iron Manganese	**EPA 6010C**
Alkalinity	**SM2320B**
Chloride	**SM4500CL C**
Sulfate	**EPA 300**
Dissolved Organic Carbon	**SM5310B**
Field Parameters pH Temperature Specific Conductance Dissolved Oxygen Oxygen Reduction Potential VOCs (headspace)	**Field Instruments**

TABLE 4
WELL AND PIEZOMETER ABANDONMENT LIST
Shepley's Hill Landfill, Devens, Massachusetts

Well ID	Screen Depth	General Location	Rationale for Abandonment
SHL-1	Unknown	West side of landfill on ridge	Well obstructed
SHM-93-10D	Unknown	Between barrier wall and pond	This well was thought to be abandoned but still has water in it
SHM-99-33A/B	Unknown	South portion of NIA, in road	Located near SHM-05-39A/B, which are used for hydraulic monitoring, and SHM-99-31C, which is monitored annually
SHP-07-01BS	Unknown	Central portion of the NIA	This piezometer has not been observed in the field. If located, it will be abandoned due to its location between SHM-13-03 and SHM-13-07.
SHP-07-01BD	Unknown	Central portion of the NIA	This piezometer has not been observed in the field. If located, it will be abandoned due to its location between SHM-13-03 and SHM-13-07.

Appendix I

New Sheets

Response to 24 June 2015 EPA Comments on
ARMY'S 12/31/14 RESPONSE TO COMMENTS PACKAGE AND
DRAFT FINAL LTMMP UPDATE
SHEPLEY HILL LANDFILL
Former Fort Devens Army Installation
April 2015

Response to Comments

Comment 1 - EPA General Comment #2 - Despite the Army's continued trepidation, EPA remains confident that the establishment of a site-specific background/baseline concentration for arsenic, derived from statistical analysis of existing monitoring locations with datasets supported from historical or on-going sampling programs, should be developed and considered in the development of a long-term remediation strategy. The proposed path forward provides the most direct way to derive site-specific cleanup target that considers all potential arsenic sources and contributors, including, but not limited to those identified in Army's December 2014 response to comment package.

Response: *As stated in the Army's December 2014 response to comments package, the Army believes that although the establishment of a local background arsenic concentration for the site is appropriate, it will be of limited value since existing data indicates that such a background arsenic concentration is still likely unattainable. However, the Army will continue to discuss the value of establishing a site-specific background concentration for arsenic at future BCT meetings and through future submittals.*

Comment 2 - Page 6, Section 2.2, Conceptual Model – For reasons previously stated, EPA disagrees with the Army's CSM for SHL as presented in the draft final LTMMP Update. While EPA is willing to discuss the development of a revised, overarching CSM that considers both EPA's and Army's positions regarding arsenic sources, it has not and will not agree to the CSM presented in this document. With that being said, EPA disagrees that issues related to the CSM must first be resolved prior to proceeding with the development of a long-term remediation strategy and hopes that the Army will continue to explore a path forward for the SHL that is amenable to Army, MassDEP and EPA.

Response: *The CSM presented in the LTMMP is based upon many years of data and studies performed by both the Army and EPA. This data and the supporting geochemical processes have confirmed that the predominant source of dissolved arsenic is naturally occurring within bedrock and aquifer sands. The Army cannot ignore the well-established data and scientific facts that form the basis for the CSM.*

A CSM is the basic supporting foundation of any site remedy. Therefore, the Army cannot proceed with the development of a long-term remediation strategy until a consensus on the CSM is reached.

Comment 3 - <u>Page 17, Section 3.1.2, DQO for Groundwater Remedy, Step 2</u> – As stated in EPA's September 29, 2014, comment letter on the draft LTMMP Update, caution should be used when placing emphasis on "redox conditions" as the primary factor governing arsenic concentrations within different parts of the aquifer. EPA requested that the decision statement be revisited to account for the potential decline in arsenic concentrations in the absence of changes in "geochemical parameters" that might be used as indicators of redox conditions. Specifically, the DQO should incorporate the evaluation of analytical parameters listed in Table 3 of the draft LTMMP (i.e. arsenic, iron, manganese, alkalinity, chloride, sulfate and DO), which will likely provide the most critical context for understanding trends in arsenic concentrations.

<u>Response</u>: *As stated in the Army's December 2014 response to comments package, there is conclusive evidence that the mechanisms for arsenic release and transport are complex geochemically, and source strength studies at the landfill suggest a significant continuing geochemical driver (anaerobic conditions and carbon sources) for the dissolution of arsenic. Consequently, the evaluation of changes in the geochemical parameters within the capture zone that indicate a shift in overall redox conditions is appropriate as one of many factors indicating the performance of the groundwater remedy. However, it should be noted that the evaluation geochemical parameters is but one of several lines of evidence that will be evaluated and that remedy performance conclusions will not be drawn from the analysis of trends in geochemical parameters alone.*

Lastly, the Army agrees to incorporate the analytical parameters listed in Table 3 of the draft final LTMMP update as part of its overall evaluation of the groundwater remedy. Consequently, Section 3.1.2 Step 2 has been revised as appropriate.

Comment 4 – <u>Section 3.1.2 - DQOs for Groundwater Remedy, DQO Step 4</u>: By reference to Figure 4 and Table 2, it appears that the following wells/piezometers will be sampled for groundwater chemistry in the North Impact Area (NIA): SHP-99-31C, SHM-99-32X, SHM-05-40X, SHM-10-10, SHM-13-02, SHM-13-03, SHM-13-04, SHM-13-05, SHM-13-06, SHM-13-07, SHM-13-08, SHM-13-14S, SHM-13-14D and SHM-13-15. Of this list, three wells/piezometers currently have periods of record that satisfy the 10-20 year requirement (SHP-99-31C, SHM-99-32X, SHM-05-40X). The remaining wells will be unable to meet this requirement within the period of the next 5-year review. Given the current rate of groundwater flow projected in the NIA, along with recent upgrades to the extraction system, it is recommended that a trend analysis be conducted as part of the next 5-year review. As part of this analysis, it is recommended that data from additional wells within the "Nearfield Area" also be analyzed, since many of these monitoring locations have a period of record that will meet the 10-20 year requirement.

<u>Response</u>: *Section 3.1.2, DQO Step 4 has been revised to include statistical analysis of data from nearfield and landfill area wells as well as the inclusion of trend analysis as part of the annual reports and the next 5-year review. In addition, the 10 to 20 years of data requirement for the statistical analysis of each data point has been removed from the document. All data sets will be evaluated annually.*

Comment 5 - Page 19, Section 3.1.2 DQOs for Groundwater Remedy, DQO Step 5 – While EPA is willing to "re-evaluate" the effectiveness of the ATP remedy component, for reasons outlined in its September 29, 2014, comment letter, it cannot agree to the decision rule regarding the adequacy of long-term monitoring of the NIA nor the "remedy performance matrices" discussed in this section. As discussed at recent BCT meetings, the goal of the SHL LTMMP Update should be to provide details on a revised monitoring program to effectively evaluate the performance of all remedial system components, and not to establish criteria for ATP shutdown or to determine whether restoration of the aquifer to beneficial use is practicable. The RAOs (and cleanup goals) set forth in the 1995 ROD are still relevant and must be the focus of the LTMMP for the SHL. While the last sentence in the first full paragraph states that "The goal of this monitoring is to estimate the length of time required for ATP remedy operation…", the first sentence in the following paragraph seems to contradict this approach by referencing "an additional five year period of operation under this LTMMP Update".

Response: *The Army agrees that the RAOs set forth in the 1995 ROD are still relevant. Consequently, these RAOs and a summary of remedy components as they relate to the RAOs were included as Sections 1.3 and 1.4 of the LTMMP Update. However, the Army disagrees that there is a disconnect between the RAOs set forth in the 1995 ROD and the decision rules outlined in Section 3.1.2, Step 5. Regarding the final sentence of the first full paragraph under Section 3.1.2, DQO Step 5, this sentence has been removed due to the contradiction of approach with the subsequent paragraph.*

It is unclear why the Army continues to pursue the development of DQOs and performance metrics for the ATP as part of the LTMMP Update, if it concurs with the EPA's position that the current SHL remedy (i.e., extraction and treatment of arsenic contaminated groundwater) is inadequate for purposes of achieving the RAOs and cleanup levels set forth in the 1995 SHL ROD, as stated in the December 31, 2014 response to comment cover letter. Unless the Army can agree to amend this discussion, specifically as it relates to time limits associated with the "sufficient collection of data for statistical analysis" (i.e. five years) and the "adequacy" of long-term monitoring within the landfill, nearfield and NIA areas, then EPA cannot concur with the draft final document.

Response: *The EPA position regarding the remedy being "inadequate" is vague and at odds with prior EPA comments that the remedy can achieve groundwater cleanup goals over time suggesting that the ATP would work if operations were modified. The Army's interpretation of the 1995 SHL remedy as "inadequate" is that the P&T technology cannot achieve groundwater cleanup goals within a reasonable timeframe. This position is based on the CSM and multiple studies/alternate remedy assessments. It is clear from the record that EPA and MassDEP have rejected both the CSM and efforts to update the remedy in favor of the current pump and treat system. Therefore, the Army will continue to collect data as prescribed in the LTMMP and evaluate this data within the DQO framework and the* Groundwater Remedy Completion Strategy *guidance to evaluate remedy performance. The Army will not operate the SHL remedy* *without performing periodic assessments on remedy effectiveness and its ability to achieve stated goals in the ROD.*

Regarding the timeframe for the evaluation of the long term performance of the extraction system, Section 3.1.2 has been revised to remove 5-year timeframe. Performance evaluation will proceed as part of the annual reporting process.

With that being said, EPA has the following comments and questions with regards to the existing text:

- Clarification should be provided as to which monitoring locations will be used to verify that "groundwater within 10 to 20 feet of the surface water of Nonacoicus Brook" is not impacted by the groundwater plume. Since many of the well screens for monitoring locations in the NIA are positioned at greater depths than stated in this decision criterion, it is recommended that details be provided on monitoring locations that will be used to support this decision and the type of data analysis that will be conducted if well/piezometer screens are only available for depths greater than the "10 to 20 feet" criterion.

<u>Response</u>: *Monitoring locations SHP-13-03, which is a piezometer located near stream gauge SHSG-13-02G and north of monitoring well SHM-13-03, and SHM-13-14S will be used to monitor groundwater at the northern extent of the impacted area within 10 to 20 feet of the brook. The screen intervals of SHP-13-03 and SHM-13-14S are 4 to 6 and 5 to 15 feet below grade, respectively. Section 3.1.2 and Table 1 have been revised accordingly.*

- <u>Section 3.1.2 - DQOs for Groundwater Remedy, DQO Step 5</u>: Use of statistical trend analysis of groundwater chemistry data as a function of time from start of the ATP system is a reasonable performance metric. However, establishment of the significance of trends or changes in groundwater chemistry data is dependent on the type of statistical test employed. It is recommended that more detail be provided for the trend testing procedure that will be implemented. As a point of reference, the 2009 Unified Guidance (EPA 530/R-09-007; Section 17.3) suggests use of parametric or non-parametric trend tests such as linear regression, the Mann-Kendall Test, or the Theil-Sen Trend Line.

<u>Response</u>: *The testing procedure that will be implemented is the Mann-Kendall Test as calculated using the latest version of ProUCL software. Section 3.1.2, DQO Step 5 will be updated as appropriate.*

Comment 6 – <u>DQOs for Barrier Wall Monitoring, DQO Step 2</u>: The first bullet under Step 3 for this data quality objective indicates that a hydraulic head differential across the wall will be the primary indicator of barrier wall effectiveness. A decrease in hydraulic head across the wall is not a sufficient indicator of wall effectiveness. In this area, a decrease in hydraulic head existed prior to wall construction. Therefore, a more definitive indicator of hydraulic performance should be used. One possible approach would be to compare the hydraulic head differential in the area before and after wall installation. However, this comparison would be challenging to implement west of the wall due to the configuration of the monitoring network in this area prior to wall construction. In Figure 1, the hydraulic gradient vector (i.e., direction and magnitude of groundwater flow) was calculated in one area west of the barrier wall using a simple three-point problem approach and groundwater elevations measured in wells on April 27, 2010, prior to wall installation (red arrow) and on April 15, 2015, after wall installation (green arrow). In this case, the groundwater flow direction on April 27, 2010, was toward the pond and on April 15, 2015, after wall installation, was north northwest and no longer toward the pond.

Another method of demonstrating ongoing barrier wall performance would be to calculate the hydraulic gradient on the west side of the wall and on the east side of the wall each time water levels are monitored. Hydraulic gradient vectors could then be calculated using simple three-point analyses to estimate groundwater flow direction and magnitude both east and west of the wall. This concept is illustrated in Figure 2 and discussed in detail in Beljin et al. (2014). A copy of this report is attached for your information.

In Figure 2, each triangle is formed using the available monitoring wells and piezometers as vertices. Groundwater elevations measured at these monitoring points on April 15, 2015, were used to calculate the direction and magnitude of the hydraulic gradient in each triangle. Orange triangles utilize wells located west and north of the barrier wall. Yellow triangles utilize wells located east of the wall. As indicated in this figure, the groundwater flow directions in the area immediately west of the wall were toward the north/northwest, in contrast to the period preceding wall installation where flow direction was predominantly towards Red Cove.

Response: In addition to hydraulic head differential across the wall, the hydraulic gradient on the west side of the wall and on the east side of the wall will be calculated as the primary indicator of barrier wall effectiveness. Section 3.1.3, DQO Step 3 will be revised as appropriate.

Comment 7 – Section 3.1.3 - DQOs for Barrier Wall Monitoring, DQO Step 3: The second bullet under Step 3 of this DQO indicates that a reduction in arsenic concentrations in groundwater on the eastern side of the wall as compared to the western side of the wall would be evidence of the effectiveness of the barrier. Given that the wall appears to be a significant hydraulic barrier to groundwater flow, it is recommended that the evaluation of arsenic flux reduction to Red Cove concentrate on data from the east side of the wall to document the reduction in flux through time.

Response: DQO Step 3 will be revised to specify that an evaluation of arsenic flux reduction to Red Cove will be based primarily on data from the east side of the barrier wall to document the reduction in flux through time.

Comment 8 – Section 3.1.3 - DQOs for Barrier Wall Monitoring, DQO Step 5: The decision rule proposed in the first bullet is based entirely on a decrease in hydraulic head and arsenic concentration across the barrier wall from west to east. As noted in the previous comments, such decreases are not definitive measures of wall performance in this situation. It is recommended that other lines of evidence, such as comparisons of hydraulic gradients east and west of the wall, comparison of current conditions with those prior to wall construction, and the continued monitoring of arsenic flux east of the wall be emphasized.

Response: Section 3.1.3, DQO Step 5 has been revised to emphasize other lines of evidence in addition to hydraulic head differential across the barrier wall when determining barrier wall effectiveness.

Comment 9 – Section 3.2.2 and Table 4: Twelve monitoring points are proposed for abandonment. Given the continued discussions regarding the characterization of background values for arsenic in groundwater, construction/calibration of the groundwater flow model, determination of barrier wall effectiveness, and the role of bedrock in the hydrologic/geochemical system, it is recommended that the abandonment of several of these wells/piezometers be delayed until these issues are resolved. The specific locations from which data could potentially be useful during this interim period are SHP-99-01B, SHM-93-24A, SHM-93-18B, SHL-21, SHM-07-05X ("SHM-07-05" in AMEC Draft Report SHL-0124, December 2008), and "Unknown well" (which appears to be SHM-93-01A).

Response: The abandonment of monitoring wells SHP-99-01B, SHM-93-24A, SHM-93-18B, SHL-21, SHM-07-05X, and "Unknown well" (SHM-93-01A) will be delayed, and these wells will be removed from Table 4.

Response to 08 May 2015 MassDEP Comments on
DRAFT FINAL LTMMP UPDATE
SHEPLEY HILL LANDFILL
Former Fort Devens Army Installation
April 2015

Response to Comments

Comment 1 – Sections 2.2 and 2.4: For the reasons outlined in comments on the draft document, MassDEP has not accepted the Army's conceptual site model. The Army's subsequent response to comments (Appendix I of the revised draft) did not change this position. During the February 19, 2015 BCT meeting, EPA expressed a similar position and recommended that that BCT members agree to disagree about the conceptual site model and refocus efforts on modifying the remedy or implementing an alternative remedy that can lead to a permanent solution for the site. MassDEP agrees, and therefore will not comment further here on the conceptual site model.

Response: Comment noted.

Comment 2 - Section 3.3.1: In accordance with the state solid waste regulations, the performance of the landfill cover system should also be evaluated by comparing the analytical results from groundwater samples collected from a downgradient compliance point established within 150 meters of the landfill perimeter to applicable groundwater standards (310 CMR 19.132).

Response: Media sampling at SHL is conducted in accordance with the existing LTMMP and its addendum which were previously reviewed and approved by the MassDEP in 2007 and 2009, respectively. The sampling rationale detailed in the LTMMP Update is consistent with these previous documents and agreements.

Comment 3 - Section 3.3.2: In accordance with the ROD, the performance of the groundwater extraction system should be evaluated by comparing the analytical results from downgradient groundwater samples to the remedial goals established in the ROD (as subsequently updated).

Response: According to the May 2014 EPA Groundwater Remedy Completion Strategy guidance document, performance metrics should include remedy performance criteria, contaminant concentration trends and hydrogeologic parameters used to evaluate the remedy performance and measure progress. As stated in the LTMMP Update, the performance metrics for the groundwater remedy are statistically significant decreases or changes in dissolved arsenic and geochemical concentrations in groundwater within and downgradient of the ATP capture zone to determine if the remedy is having a beneficial impact sufficient to meet MCLs throughout the NIA area of attainment within a reasonable timeframe. Therefore, analytical results from *downgradient groundwater samples will be compared to remedial goals established in the ROD as part of the remedy performance evaluation process. Consequently, DQO Step 5 of the groundwater remedy will be revised for clarity.*

Comment 4 – Section 3.3.2: The rationale for deferring an evaluation of the long-term performance of the extraction system for 5 years is not apparent. The results from nearly 10 years of extraction system operation, the relatively high groundwater velocities downgradient of the landfill, and the reasonable possibility that a significant portion of the dissolved arsenic migrating from the site by-passes the extraction system (refer to MassDEP Comment 2 on the draft document) indicate that the system is not performing as expected. Unless there is sound justification for deferring a decision about the effectiveness of the extraction system, the Army should proceed with the performance evaluation.

Response: *As stated in the Army's response to MassDEP Comment 2 on the draft document, the Army disagrees with the MassDEP's assessment of the flowpaths and concentration gradients in the area of the extraction wells. As indicated on the expanded iso-contour plan presented with the Army's response to Comment 2 of the draft document, the EPA's capture zone assessment, and the groundwater model update, the capture zone of the extraction system includes the east side of the landfill. Regarding the timeframe for the evaluation of the long term performance of the extraction system, Section 3.1.2 has been revised to remove 5-year timeframe. Performance evaluation will proceed as part of the annual reporting process.*

Comment 5 – Section 3.1.3: The information needed to assess the performance of the barrier wall (DQO Step 3) should include periodic collection and analysis of sediment and surface water samples from Red Cove (refer to Army response to MassDEP Comment 9 on the draft document).

Response: *Because previous modeling suggests that existing arsenic-impacted groundwater on the eastern side of the wall may require several years to flush from the aquifer, the performance of the barrier wall will be assessed through the collection of hydraulic head data on either side of the barrier wall to confirm a hydraulic head differential across the wall and to calculate the hydraulic gradient on the west and east sides of the barrier wall. In addition, dissolved arsenic data will be collected from groundwater monitoring wells on the up-gradient and down-gradient sides of the barrier wall to document a reduction in arsenic concentration across the wall and ultimately a decrease in arsenic concentrations entering Red Cove. As stated in the Section 3.1.3, future data collection optimization including the collection of additional sediment and surface water samples from Red Cove may be recommended in this area considering the long term life cycle of the barrier wall.*

Comment 6 – Table 2: Well SHP-99-01B should be deleted from the table if it will be abandoned as proposed in Table 4.

Response: *Well SHP-99-01B has been deleted from Table 2.*

Comment 7 – The revised document should include an updated map of the arsenic plume (refer to Army response to MassDEP comment 6 on the draft document).

<u>Response</u>: *A downgradient arsenic limit of impact map has been included as Figure 3.*