REMEDIAL INVESTIGATION AND FEASIBILITY STUDY

FEASIBILITY STUDY REPORT

Sutton Brook Disposal Area Superfund Site

Tewksbury, Massachusetts

May 2007

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1. INTRODUCTION

This *Feasibility Study (FS)* has been prepared for the Sutton Brook Disposal Area Superfund Site (Site). The Sutton Brook Disposal Area, also referred to as Rocco's Landfill, is located off South Street on the eastern boundary of the Town of Tewksbury, Middlesex County, Massachusetts. A small portion of the Site also extends into the Town of Wilmington.

Per the *Administrative Order by Consent for the RI/FS* and the *September 2004 EPA-approved RI/FS Workplan*, the Feasibility Study for the Site was conducted in two phases. The first phase, *Phase 1 Feasibility Study (FS) – Development and Initial Screening of Alternatives*, was completed and submitted to EPA on September 22, 2006. The main objective of the Phase 1 FS was to identify and develop remedial alternatives which address the human health and ecological risks resulting from Site conditions. These selected remedial alternatives were then further evaluated in the *Phase 2 FS - Detailed Analysis of Alternatives* submitted to the EPA on February 12, 2007. The second phase of the FS presented the detailed and comparative analysis of remedial alternatives. This FS evaluation process has presented an appropriate range of remedial alternatives developed based on site-specific conditions in accordance with the National Oil and Hazardous Substances Pollution Contingency Plan (NCP), the *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA, Interim Final* and *the Presumptive Remedy of CERCLA Municipal Landfill Sites*.

Following submittal of the Phase 1 and 2 FS documents, EPA provided comments on the deliverables on November 2, 2006, March 14, 2007, and April 2, 2007. Written responses to comments and follow-up correspondence and telephone conference calls were conducted as part of the comment resolution process. The subsequent comment resolutions have been incorporated into this FS report.

1.1 OBJECTIVE OF THE FEASIBILITY STUDY

The main objective of the FS is to develop a range of remedial alternatives which address human health and ecological risks resulting from site conditions (Phase 1 FS) and evaluate each one against a series of nine criteria to ensure protection of human health and the environment and compliance with Applicable or Relevant and Appropriate Requirements (ARARs) once implemented (Phase 2 FS).

The specific objectives of the FS process are to:

Phase 1 -

- Review the applicability of various remedial technologies, including innovative technologies, to determine whether they are applicable to the Site.
- Combine technologies into alternatives and determine if each developed alternative is feasible by evaluating, in the short and long term, each alternative's effectiveness, implementability, and cost.
- Upon conclusion of the Phase 1 FS, identify a range of alternatives to be evaluated in the Detailed Analysis (Phase 2 FS).

Phase 2 -

- Evaluate each alternative or combination of alternatives through a detailed and comparative analysis based upon the nine criteria listed in the *Guidance for Conducting Remedial*

Investigations and Feasibility Studies Under CERCLA, Interim Final (October 1988), and criteria identified in the NCP (40 C.F.R Part 300) or CERCLA. This comparative analysis focuses on the relative performance of each alternative against the criteria.

1.2 ORGANIZATION OF THE FEASBILITY STUDY

This FS report is organized into the following sections:

Section 1 – Introduction– provides the objectives of the Feasibility Study and layout of the report.

Section 2 – Site Background – includes a summary of site conditions, including the nature, extent, fate and transport of contamination and the conclusions drawn from the human health and ecological risk assessments.

Section 3 – Identification of ARARs and TBCs and Development of RAOs and PRGs – provides the identification of Applicable or Relevant and Appropriate Requirements (ARARs), To Be Considered Guidelines (TBCs), and the development of Remedial Action Objectives (RAOs). In addition, this section summarizes the approach used to develop the Preliminary Remediation Goals (PRGs) and provides the site areas and volumes identified with concentrations exceeding these PRGs that were used in the FS.

Section 4 – Screening and Selection of Potential Remedial Technologies and Process Options – presents the initial screening of general response actions, remedial technologies, and process options.

Section 5 – Development and Initial Screening of Remedial Alternatives – presents the formulation and screening of a range of site-wide remedial action alternatives.

Section 6 – Remedial Alternatives Retained from Initial Screening – provides a summary of the remedial alternatives retained from the initial screening that will be further evaluated in the detailed analysis in Section 8.

Section 7 – Supplemental Investigation and Assessment – presents additional data collected to aid in the detailed analysis. This includes supplemental soil gas and groundwater results.

Section 8 – Detailed Analysis of Remedial Alternatives – presents the detailed analysis of the remedial alternatives that will be used to compare alternatives and facilitate selection of a specific remedy for the Site.

Section 9 – Comparative Analysis of Remedial Alternatives – presents the comparative analysis of remedial alternatives, evaluating the relative performance of each alternative in relation to each specific criterion to aid in the selection of a remedial alternative.

Section 10 – References – provides a listing of applicable references.

Tables or figures for each respective section are included at the end of the text within that section.

2. SITE BACKGROUND

The Sutton Brook Disposal Area, also referred to as Rocco's Landfill, is located off South Street on the eastern boundary of the Town of Tewksbury, Middlesex County, Massachusetts. A small portion of the Site also extends into the Town of Wilmington, as shown on the Locus Map (Figure 2-1). Key site features and ground surface contours are illustrated on Figure 2-2**.** For purposes of presentation and discussion, the Site is divided into the following two major source areas: the Landfill Lobes, referred to as the Northern Lobe and Southern Lobe, and the former drum disposal area, referred to as the FDDA in this report. The solid waste source areas on the Site comprise about 40 acres of the Site. In 2000, between 300 and 400 buried drums were removed from the FDDA, which is located northwest of the Northern Lobe. Sutton Brook (and associated wetlands) flows east to west through the property, dividing the landfill into the Northern and Southern lobes. Additional wetland areas are located south of the landfill and along the eastern and western portions of the RI area.

A brief summary of the environmental setting, nature and extent of contamination and the results of the risk assessment is presented in the following sections. Refer to the February 2007 *RI Report* and the May 2007 *Baseline Risk Assessment* for a more detailed discussion.

2.1 ENVIRONMENTAL SETTING

The majority of the Site is unpaved and relatively flat, aside from the steeply sloped landfill lobes. Outside the landfill lobes, the Site primarily consists of wetlands including several individual wetland areas (red maple swamp/floodplain associated with Sutton Brook [greater than 50 acres]; small isolated man-made pond [approximately 2 acres]; isolated man-made areas subject to flooding [small forested wetland area and a borrow pit]; and an isolated emergent wetland area).

The overburden geology of the area is characterized by glacial features (e.g., outwash and till deposits). The site-specific unconsolidated materials underlying these surficial deposits consist primarily of sand layers (stratified drift) underlain by a till laid down on top of bedrock. Depth to rock at the Site ranges from 20 to 60 feet below ground surface (ft bgs). The mapped rock along with the rock cores obtained during the RI indicate that two types of rock were encountered beneath the Site. A granite or granodiorite, referred to as the Andover Granite, is classified as a light to medium-gray, foliated, medium to coarse grained muscovite-biotite granite. The other rock type, gneiss, is classified as a thinly bedded to massive amphibolite; minor biotite gneiss. A weathered zone was observed at the top of the rock followed by more competent rock with moderate fracturing.

Unlike the ground surface topography (aside from the landfills), the bedrock surface topography varies considerably across the Site. A bedrock outcrop was observed on the westernmost portion of the area adjacent to Sutton Brook. The bedrock surface generally slopes in a southerly to southwesterly direction across the site. A deep bedrock valley on the southwestern portion of the Site has been filled with glacial drift deposits creating a higher transmissive water zone (e.g., the Town's former Poplar Street wellfield was located in this valley).

The ground surface across the Site consists of landfill lobes or fill areas, wetland soils, or an upper sand layer. The upper sand layer (10 to 45 feet in thickness) is comprised of a brown to gray medium to fine sand with a little silt and exists across the entire Site. The units underlying this layer are controlled by the depth to bedrock and the presence and thickness of a till layer. In areas of deeper bedrock, coarser sand with some gravel was encountered beneath this upper sand, as seen on the western portion of the Site.

The main hydrologic feature at the Site is Sutton Brook and associated tributaries and wetlands. Sutton Brook is a medium gradient stream that includes both moderately moving water through established

banks and slower moving water through much wider and less-established channels. The stream bed is comprised of sand and gravel with some areas of muck and peat. Sutton Brook originates in an upland area north of the Site in Andover and flows southerly, turning westerly to northerly through the Site with discharge to the Shawsheen River approximately 2,500 feet northwest of South Street. As Sutton Brook traverses the Site, the character of the brook is affected by the channel width, the channel depth, the composition of the soils underlying the brook, and tributaries that contribute to the brook.

Based on the majority of the water table elevations, surface water elevations, and stream gauging measurements, overall, shallow groundwater discharges to the brook; whereas the wetlands area and smaller tributaries experienced variable elevations ranging from discharging to recharging shallow groundwater throughout the seasons.

Depth to groundwater at the Site ranges from approximately near/at ground surface to a depth of approximately 12 feet below ground surface. In general, the water table surface (i.e., top of the groundwater surface) mimics the natural land surface topography of the area and is influenced by the streams and wetland areas. Generally, throughout seasons, the overall groundwater flow patterns are similar: north of the Site, groundwater flows southerly towards Sutton Brook or westerly towards the Shawsheen River; groundwater east of the Site flows westerly or southerly towards Sutton Brook and an un-named tributary; groundwater south of the Site flows northerly towards Sutton Brook or the Shawsheen River; and groundwater west of the Site flows either northerly toward the Shawsheen River or easterly towards Sutton Brook. A similar groundwater flow pattern was observed in the intermediate overburden with flows toward Sutton Brook and the Shawsheen River.

Due to the changes in water levels, slight changes in the direction of groundwater flow were observed from the groundwater low measurements (September 2005) to the groundwater high measurements (May 2006), specifically on the northwest portion of the Site near the FDDA and in the wetland area south of Sutton Brook. Still, under both seasons, flow continued towards Sutton Brook and eventually followed the direction of the stream flow of Sutton Brook. The FDDA also exhibited the flattest horizontal gradients at both the water table surface and the intermediate overburden potentiometric surfaces. There were similar, slight localized changes in the groundwater flow patterns on other areas of the Site from season to season. However, overall, groundwater flow at the Site measured over the seasons remains consistent with the regional groundwater flow patterns.

Based on a review of the hydraulic gradients, groundwater flow is in a predominantly horizontal direction (horizontal gradients greater than vertical gradients) with an upward flow component under the majority of conditions. This average upward flow pattern is maintained through the seasonal variations measured at the Site.

2.2 NATURE AND EXTENT OF CONTAMINATION

For discussion purposes, the nature and extent of contaminants at the Site have been divided into the following areas:

- Source Areas
    - Landfill Lobes
    - Former Drum Disposal Area
    - Garage and Storage Area
- Non-Source Areas – wetlands, brook and downgradient groundwater

A summary of the principal RI findings for each of these areas is presented in the following sections.

2.2.1 Landfill Lobes

Of the two landfill lobes, the Northern Lobe is the largest at approximately 30 acres (estimated 1.9 million cubic yards of material) whereas the Southern Lobe comprises approximately 10 acres (estimated 0.3 million cubic yards of material). Small debris/waste piles have also been identified in five distinct areas proximate to the landfill lobes. The landfill lobes constitute the primary source areas at the Site. A depiction of the landfill lobes is presented on Figure 2-3**.**

The primary migration pathways for contaminants from the landfill lobes are:

- infiltration/leaching of contaminants from the waste with subsequent transport via groundwater flow;
- soil erosion and wind blown transport of contaminants that are exposed at the surface, and includes both dust and surface water runoff; and
- volatile air emissions and transport.

Landfill gases generated from the two lobes ranged from 14 to 70% methane; 15 to 34% carbon dioxide; and 0.7 to 540 ppm total VOCs. The VOCs detected at the greatest frequency in the samples were toluene, xylene, ethyl benzene, n-hexane, and dichlorofluoromethane.

Based on the RI data (visual observations of the slopes; groundwater samples proximate to the lobes; surface water and sediment samples; and landfill gas and ambient air samples), groundwater migration is the primary contaminant migration pathway associated with the lobes given: 1) the uncapped/uncontained nature of the landfill does not limit infiltration and subsequent leaching; 2) wastes are most likely located at or near the water table surface; 3) the proximity of Sutton Brook to the landfill lobes; 4) typical landfill gas levels in the subsurface and low to non-detect concentrations of VOCs in ambient air indicating minimal mass transport; and 5) the majority of the material in the lobes is covered on the ground surface with soil and/or vegetation, thereby reducing transport by runoff.

The primary constituents detected in groundwater samples were VOCs and metals. The highest concentrations of VOCs were detected in the groundwater collected from monitoring wells located adjacent to the northern sides of the Southern Lobe. Total VOC concentrations in these wells ranged from 3,450 to 57,210 ug/l (2004 data). The VOC generally detected at the highest concentration in the wells was toluene. Groundwater data from the wells along the perimeter of the Northern Lobe were much lower in concentration (total VOCs ranged from 53 to 842 ug/l – 2004 data). Unlike the Southern Lobe, the VOC generally detected at the highest concentration in the wells was either 1,4-dioxane or tetrahydrofuran. Based on information collected during the RI, the Southern Lobe appears to be the primary contributor to the elevated concentrations of volatile organics in groundwater and in Sutton Brook sediments proximate to the lobes.

The overall distribution of the total VOCs in groundwater supports groundwater flow in the direction of Sutton Brook. Similar constituents to those detected in groundwater were also detected in leachate samples and in surface water and sediment samples. The samples with the highest concentrations were detected in the stretch of Sutton Brook between the two lobes. A depiction of this area along with the approximate limits of solid waste is depicted on Figure 2-3.

2.2.2 Former Drum Disposal Area

A removal action was conducted in this area by EPA in 2000, in which approximately 300 to 400 crushed drums were excavated and 13,786 tons of soil was transported off-site for disposal (as non-hazardous waste). Post-excavation data indicates that residual levels of VOCs (TCE, toluene, PCE, ethyl benzene, trimethylbenzenes, and xylenes) are present in soils with toluene, ethyl benzene, and xylenes exhibiting the highest concentrations and greatest frequency of detection. The highest total VOC concentration was detected in samples located on the southeast portion of the area. This area (southeast portion) also corresponds to an area of elevated SVOCs, specifically bis(2-ethylhexyl)phthalate, di-n-octylphthalate, and naphthalene and the area where more of the drums were formerly located. A depiction of the impacted soil area is presented on attached Figure 2-4.

Similar to soils, VOCs were the primary constituents detected in the groundwater samples with benzene, toluene, ethyl benzene and xylenes (BTEX) and lower concentrations of 1,1,1-TCA, TCE, and 1,1-DCA being detected at the greatest frequency. Elevated concentrations of 4-methyl-2 pentanone, 2-butanone, and phenols were also detected in groundwater proximate to the area of the FDDA.

The dissolved VOC concentrations in groundwater were found to be decreasing with distance from this source area. The highest concentrations of VOCs are located at an intermediate depth within the overburden aquifer and within a low hydraulic conductivity medium to fine sand layer. The groundwater data also indicates that impact is limited to the overburden and has not migrated into the bedrock aquifer.

As the groundwater plume approaches Sutton Brook, the groundwater flow patterns and the presence of conditions supporting natural degradation appear to be the controlling factors to the nature and extent of the groundwater contamination in this area. Local groundwater (immediate sides of the brook and wetland areas) flows east or west, respectively, towards the brook and wetlands. There is also a net northerly component of flow (regional flow path) that parallels the flow of the brook. The horizontal hydraulic gradients are relatively flat, especially in the intermediate overburden (area of higher groundwater contamination) as groundwater approaches the wetlands/brook. These low gradients and low hydraulic conductivity result in a reduced groundwater velocity and subsequent contaminant migration rates.

Historical contaminant analytical data and the existing subsurface geochemistry indicate that a combination of natural attenuation processes (biodegradation, dispersion, dilution, adsorption, volatilization, and/or chemical or biological stabilization, transformation, or destruction of contaminants) are reducing contaminant concentrations and preventing the continued downgradient migration. The combination of hydrological conditions and natural degradation factors has resulted in a stable plume configuration that is not expected to migrate beyond its current configuration. Refer to the February 2007 *RI Report* and Section 7.2 of this document for further discussion on natural attenuation at the Site.

2.2.3 Former Residence, Garage, and Storage Area

This area is located on the northwest portion of the Site and consists of the former residence, garage, and storage areas (see attached Figure 2-5). The majority of the area contains surficial debris from past and current storage activities. Impacted soils (petroleum hydrocarbons, PAHs, and metals) are present on the south central portion of the area and most likely were caused by the storage or operation activities in this area. A subsurface fill area, comprised of wood, metal, and concrete, is present on the southern portion of the area. Groundwater is not impacted from operations within this area.

2.2.4 Non-Source Areas

The "non-source" areas primarily consist of the wetlands in areas away from the source areas (i.e., hydraulically downgradient areas, upstream areas of Sutton Brook, and the nearby tributaries). These areas and samples collected within these areas are shown on Figure 2-6.

The non-source areas also include the area of groundwater located hydraulically downgradient of the 'Source Areas" with organic constituents detected in excess of Federal drinking water maximum contaminant levels (MCLs) (see attached Figure 2-7). A combination of natural attenuation processes (biodegradation, dispersion, dilution, adsorption, volatilization, and/or chemical or biological stabilization, transformation, or destruction of contaminants) and hydrogeological conditions are reducing contaminant concentrations in this "downgradient" area, reducing the overall mass and preventing contaminant migration beyond the current configuration of the plume. This conclusion was determined as a result of the decreasing and/or stabilization of the groundwater plume, the presence of breakdown products, reduced levels of electron acceptors, and increased levels of metabolic byproducts (i.e. ferrous iron and methane) across the Site. Refer to the February 2007 *RI Report* and Section 7.2 of this document for further discussion on natural attenuation at the Site.

In contrast, unlike the dissolved VOC plumes, arsenic concentrations in groundwater in excess of MCLs are detected in both site wells as well as upgradient wells suggesting that arsenic concentrations may be naturally occurring at "elevated" levels. Arsenic is a common contaminant of concern at many landfills and the precise origin of the arsenic in groundwater is often difficult to determine. A review of the analytical data indicates that arsenic levels have remained fairly consistent over time with a slight upward pattern in select areas.

Higher concentrations of arsenic are found in areas adjacent to or immediately downgradient of the site source areas (landfill and FDDA). This condition appears to be related to the subsurface environment and resulting geochemical processes caused by these source areas (e.g., reducing conditions causing increased arsenic concentrations). As oxidizing conditions return to the subsurface at locations away from these areas, the arsenic concentration in groundwater decreases.

These conditions demonstrate that although some mass of arsenic may be a result of deposition into the source areas, the resulting geochemistry within the subsurface has likely played a significant role in the elevated arsenic levels immediately downgradient of the source areas. Further discussion of arsenic in groundwater at this Site is provided in the February 2007 *RI Report* and Section 7.2 of this document. Regardless of the source, in either waste material or remobilization from native soils and/or bedrock by reducing conditions, the evaluation of remedial technologies to address arsenic in groundwater has been included in this FS.

2.3 HUMAN HEALTH RISK ASSESSMENT CONCLUSIONS

A baseline human health risk assessment (HHRA) was performed as part of the RI/FS to evaluate the potential for risks to human health associated with exposure to constituents identified in various media at the Site. The intent of the HHRA is to gain an understanding of potential current and (hypothetical) future human health risks using environmental data that reflects existing conditions at the Site. These results are also used as a basis for evaluating the need for additional remediation and/or institutional controls on land use.

The HHRA presumed that the Northern and Southern landfill lobes will be capped; thereby eliminating access to soils located in these areas. As such, the HHRA did not quantitatively evaluate risks associated with soils in these two areas of the Site. Given this assumption, the remedial action alternatives in the FS incorporate technologies to contain or cap the two landfill lobes.

The HHRA also included evaluation of the potential development and subsequent commercial and residential re-use of the upland site areas (FDDA and former residence, garage, and storage area). It was assumed that Sutton Brook and associated ponds/wetlands would not be developed in the future due to their status as wetlands and/or riverways and, as such, are regulated under the Massachusetts Wetlands Protection Act and Riverways Protection Act. Furthermore, the HHRA evaluated the potential potable use of groundwater across the Site due to its current classification, even though site groundwater is currently not being used for this purpose.

A number of receptors and exposure scenarios were evaluated under both existing and potential future site conditions. Based on the potential for exposure, impacted media, and/or likely activities and uses, the Site was subdivided into several "groups" including: Groups 1 and 2 (former landfill lobes), Group 3 (Former Drum Disposal Area), Group 4 (Former Residence, Garage and Storage Area), Group 5 (Sutton Brook and associated wetlands and tributaries), Group 6 (Areas South of the Southern Landfill Lobe), and Group 7 (Reference locations).

Receptors assumed to have potential exposures under current and potential future conditions included the Trespassers/Recreational users. These receptors were assumed to trespass onto upland site areas (Group 3 or 4) and engage in recreational activities in wetland areas and/or Sutton Brook and its tributaries (Groups 5 and 6). Additional receptors (to those listed above) evaluated under (hypothetical) future uses and conditions, which assumed to include redevelopment of upland site areas (i.e., Groups 3 and 4) for commercial and/or residential use, included:

- Site Residents,
- Commercial facility workers, and
- Construction workers.

For some of the receptors listed above, exposures were assumed to occur at several exposure points (e.g., future residents were assumed to be exposed to COPCs in either Group 3 or Group 4, as well as to surface water, wetland soil and/or sediments in Groups 5 and 6). Specifically, the residential receptors were assumed to live in Group 3 or Group 4. However, the Group 3 and Group 4 residential receptor was also assumed to come in contact with sediment, wetland soil and surface water in Groups 5 and 6 and to groundwater (as a potable water source) in Groups 3-6. In addition, risks were evaluated separately for residents who were assumed to use Groups 1&2 groundwater as a source of potable water.

Due to the classification of groundwater underlying the site as potentially usable for potable purposes (in the future), both residential and commercial development scenarios assumed extraction of groundwater for potable purposes. In addition, potential exposures to multiple media (soil, groundwater, airborne dust, vapors, surface water, and/or sediment) were evaluated, as appropriate, for each receptor at each exposure point. Lastly, both central tendency (CT) and reasonable maximum exposure (RME) scenarios were evaluated for each of these receptors. This was done to better understand the potential range of health risks that may occur under "typical" (CT) and upper bound/reasonable worst case (RME) conditions.

Pathway-specific risks for each receptor group were summed so that the cumulative receptor risks could be compared to USEPA criteria. These risk management criteria correspond to a cumulative hazard index (HI) of 1 and a target cancer risk range of 1×10^{-4} to 1×10^{-6}. Three separate pathway and cumulative risks were estimated for each receptor, the results of which are summarized below:

- Total Risks: these risks reflect calculated HIs and cancer risk estimates associated with exposure to ***all*** COPCs within each medium;

- Site-related Risks: these risks reflect calculated HIs and cancer risk estimates associated with exposure to COPCs which were assumed to be site-related based on collected information and analytical data and their concentrations relative to measured reference concentrations: and,

- Reference Risks: these risks reflect calculated HIs and cancer risk estimates associated with exposure to COPCs which are present at levels consistent with measured reference concentrations.

In the risk assessment, all three types of risks were presented with the site-related risks being the focus of comparisons to USEPA criteria. Calculated non-cancer risk estimates were described relative to the hazard index criterion of 1, and calculated cancer risk estimates were classified as *above the USEPA risk range* (i.e., greater than 1×10^{-4}), *within the EPA risk range* (between 1×10^{-6} and 1×10^{-4}) or *below the USEPA risk range* (less than 1×10^{-6}). For ease of presentation, we summarized the results for current and then hypothetical future receptors. These summary conclusions highlight the data group(s), media, and chemicals that were the most significant contributor(s) to risks identified in excess of the USEPA non-cancer and cancer criteria described above. If risks were below the non cancer limit or below/within the caner risk range, explanation of these specifics, such as COPCs drivers, was not included in this summary.

Current Conditions

Under current conditions for the CT scenario, both of the cumulative (receptor) HIs for the Trespasser/Recreator receptors *were at or below 1*. All of the CT cancer risk estimates for these current receptors were *within USEPA's target risk range*. Similarly, under the RME scenario, all of the cumulative HIs *were at or below 1* and the ILCR estimates were *within the USEPA risk range.*

In summary, neither the Group 3 or Group 4 Trespasser/Recreational user had non-cancer risks above the cumulative limit of 1 or cancer risks above the USEPA risk range (i.e., greater than 1×10^{-4}) .

Future Conditions

Under future conditions, the risks are identical for the Group 3 Trespasser/Recreational user as those presented under current conditions; therefore they are not repeated in this section.

- For the CT and RME scenarios, the residential receptors (Groups 1&2 [groundwater only], Group 3, and Group 4) and the facility worker receptors (Group 3 and Group 4) all had *cumulative HIs greater than 1 and cumulative cancer risks above the USEPA risk range*. In the case of both the residential receptors (in all Groups described above) and the facility worker receptors (Groups 3 and 4), the assumed use of groundwater from either Groups 1&2 or Groups 3-6 for potable purposes resulted in the highest exposure medium risks. Arsenic in Groups 1 and 2 groundwater contributed most significantly to both the cumulative HI and ILCR for the

residential receptor in these areas, with chlorinated and non-chlorinated VOCs and phenols also contributing significantly to non-cancer risks. For residential receptors and facility worker receptors in both Group 3 and 4, potable water was assumed to be drawn from groundwater underlying Groups 3-6 collectively. For these receptor groups, arsenic in groundwater contributed significantly to both non-cancer and cancer risks, with numerous VOCs, SVOCs and heavy metals in groundwater also contributing to the non-cancer risk. Although other media (such as wetland and upland soil) contained individual chemicals associated with non-cancer risks above 1 or cancer risks above 1×10^{-6}, the contribution of these other media were typically small when compared to the potable groundwater risks. The only exceptions to this condition were for upland soils in Group 4, and for sediments in Groups 5&6, where elevated cancer risks were associated with carcinogenic PAHs, notably benzo(a)pyrene. However, as explained below, the drivers of sediment associated cancer risks were found at site concentrations consistent with data collected from upstream (reference) locations. Hence, *site-related* risks for sediment were relatively low when compared to groundwater.

- Under both the CT and RME scenarios, the Group 4 trespasser/recreators had *non-cancer risks below the limit of 1,* while the cancer risks were *within the acceptable risk range.*

- Under the CT scenarios, both the Group 3 and Group 4 construction workers had cumulative HIs and ILCR estimates *below or within applicable USEPA target risks and risk ranges,* respectively. The Group 4 construction worker also had *no risks above the target risk or risk range* identified under the RME scenario. Under the RME scenario, the Group 3 construction worker receptor had a cumulative *non-cancer risk (HI) slightly greater than 1,* primarily associated with the dermal contact with arsenic and phthalates in soil, while the ILCR estimate for this receptor was *within the target risk range*. Note that arsenic in soil is consistent with reference conditions.

Generally, the site-related human health risk estimates that were most significantly above the USEPA target risks or risk ranges were associated with exposure to groundwater, primarily through its assumed potable use in the future. The chemicals contributing most significantly to these groundwater risks included arsenic, phenols, aromatic VOCs and tetrahydrofuran in Groups 1&2 groundwater, and arsenic, xylenes, ketones and phenolic compounds in Groups 3-6 groundwater. Exposure to upland soils in Group 3 generally resulted in risks below or within the target risk range, whereas residential exposures to upland soils in Group 4 were associated with risks above the risk range, primarily associated with exposure to carcinogenic PAHs (e.g., benzo(a)pyrene). Exposures to wetland soils and/or surface water in Groups 5&6 by trespassers/recreational users and/or future site residents were not associated with risks above the applicable risk limit or range. Lastly, although the cumulative (total) risks to sediments in Group 5&6 by trespassers/recreational users and/or hypothetical future site residents were above the target risk range, the site-related risks for this medium were at or below applicable limits, since the excess risk was almost completely due to levels of PAHs and arsenic, both found to be consistent with levels detected in sediments upstream of the Site.

2.4 ECOLOGICAL RISK ASSESSMENT CONCLUSIONS

A baseline ecological risk assessment (BERA) was performed as part of the RI/FS to evaluate the potential for risks to ecological receptors associated with exposure to constituents identified in various media at the Site. In the BERA, concentrations of COPCs in surface water, sediment and site soils were

used to estimate the potential for effects on aquatic and semi-aquatic receptors, waterfowl, and terrestrial wildlife at the Site. Risks to these different receptors were evaluated by either comparison to ecological benchmarks or estimation of exposure doses and comparison to established Toxicity Reference Values (TRVs). These comparisons were supplemented by the results of toxicity testing to refine levels of effect in sediment.

Risks were evaluated at five separate areas, which generally correlate to different habitats types and exposure points. These areas consist of: the Upper Sutton Brook, which was further subdivided into the Eastern Reach, Southern Tributary, and Site Channel; the Aquatic Wetland; the Site Pond; Wetland Soils; and Upland Soils. To better understand the potential range of risks, three separate exposure point concentrations were considered for each of these areas: average, 95% UCL, and maximum concentrations. In general, the arithmetic average concentration is considered to be the most reasonable and likely since feeding and/or exposure potential was equally probable at any location in that exposure area. An exception is the shrew, which, because of a small home range, was evaluated by use of maximum values.

Assessment endpoints varied by Habitat Area but included for aquatic environments: benthic invertebrates, fish, amphibians, and waterfowl. Assessment endpoints for terrestrial environments included: plants, soil invertebrates, and mammalian or avian wildlife. A review of rare, threatened and endangered species databases and information sources indicated that the New Jersey Tea Inchworm (*Apodrepanulatrix liberaria*) (an Endangered moth) and frosted elfin (*Callophrys irus*) (a Special Concern butterfly) have been documented in the vicinity of the Site. The search also indicated that the project area is located within a priority habitat, *Priority Habitat 380* (PH X380). Both of these species are upland species that are dependent on one or two specific host plants for reproduction and/or feeding, a characteristic that limits the suitability of many apparently appropriate habitats. Based on an assessment conducted as part of the BERA, neither of these species is considered likely to occur at the Site because of the lack of available populations of critical host plants; however, an evaluation of the potential effects of contaminants on these species was considered in the BERA.

Concentrations were compared first to conservative no-effect benchmarks in a Screening Level Ecological Risk Assessment (SLERA). COPCs that exceeded no-effect benchmarks in the SLERA were further evaluated in the BERA by considering the magnitude and location of the exceedances and the COPC concentrations relative to lowest-effect level values. To aid in assessing the data, concentration of inorganic COPCs were also compared to reference concentrations in some instances.

Two areas, the Upper Sutton Brook Site Channel and the Former Drum Disposal Area, were not subject to additional evaluation in the BERA. Risk conclusions for these areas were based on the results of the SLERA alone.

Based on the results of the BERA, the following areas were associated with potential risks:

Upper Sutton Brook:

Reach:	Eastern Reach
Media:	Surface water
Assessment Endpoints:	Fish and pelagic invertebrates
COPCs:	Iron (exceedance of chronic WQC)

Reach:	Site Channel
Media:	Surface water
Assessment Endpoints:	Fish and pelagic invertebrates
COPCs:	DDT, ethylbenzene, toluene, xylenes, barium, and manganese (from NOAEL exceedances in SLERA)

Reach:	Site Channel
Surface Water:	Sediment
Assessment Endpoint:	Benthic invertebrates
COPCs:	1,2,4-trimethylbenzene, 1,3,5-trimethylbenzene, 2-methylphenol, 3-methylphenol/4-methylphenol, 4-methyl-2-pentanone, acetone, carbon disulfide, chloroethane, ethylbenzene, xylenes, toluene, arsenic, and manganese (from NOAEL exceedances in SLERA)

Aquatic Wetland

Media:	Surface Water
Assessment Endpoint:	Aquatic life
COPCs:	Iron (exceedance of chronic WQC)

Media:	Surface Water
Assessment Endpoint:	Amphibians
COPCs:	Aluminum

Former Drum Disposal Area - Soils:

Assessment Endpoint:	Plants
COPCs:	Bis(2-Ethylhexyl)phthalate, ethylbenzene, naphthalene, xylenes

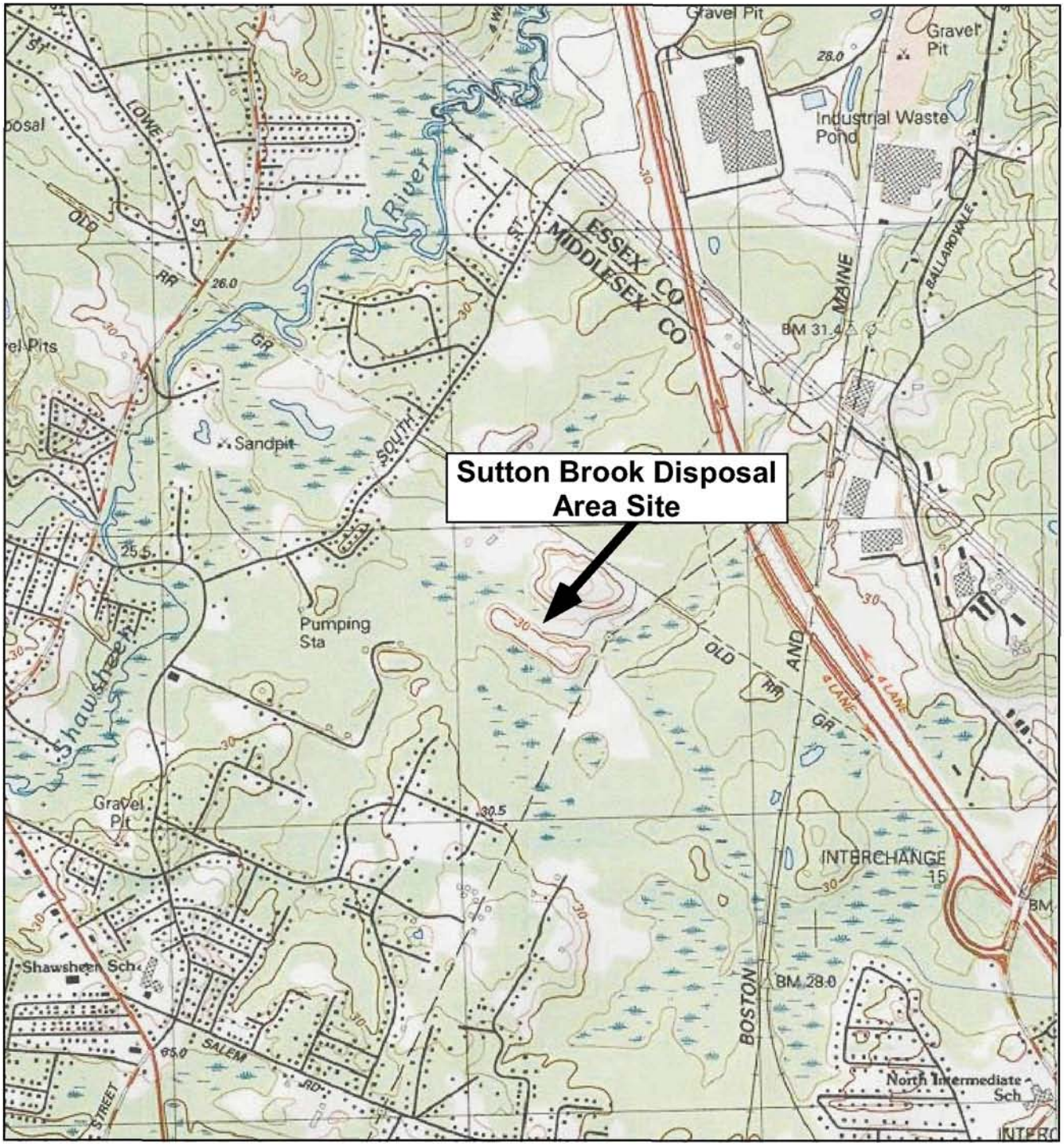
Assessment Endpoint:	Soil Invertebrates
COPCs:	1,2,4-Trimethylbenzene, 1,3,5-Trimethylbenzene, ethylbenzene, toluene, xylenes

Assessment Endpoint:	Carnivores (robin)
COPCs:	1,2,4-Trimethylbenzene, bis(2-ethylhexyl)phthalate, di-n-octylphthalate, xylenes

Upland Soils (excluding Former Drum Disposal Area):

Assessment Endpoint:	Soil invertebrates
COPCs:	Zinc (localized)

Assessment Endpoint:	Carnivores
COPCs:	di-n-octylphthalate and lead



0 .5 1 MILE

0 1000 FEET 0 500 1000 METERS

Base Map Source:
TOPO!™ © 2000
Wildflower Productions

MN 15½° TN

DES.BY:	DR.BY: EVR	CK.BY:

FIGURE 2-1

SITE LOCUS MAP

SUTTON BROOK DISPOSAL AREA

SCALE: AS SHOWN	JOB NO.: 210517
DATE: APRIL 2007	FILE NAME: Site Locus 9-1.cnv

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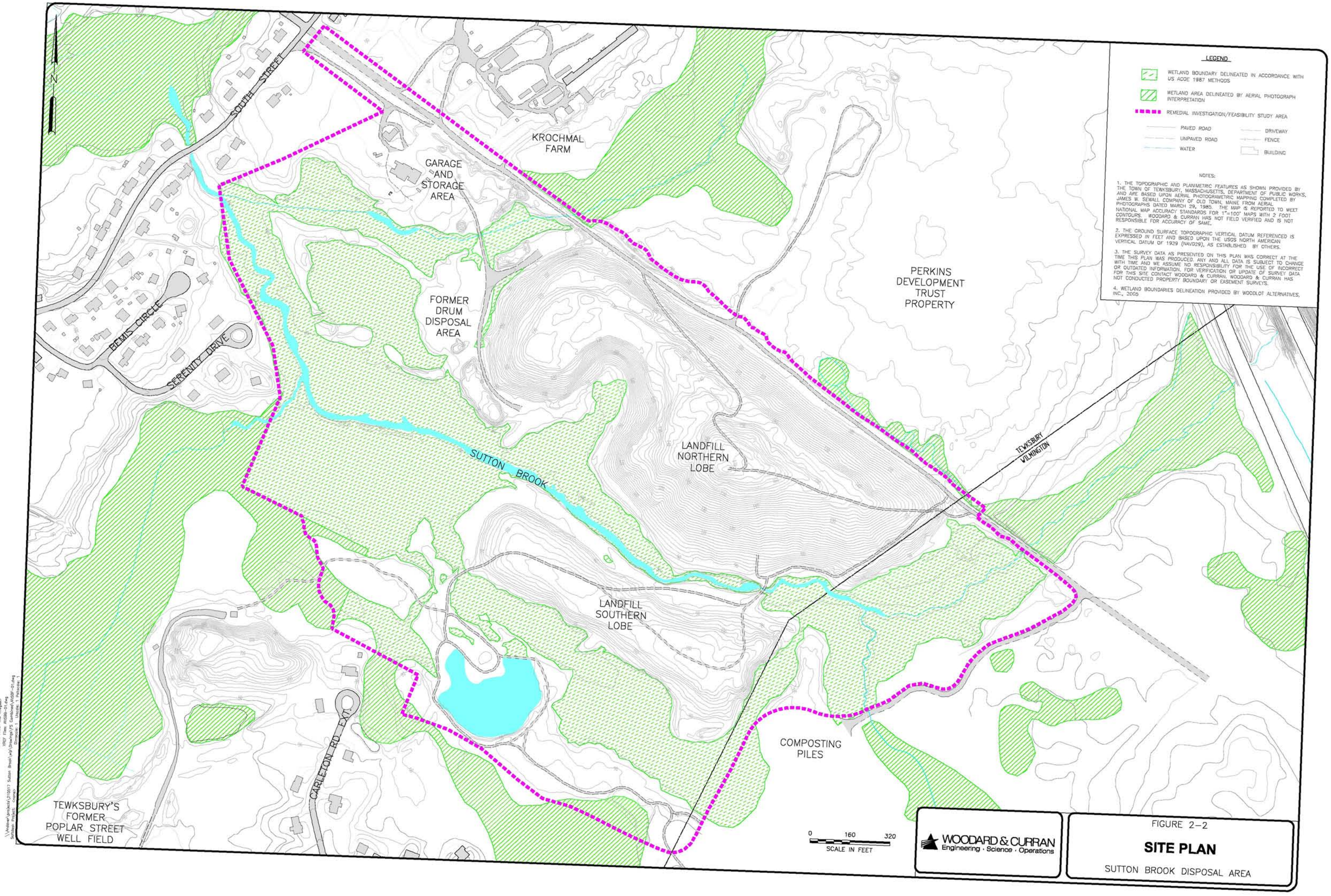

FIGURE 2–2

SITE PLAN

SUTTON BROOK DISPOSAL AREA

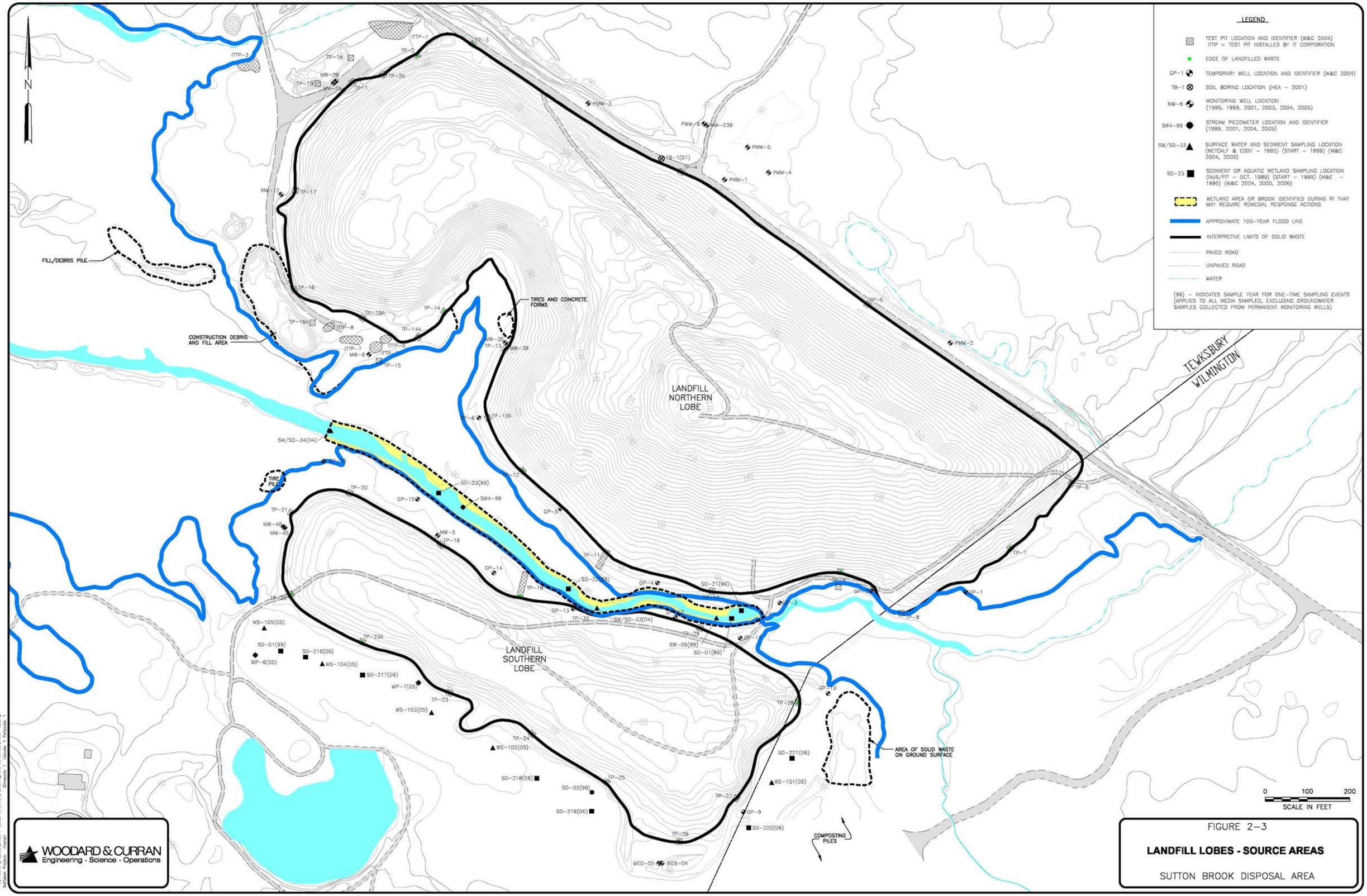

FIGURE 2-3

LANDFILL LOBES - SOURCE AREAS

SUTTON BROOK DISPOSAL AREA

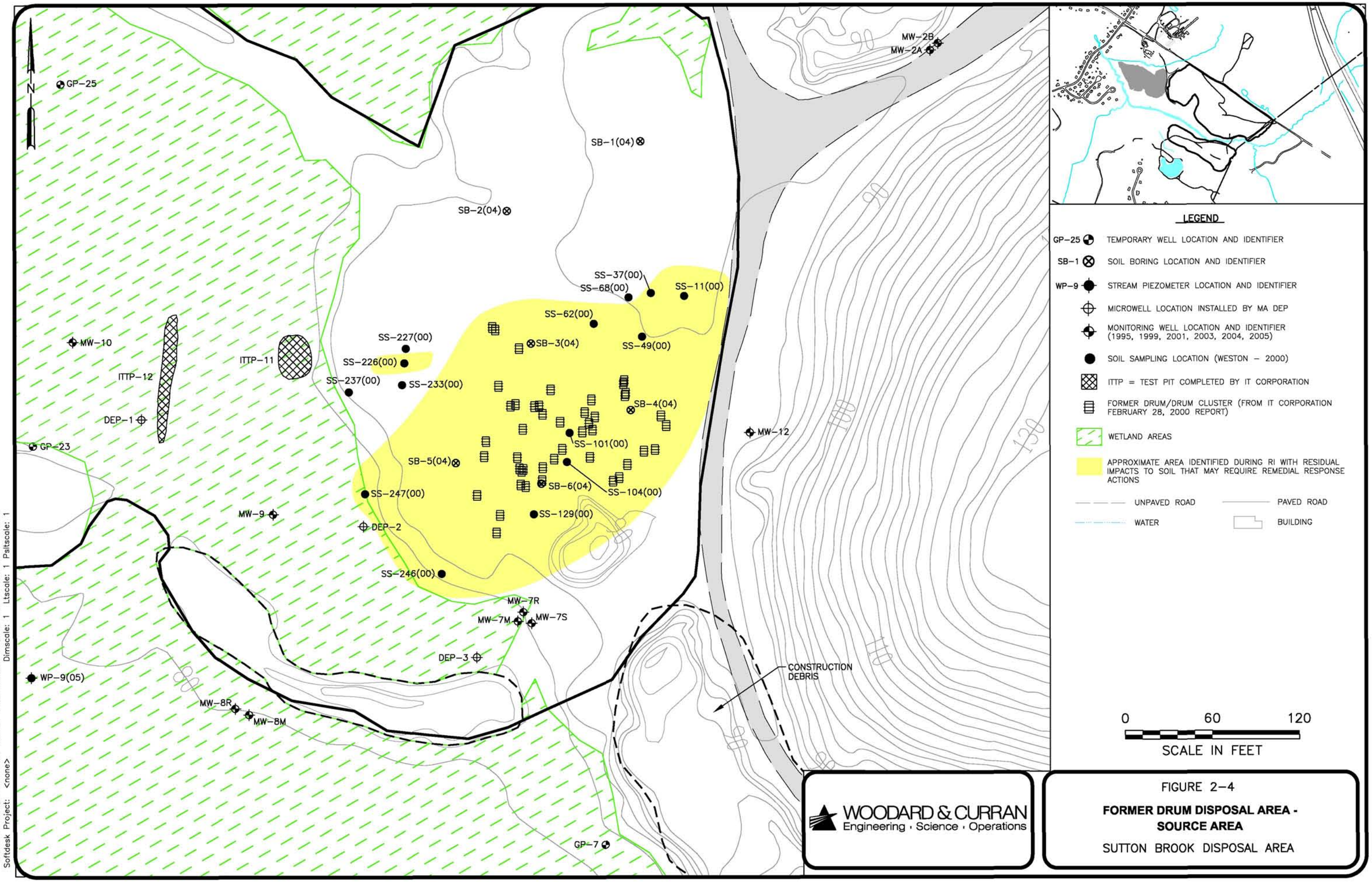

FIGURE 2–4

FORMER DRUM DISPOSAL AREA - SOURCE AREA

SUTTON BROOK DISPOSAL AREA

IMAGE Files: <No Images>
XREF Files: ANSBB-01.dwg ANSBBD01.dwg
\\Andover\projects\210517 Sutton Brook\wip\Drawings\FS Combined\ANSBF-03.dwg
Dimscale: 1 Ltscale: 1 Paltscale: 1
Softdesk Project: <none>
1" 1/2" 0" 1"

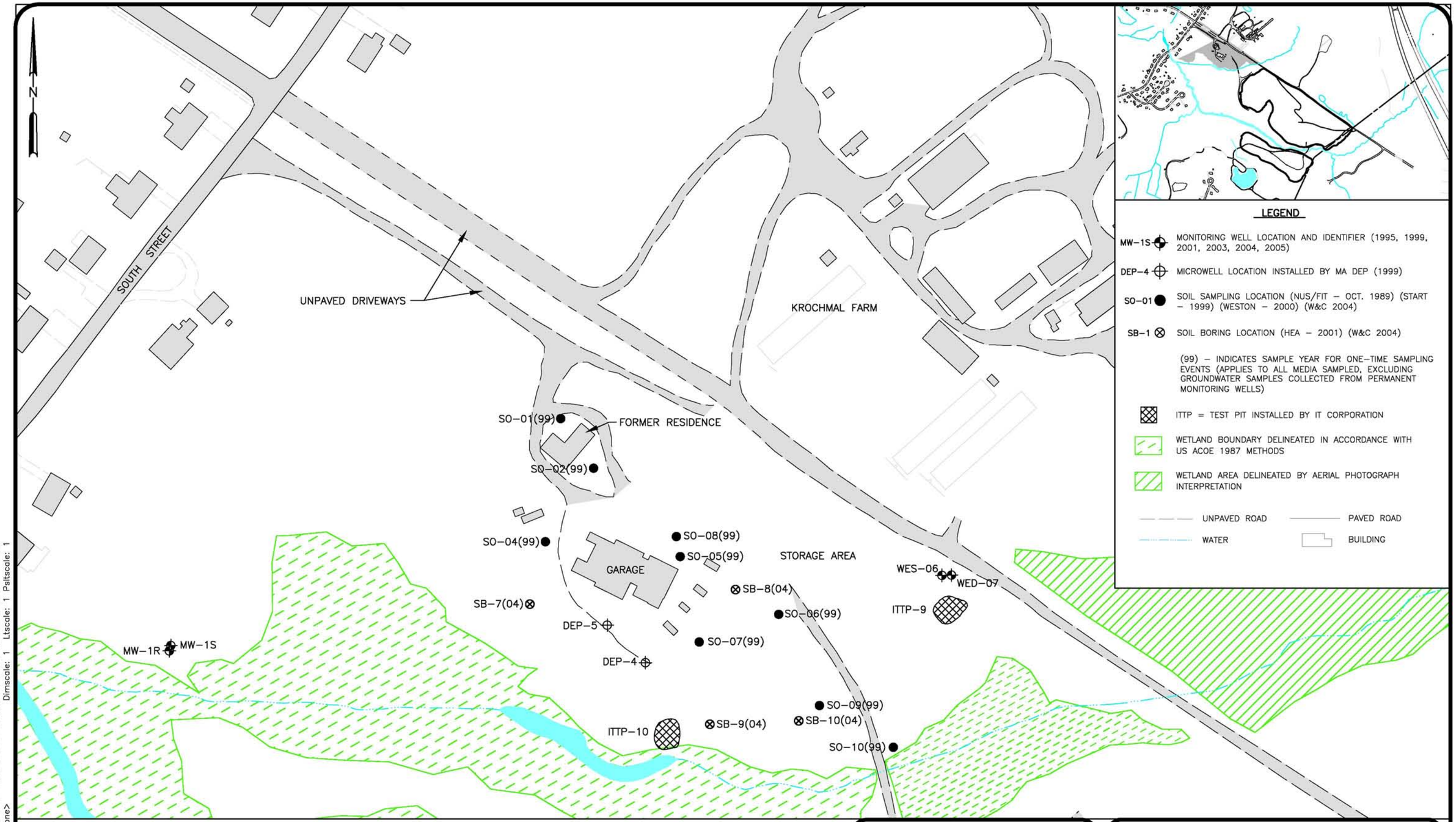

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FIGURE 2-5

GARAGE AND STORAGE AREA - SOURCE AREA

SUTTON BROOK DISPOSAL AREA

IMAGE Files: <No Images>
XREF Files: ANSBB-01.dwg ANSBBD01.dwg
\\Andover\projects\210517 Sutton Brook\wip\Drawings\FS Combined\ANSBF-04.dwg
Softdesk Project: <none> Dimscale: 1 Ltscale: 1 Psltscale: 1
1" 1/2" 0" 1"

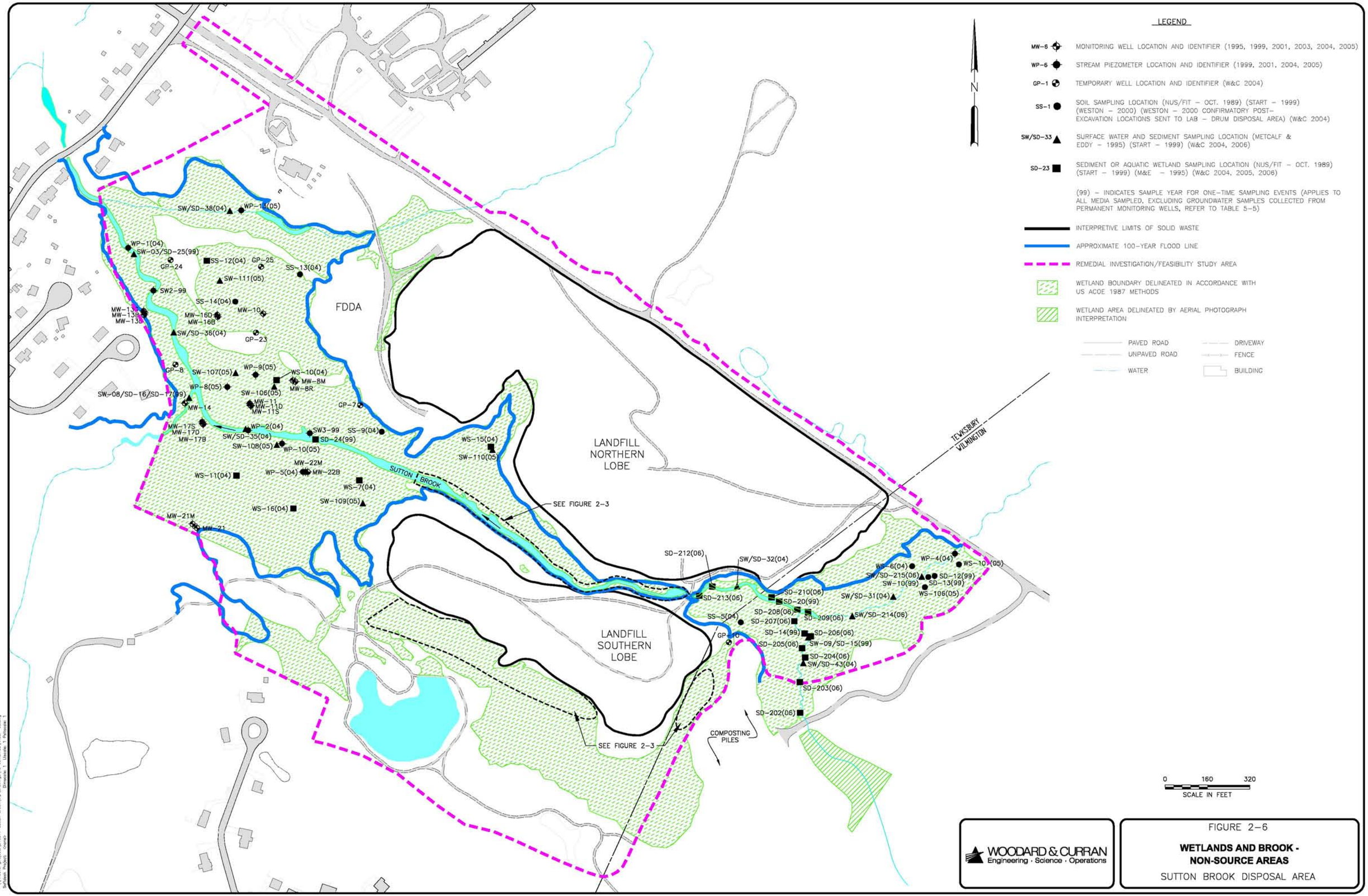

FIGURE 2-6

WETLANDS AND BROOK - NON-SOURCE AREAS

SUTTON BROOK DISPOSAL AREA

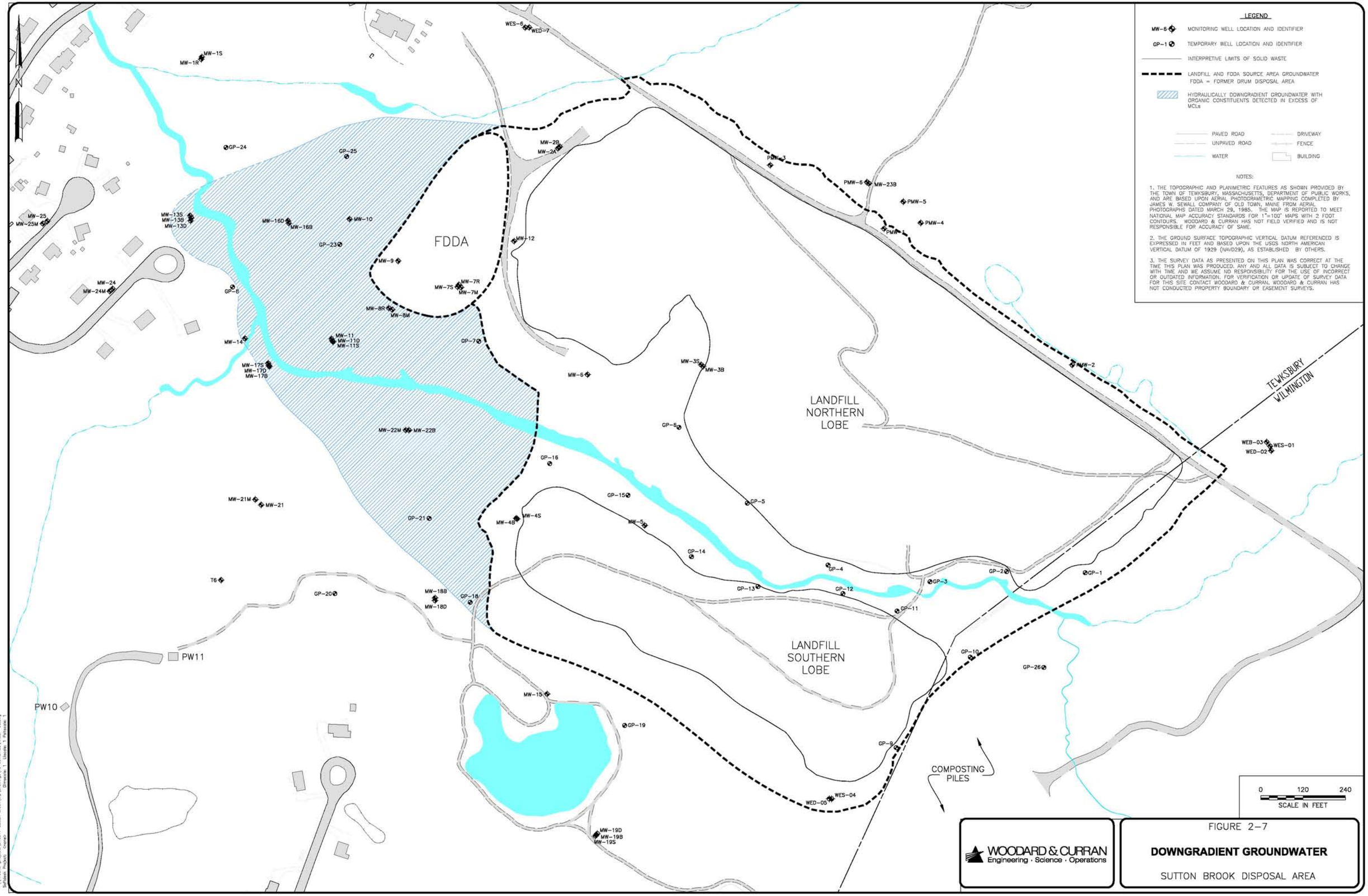
LEGEND
MW-6 MONITORING WELL LOCATION AND IDENTIFIER
GP-1 TEMPORARY WELL LOCATION AND IDENTIFIER
INTERPRETIVE LIMITS OF SOLID WASTE
LANDFILL AND FDDA SOURCE AREA GROUNDWATER
FDDA = FORMER DRUM DISPOSAL AREA
HYDRAULICALLY DOWNGRADIENT GROUNDWATER WITH ORGANIC CONSTITUENTS DETECTED IN EXCESS OF MCLs
PAVED ROAD
UNPAVED ROAD
WATER
DRIVEWAY
FENCE
BUILDING
NOTES:
1. THE TOPOGRAPHIC AND PLANIMETRIC FEATURES AS SHOWN PROVIDED BY THE TOWN OF TEWKSBURY, MASSACHUSETTS, DEPARTMENT OF PUBLIC WORKS, AND ARE BASED UPON AERIAL PHOTOGRAMETRIC MAPPING COMPLETED BY JAMES W. SEWALL COMPANY OF OLD TOWN, MAINE FROM AERIAL PHOTOGRAPHS DATED MARCH 29, 1985. THE MAP IS REPORTED TO MEET NATIONAL MAP ACCURACY STANDARDS FOR 1"=100' MAPS WITH 2 FOOT CONTOURS. WOODARD & CURRAN HAS NOT FIELD VERIFIED AND IS NOT RESPONSIBLE FOR ACCURACY OF SAME.
2. THE GROUND SURFACE TOPOGRAPHIC VERTICAL DATUM REFERENCED IS EXPRESSED IN FEET AND BASED UPON THE USGS NORTH AMERICAN VERTICAL DATUM OF 1929 (NAVD29), AS ESTABLISHED BY OTHERS.
3. THE SURVEY DATA AS PRESENTED ON THIS PLAN WAS CORRECT AT THE TIME THIS PLAN WAS PRODUCED. ANY AND ALL DATA IS SUBJECT TO CHANGE WITH TIME AND WE ASSUME NO RESPONSIBILITY FOR THE USE OF INCORRECT OR OUTDATED INFORMATION. FOR VERIFICATION OR UPDATE OF SURVEY DATA FOR THIS SITE CONTACT WOODARD & CURRAN. WOODARD & CURRAN HAS NOT CONDUCTED PROPERTY BOUNDARY OR EASEMENT SURVEYS.
FDDA
LANDFILL NORTHERN LOBE
LANDFILL SOUTHERN LOBE
TEWKSBURY
WILMINGTON
COMPOSTING PILES
PW11
PW10
MW-1S
MW-1R
WES-6
WED-7
GP-24
GP-25
MW-2B
MW-2A
PMW-3
PMW-6
MW-23B
PMW-5
PMW-4
PMW-1
PMW-2
MW-25
MW-25M
MW-13S
MW-13B
MW-13D
MW-16D
MW-16B
MW-10
GP-23
MW-12
MW-9
MW-24
MW-24M
GP-8
MW-7S
MW-7R
MW-7M
MW-8R
MW-8M
MW-14
MW-11
MW-11D
MW-11S
GP-7
MW-17S
MW-17D
MW-17B
MW-6
MW-3S
MW-3B
GP-6
MW-22M
MW-22B
GP-16
WEB-03
WES-01
WED-02
MW-21M
MW-21
GP-21
MW-4B
MW-4S
GP-15
MW-5
GP-5
GP-14
GP-4
GP-13
GP-12
GP-3
GP-2
GP-1
T6
GP-20
MW-18B
MW-18D
GP-18
GP-11
GP-10
GP-26
MW-15
GP-19
GP-9
WED-05
WES-04
MW-19D
MW-19B
MW-19S
0 120 240
SCALE IN FEET
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FIGURE 2-7
DOWNGRADIENT GROUNDWATER
SUTTON BROOK DISPOSAL AREA

3. IDENTIFICATION OF ARARs AND TBCs AND DEVELOPMENT OF RAOs AND PRGs

This section provides the identification of Applicable or Relevant and Appropriate Requirements (ARARs), To Be Considered Guidelines (TBCs), and Remedial Action Objectives (RAOs). In addition, the approach used to develop the Preliminary Remediation Goals (PRGs) and the areas identified for remedial action are also included in this section.

3.1 IDENTIFICATION OF ARARs AND TBCs

A list of preliminary and probable applicable or relevant and appropriate requirements (ARARs) and publicly available EPA and Massachusetts Department of Environmental Protection (MassDEP) criteria, advisories, and guidance (to be considered or TBCs) were developed, revised, and used throughout the RI/FS implementation.

ARARs are environmental or public health requirements that are promulgated by the federal or state government and are determined to be legally applicable or relevant and appropriate to the chemicals/contaminants, remedial activities, or other actions/circumstances at a CERCLA site. The two types of ARARs, applicable and relevant and appropriate, are defined below.

- Applicable requirements are those cleanup standards, standards of control, and other substantive requirements, criteria, or limitations promulgated under federal or state environmental or facility siting laws that specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstances at a CERCLA site.
- Relevant and appropriate requirements are those cleanup standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under federal or state environmental or facility siting laws that, while not applicable to a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstances at a CERCLA site, address problems or situations sufficiently similar to those encountered at the CERCLA site that their use is well suited to the particular site.

Other requirements to be considered (TBCs) are non-promulgated guidance or advisories established by the federal or state government that are not legally enforceable or binding. However, they may be considered during development and evaluation of remedial alternatives and cleanup levels for the protection of public health and the environment.

A summary of the chemical, location and action specific ARARs and TBCs is presented in attached Tables 3-1 through 3-3, respectively. These tables include a listing of the regulation, criteria, guidance, etc., a brief summary of the requirement, its status, and what media it pertains to (e.g., surface water, groundwater, etc.). A discussion on the actions to be taken to attain the requirement is presented in the detailed analysis (refer to Section 8).

ARARs and other criteria, advisories, and guidance will be considered in terms of their chemical-specific, location-specific, and action-specific attributes as discussed below.

Chemical-specific ARARs generally involve health or risk-based numerical limits on the amount of, or concentration of, a chemical that may be found in, or discharged to the ambient environment. The chemical specific ARARs for the site are presented in Table 3-1.

Location-specific ARARs are general restrictions placed upon the concentration of hazardous substances or the conduct of activities solely because they are in special locations, such as, floodplains, wetlands, historic places, places with objects of archaeological significance, and sensitive ecosystems or habitats. The location specific ARARs for the site are presented in Table 3-2.

Action-specific ARARs are usually technology-based or activity-based directions or limitations that control actions taken at CERCLA sites. Action-specific ARARs, as the name implies, govern the remedial actions themselves. The action specific ARARs for the site are presented in Table 3-3.

In addition to their chemical-specific, location-specific, and action-specific attributes, ARARs and other criteria, advisories, and guidance will be:

- evaluated for each medium (surface water, ground water, sediment, soil, etc.), particularly for chemical-specific ARARs, but including other ARARs as appropriate;
- distinguished for each technology considered, particularly for action-specific ARARs, but including other ARARs as appropriate; and
- considered at each major step of the RI/FS where they are indicated.

3.2 MEDIA OF CONCERN

For the development and evaluation of remedial alternatives for the Site, the media of concern (soil, sediment, indoor air, leachate, surface water and groundwater) have been organized based on their location (source area or non-source area (i.e. downgradient)). Throughout this remedial evaluation, the following areas and associated media will be combined:

- "Source Areas":
  - Landfill lobes – waste, air, leachate, sediment, surface water and groundwater
  - Former Drum Disposal Area – soil, groundwater, and indoor air
  - Garage and Storage Area – soil and groundwater
- "Non-Source Areas" (Management of Migration) – sediment, wetland soil, surface water and groundwater in areas outside of the source areas

3.3 REMEDIAL ACTION OBJECTIVES

Remedial action objectives (RAOs) consist of media-specific goals for protecting human health and ecological and environmental receptors. Typically, the RAOs specify the environmental media and contaminants of concern (COCs), exposure routes and receptors, and Preliminary Remediation Goals (PRGs) for each exposure medium of concern.

The preliminary RAOs utilized in the FS, are summarized below.

- Prevent direct contact/ingestion of landfill contents for the protection of human and ecological receptors;
- Prevent direct contact and ingestion of residual levels of SVOCs and VOCs in soils in the FDDA and metals and SVOCs in soils in the garage and storage area above applicable human health or ecological based criteria;

- Prevent direct exposure to impacted surface water and sediments in those areas of the wetlands and brook determined by the ecological risk assessment;
- Prevent contaminant migration via surface run-off and erosion through the "source areas" to surface water or sediments in the brook or wetlands for the protection of ecological receptors;
- Control landfill gas;
- For the protection of potential human receptors, reduce contaminant leaching via infiltration through the "source areas" with subsequent migration to groundwater at concentrations in excess of state or Federal Maximum Contaminant Levels (MCLs) and applicable groundwater quality standards. For contaminants where no state or Federal drinking water standard has been established, reduce leaching such that groundwater concentrations will not exceed human health risk-based levels (i.e., greater than the carcinogenic target risk range of 10^{-4} to 10^{-6} or non-carcinogenic target organ Hazard Index of 1);
- For the protection of potential human receptors, prevent exposure to groundwater impacted by site contaminants at concentrations that exceed state or Federal drinking water standards (MMCLs or MCLs). For contaminants where no state or Federal drinking water standard has been established, prevent exposure to concentrations which exceed human health risk-based levels (i.e., greater than the carcinogenic target risk range of 10^{-4} to 10^{-6} or non-carcinogenic target organ Hazard Index of 1). For contaminants that are a concern with respect to vapor intrusion, prevent exposure to indoor air concentrations that are not protective of human health;
- Limit the discharge of impacted groundwater to Sutton Brook to prevent site contaminants in surface water or sediment from exceeding ecological based criteria or unacceptable levels of risk to ecological receptors;
- Prevent migration of contaminants off-site via groundwater or surface water at levels in excess of Federal and/or state standards/criteria or unacceptable levels of risk to human or ecological receptors.

3.4 PRELIMINARY REMEDIATION GOALS

Preliminary remediation goals (PRGs) have been developed for each medium of concern based on the potential human health and ecological risks as a result of site specific conditions. The following sections describe how the PRGs were developed and provide a listing of numerical PRGs separated by human health based and ecological based PRGs. These PRGs were used to identify areas for remedial actions and to define the areas and/or volume of impacted media on-site requiring remediation.

It should be noted that consistent with the overall approach of the RI/FS, soil and waste in the landfill lobes will be capped; therefore, soil PRGs were not derived for this portion of the Site. Similarly, although benzene in ambient air (samples were collected on the landfill lobes) was associated with potential human health risks slightly above risk management criteria ($2x10^{-6}$), the landfill lobes will be capped and a gas collection system will be installed to address emissions. Accordingly, PRGs were not derived for benzene in ambient air.

3.4.1 Human Health PRGs

The initial step in the PRG development process was to identify COPCs for each site medium with risks elevated above the cumulative incremental lifetime cancer risk (ILCR) or hazard index (HI) risk management criteria used in the baseline risk assessment (ILCR greater than 10^{-4} to 10^{-6} and/or a target organ HI greater than one (1) in any site medium). These COPCs or 'risk drivers" are presented by area and medium on Table 3-4. With one exception, noted below, this list of COPCs was carried forward through the PRG development process for the respective media. The one exception was related to groundwater and a comparison of groundwater data to chemical specific ARARs for the site (e.g., Federal Maximum Contaminant Levels [MCLs]). As part of this process, for compounds without MCLs, other levels or health advisories identified as ARARs or TBCs were also used in the comparison. This evaluation consisted of comparing the maximum detected concentration in groundwater to the respective ARAR or TBC. The results of this comparison are presented in Tables 3-5 for Groups 1 and 2 groundwater and Table 3-6 for Groups 3 through 6 groundwater. COPCs not identified as primary risk drivers with maximum concentrations in excess of the respective ARAR/TBC were also carried forward through the PRG development process. These COPCs included aluminum, iron, lead, nickel, selenium, sodium, styrene, 1,1,1-TCA, and 1,1-DCE. However, because there was no risk associated with aluminum, iron and sodium and cleanup levels are typically not set on secondary MCLs or advisories, these three inorganics were not carried forward in the PRG development process.

The next fundamental step in the PRG development process was to assess the risk drivers in the context of reference concentrations. In accordance with EPA guidance (*Role of Background in the CERCLA Cleanup Program, OSWER 9285.6-07P, 2002*), cleanup of constituents to concentrations below natural and/or anthropogenic levels found in the area of the site is generally not required. As described in the RI report, reference samples were collected from off-site locations where no overt sources of constituents were present, other than those naturally-occurring or related to anthropogenic non-point sources (such as roadway run-off). These conditions were assessed to evaluate whether concentrations of inorganic or PAH COPCs or possible laboratory contaminants identified in each medium at the site are consistent with reference concentrations.

As described in the baseline risk assessment, inorganics are naturally-occurring and are also constituents that often may exert elevated toxicity; therefore, inorganic COPC concentrations that, based on the statistics presented in the risk assessment, were not significantly different from the reference concentrations were identified as a "Reference" throughout the risk assessment. This approach was also used for PAHs which are ubiquitous in the environment. This identification was performed to understand how potential site risks compared to reference-related risks.

The comparison of Site to Reference concentrations was performed in accordance with EPA's *Guidance for Comparing Background and Chemical Concentrations in Soil for CERCLA Sites* (USEPA, 2002). As presented in Appendix D of the baseline risk assessment, data distributions were evaluated for pertinent SVOCs and inorganics within the groundwater, surface water, soil, and sediment datasets. The majority of the site and reference data distributions were highly right-skewed. Few of the data sets approximated a normal distribution and, in the majority of cases, standard log transformations did not normalize the data. Due to this condition, and because fewer than 20 Reference samples were generally analyzed from each medium or area, the non-parametric Wilcoxon Rank Sum test, which compares medians of the data sets, was utilized.

EPA's *Guidance for Comparing Background and Chemical Concentrations in Soil for CERCLA Sites* (USEPA, 2002) recommends that the Wilcoxon Rank Sum test not be used in cases where greater than 40% of the data are non-detects. This condition was encountered for several of the constituents; however, in all of these cases, the inorganic or PAH constituent was determined to be Site-related (i.e., higher in Site data than in reference data).

Based on the comparisons described above, select COPCs in select media were found to be consistent with reference, and these were noted as applicable on risk tables wherein three risks were presented – "Total Risks" (site-related and reference related risks summed together), "Site-related Risks" (includes risks for those COPCs associated with site conditions) and "Reference Risks" (includes risks for those COPCs found to be consistent with reference conditions).

Applying the statistical evaluation results to the primary risk drivers in Table 3-4, arsenic in soil (upland and wetland) is the only COPC considered consistent with reference concentrations and thus a PRG has not been developed for this specific COPC. Given the uncertainty associated with the statistical methods, those COPCs, that were found to be consistent with reference and for which > 40% of the data were non-detected values (see Table D-6 of Appendix D in the Baseline Risk Assessment), have been excluded from the consistent with reference list (i.e., they will continue to be evaluated in the PRG development process).

The third step in the PRG development process was the calculation of risk based clean-up levels (RBCGs) for those COPCs identified in the baseline human health risk assessment (HHRA) as primary "risk drivers" for a particular medium at the Site (Table 3-4). Given the discussion presented above, RBCGs were not derived for arsenic in soils due to being consistent with reference conditions. RBCGs were not derived for Group 5 and 6 sediments based on estimated risks. The risk associated with 30-year exposure to a child/adult resident assumed to access the area recreationally is estimated to be in the upper-end of the acceptable risk range. The risk associated with 10-year exposure to older children (ages 8 to 18) assumed to be trespassing in the area is well within the acceptable risk range. Residents, including young children, were conservatively assumed to have exposure to sediment for 90 days (approximately 3 times per week over a 7 month period). Older children were also assumed to be exposed to contaminated sediments for 90 days per year. Given the difficult access to the Group 5 and 6 sediments, the risks associated with exposure to contaminated sediments by older children is considered more likely than by a young child/adult resident.

A list of media and receptors with risks above risk management criteria are provided below:

- Groups 3-6 Groundwater: future resident (potable use) and future facility worker (commercial groundwater use)
- Groups 1-2 Groundwater: future resident (potable use)
- Group 3 (FDDA) Indoor Air (based on intrusion from groundwater only): Future residential and future facility worker
- Group 4 (GSA) Upland Soil: Future resident

The chemical specific RBCGs are concentration goals for individual chemicals for specific medium and land uses/exposure scenarios. The specific chemical information, exposure parameters and toxicity values used to develop the RBCGs rely on the baseline HHRA. The cumulative cancer and non-cancer risk estimates for the reasonable maximum exposure (RME) scenarios evaluated for the Site were used as the basis for deriving RBCGs, as these scenarios address the most comprehensive and intense exposures

(i.e., resulting in the highest cumulative risks) for both current and/or potential future land and groundwater uses at the Site.

Although the HHRA evaluated risks associated with different areas (Groups) of the Site, PRGs are medium-specific and independent of each Group, assuming that exposures may vary among media but not within a specific medium.

For soil, relevant exposure routes include dermal contact with and incidental ingestion of these media. The risks associated with inhalation of soil-borne (fugitive) dust were negligible relative to these exposure routes and thus, this exposure pathway is eliminated from further consideration. For groundwater, exposure routes include ingestion of and dermal contact with potable groundwater, and inhalation of volatile constituents while showering. The HHRA also evaluated risks associated with the inhalation of volatiles in indoor air resulting from vapor intrusion from the subsurface. PRGs were not developed for indoor air, however, risks from vapor intrusions will require evaluation prior to residential and commercial construction. Potential risks associated with vapor intrusion of contaminants in soil under future scenarios were not quantified separately from risks associated with vapor intrusion from contaminated groundwater. These risks will also be evaluated prior to any future construction.

Within the targeted media, both non-cancer and cancer based RBCGs were calculated for individual COPCs above the risk limit or risk range. For those COPCs for which PRGs were developed, the following approach was utilized in deriving RBCGs. The RBCG is essentially a "back-calculation" of the risk, wherein the equation is "solved" for the acceptable medium concentration, rather than performing the "forward" risk calculation using the site concentration to calculate risk. The RBCG is a function of the target risk limits, human exposure assumptions and toxicity information, where:

$RBCG_{nc}$ = Target HI / [(oral intake factor/oral reference dose) + (dermal intake factor* dermal absorption fraction/dermal reference dose)]

$RBCG_{c}$ = Target ILCR / [oral intake factor * oral cancer slope factor) + (dermal intake factor * dermal absorption fraction * dermal cancer slope factor)]

Consistent with EPA guidance, for noncarcinogenic effects, a RBCG was calculated corresponding to an HI of 1, which is the level of exposure to a chemical from all significant exposure pathways in a given medium below which adverse health effects are unlikely. For carcinogenic effects, a RBCG was calculated to correspond to a 10^{-6} incremental risk of an individual developing cancer over a lifetime considering exposure to the potential carcinogen from all significant exposure pathways for a given medium. It should be noted that the 10^{-6} target cancer risk level is considered a "point of departure" for derivation of cancer-based RBCG, representing the most conservative (stringent) end of EPA's target cancer risk range of 10^{-6} to 10^{-4}. Cancer-based RBCGs using a 10^{-5} target cancer risk level were also derived to support subsequent evaluations and risk management decisions weighing the extent of remediation required relative to the resulting level of protectiveness.

A summary of the RBCGs (non-cancer and cancer [10^{-5} and 10^{-6}]) for each media and for each receptor group is presented on Tables 3-7 (residential scenario) and Table 3-8 (facility worker). The back-up calculations/derivations (toxicity values, exposure factors for each relevant receptor, exposure route and chemical, etc.) for the RBCGs for each receptor group are provided in Appendix A. For ease of presentation, the 10^{-5} based RBCGs are not presented on the RBCG "back-up" tables in Appendix A. As shown on these tables, RBCGs based on cancer were typically more stringent than those based on

threshold effects, and RBCGs for residential receptors were generally the lowest relative to the other receptors considered.

The final step in the PRG development process was to compare the RBCGs to ARARs, TBCs, reference concentrations, and laboratory project quantitation limits (PQLs) with the objective a selecting a PRG for use in the FS. PQLs for each medium and COPC were obtained from the September 10, 2004 Quality Assurance Project Plan (QAPP) prepared for the Site with additions for those compounds not included in the QAPP. Reference concentrations were based on the "reference" dataset for soil, sediment and groundwater, as discussed in the HERA. The 90th percentile concentration of each dataset was selected as the reference concentration. This PRG and its basis is also included on Tables 3-7 and 3-8.

For soils, the only chemical-specific ARAR identified for human health was the Method 1 Soil Standards (S-1/GW-1) identified in the Massachusetts Contingency Plan (MCP; 310 CMR 40.0000). These standards are considered relevant and appropriate with respect to soils (upland or wetland) under the residential scenario. The S-1/GW-1 soil standards are protective of residential soil exposures as well as leaching to aquifers that are or may be used as a source of potable water. Given that the full provisions of the MCP are not considered an ARAR for the site, other Method 1 soil standards (i.e., S-2 or S-3) for exposures based on frequency, intensity, and activity and use restrictions were not incorporated into the PRG development process.

The PRG for soils was set at the lower of the RBCG or ARAR provided that the PRG was above the laboratory's PQL. In some instances the lowest RBCG was the 10^{-6} RBCG and this level was below the PQL, especially in cases of PAHs. In this case, the lower of the ARAR or the 10^{-5} RBCG was selected as the PRG. In addition, the PRG was also compared to the reference concentration to verify that cleanup levels were not set at concentrations below those naturally-occurring or non-point anthropogenic sources of contaminants, such as PAHs, that are ubiquitous in the environment (this was not the case in any of the scenarios).

For groundwater, ARARs included the Federal Maximum Contaminant Levels (MCLs). In addition, Massachusetts DEP Office of Research and Standards Drinking Water Guidelines (ORSGs) and EPA Office of Water, Drinking Water Health Advisories (HAs) were considered TBCs for compounds in which MCLs are not available. The PRGs for groundwater followed the same approach as that for soils; however, the PRG was typically set at the ARAR (MCLs) or in instances with no MCLs, the PRG was set at the TBC or RBCG.

3.4.2 Ecological Based PRGs

Ecological based PRGs were developed following a similar step-wise process as that followed for the human health based PRGs. The initial step in the process was to identify those COPCs determined in the Baseline Ecological Risk Assessment (BERA) to have a potential to cause adverse ecological effects (i.e., are considered to be the ecological "risk drivers"). These COPCs are presented by location, receptor, and assessment endpoint on Table 3-9.

As discussed in the BERA, sample results were also screened against those chemical specific ARARs and TBCs identified for the site. The only chemical specific ARAR/TBC pertinent to the ecological risk assessment was ambient water quality criteria (AWQC) of the Clean Water Act, which was identified by EPA as an ARAR. Surface water is a medium of concern for only ecological receptors (hence, human health PRGs were not derived for surface water); therefore, the Criterion Continuous Concentration

(CCC), which is protective of chronic exposures for aquatic organisms, was selected as the applicable surface water value. The only ecological risk drivers that were based on an exceedance of a chronic AWQC were iron and 4,4'-DDT.

With regard to 4,4'-DDT, this compound was not detected in the 27 other surface water samples collected across the site. However, given that DDT was detected in 1 of the 3 samples collected within the site channel portion of the Upper Sutton Brook and its proximity to the landfill lobes, DDT was carried through the PRG development process.

A discussion of iron in the context of the PRG development process is provided below.

Iron in surface water: Iron was identified as a risk driver in the surface water of both the Aquatic Wetland and the Eastern Reach of Upper Sutton Brook due to concentrations exceeding the federal chronic water quality criteria for iron (an ARAR for this Site).

Although variable, the highest concentrations of dissolved iron were detected in an area adjacent to the Southern Lobe (Deep Marsh). Visible iron staining is observable on sediments/surface water in this area with landfilled waste up to the wetland boundary. As part of the capping of the landfill, this area will be disturbed (cap construction) as well as potentially be used for a stormwater detention basin (refer to Section 8). The other area of AWQC exceedance is in the large wetland area downstream of the landfills. Concentrations of dissolved iron were fairly consistent in this area across the spatially distributed sample locations (1.1, 1.1, 1.1, 1.7 mg/l) and only slightly in excess of the chronic AWQC of 1.0 mg/l. Samples collected within the channelized flow of Sutton Brook were variable in both concentration, location, and season. For example the concentrations of dissolved iron detected in SW-36 over the seasons were 2.6 mg/l (October 2004), 0.51 mg/l (September 2005), 0.55 mg/l (February 2006), and 1.2 mg/l (October 2006).

No acute AWQC exist for iron, however, the LOAEL developed as part of the BERA is 7.3 mg/l (based on effects to a mayfly, a sensitive species). The maximum detected concentration of iron of 5.3 mg/l is below this value.

Iron is a naturally occurring element that was detected in all reference surface water samples and is characteristic of wetland waters generally because of the reducing conditions associated with anaerobic sediments and waters.

Given that maximum concentrations are below estimated LOAEL values, there is seasonal variability in the iron concentrations with concentrations being above or below the AWQC in different seasons from the same location, remedial action in the highest area of iron concentrations will be conducted as part of cap construction, and iron is naturally elevated in anaerobic environments, detected concentrations are considered to be largely reflective of natural conditions and/or will be addressed as part of the landfill capping. As such, a PRG for iron for the purposes of this FS has not been developed.

The next step in the PRG development process was to assess these risk drivers in the context of reference and/or naturally occurring concentrations in the area of the site given that in accord with EPA guidance cleanup of constituents to concentrations below natural and/or anthropogenic levels found in the area of the site is generally not required. A discussion of the constituents that fall into this category is presented below.

Barium and Manganese in USB Site Channel surface water: Both barium and manganese were identified as risk drivers because they exceeded NOAEL-based benchmarks used in the SLERA. However, they are both naturally occurring constituents of sediment and surface water and were detected in all reference samples. The Agency for Toxic Substances and Disease Registry Toxicological Profile for barium indicates that barium is present in most drinking water supplies at average concentrations up to 0.06 mg/L, similar to the maximum of 0.08 mg/L measured in USB Site Channel surface water. The average barium concentration detected in site channel surface water of 0.03 mg/l was similar to the average barium concentration detected in reference locations of 0.02 mg/l.

Manganese is a dominant soil and sediment constituent that is mobilized from sediment under anoxic conditions. The maximum concentration in Site Channel surface water (0.53 mg/L in SW-33(05)) and average concentration (0.22 mg/l) is generally similar to the maximum reference concentration of 0.35 mg/L in SW-30(05) and average concentration (0.21 mg/l). These COPCs are thus considered to be reflective of natural conditions and PRGs for the purposes of this FS have not been developed.

Aluminum in Aquatic Wetland Surface Water: Concentrations of aluminum were detected in Aquatic Wetland surface water in one of 14 samples, at a concentration of 0.22 mg/L. Aluminum was detected in one of two reference samples (SW-222) at a concentration of 0.1 mg/L. Aluminum can exist in a range of concentrations in small quiescent water bodies frequented by amphibians; for example, aluminum concentrations in the range of 0.2 mg/L to 1.85 mg/L were documented in 50 temporary ponds in Pennsylvania (Horne and Dunstan, 1995). Aluminum solubility is related to water pH, which can vary throughout the day as the result of temperature and photosynthetic activity, so small fluctuations may occur naturally. Thus, aluminum is considered to be reflective of natural conditions and a PRG for the purposes of this FS has not been developed.

Manganese in USB Site Channel sediment: Manganese was included as a risk driver in sediment for the Site Channel portion of Upper Sutton Brook because of exceedances of NOAEL-based benchmarks in the SLERA. However, the concentration of manganese in Site Channel sediments was well within the range detected in reference samples. Concentrations of manganese in Site Channels sediments ranged from 79 mg/kg to 550 mg/kg, whereas reference concentrations ranged from 39 mg/kg to 2730 mg/kg. Manganese is a dominant element in rock and soil, and is typically present in sediment, particularly in slow-moving streams and wetlands. Because manganese in Site Channel sediment is consistent with reference concentrations, a PRG for the purposes of this FS has not been developed.

Arsenic in USB Site Channel sediment: Arsenic was included as a risk driver in sediment for the Site Channel portion of Upper Sutton Brook because of exceedances of NOAEL-based benchmarks in the SLERA. Concentrations of arsenic in the five Site Channel sediments ranged from 8.3 mg/kg to 160 mg/kg, and four of the five samples exhibited concentrations of 78 mg/kg or less. However, as described in the BERA Section 4.3.4.1, toxicity testing on sediments from the adjacent Southern Tributary showed no effects on test invertebrate survival at sediment arsenic concentrations up to 130 mg/kg, and no discernable correlation in growth reduction with arsenic levels. Based on these findings, the HQ reflected by the arsenic NOAEL-based benchmark used in the SLERA likely overestimates actual arsenic-related effects. The results of the toxicity testing suggest a site-specific invertebrate NOAEL for mortality of 130 mg/kg, and the maximum arsenic concentrations detected in the Site Channel (160 mg/kg) only slightly exceeded this value, producing a site-specific NOAEL-based HQ of 1.2. As described in BERA Section 4.3.4.2, arsenic concentrations in Upper Sutton Brook appear to be affected by contributions from the Southern Tributary, which is a current and historical location of elevated arsenic from areas up stream

of the site. As such, a PRG for arsenic in site channel sediments for the purposes of this FS has not been developed.

The final step in the PRG development process was the calculation of numerical PRGs for those COPCs identified in the BERA as the primary "risk drivers" for a particular medium at the Site (Table 3-9, excluding those constituents described above). Based on assumptions used in the ecological risk assessment, the PRGs developed for the Upper Sutton Brook and Former Drum Disposal Area were based on the screening level risk assessment and therefore, depending on their use, may not be applicable as numerical cleanup goals as typically used in remediation verification. For example, prior to sediment removal from the site channel, additional delineation data may be collected which could be used to refine the preliminary remediation goals as presented in the FS. Ecological based PRGs are summarized in Table 3-10.

3.5 DEFINITION OF AREAS AND/OR VOLUMES OF IMPACTED MEDIA

With the establishment of PRGs, the areas and/or volumes of impacted media on-site presenting current or potential future human health or ecological risks have been further defined for the purposes of this FS. The PRGs used for this purpose were: 1) the lower of the human health based PRGs for each receptor group (e.g., residential scenario); and 2) the ecological PRGs.

In addition to the numerical based PRGs, other remedial action objectives were also used in the development of these areas/volumes. For example, in the FDDA, the specific area of impacted soils identified for evaluation in this FS is larger than the area in excess of the human health or ecological PRGs due to the objective of removing residually impacted soils that are continuing to be a source to groundwater concentrations in excess of PRGs.

Utilizing the remedial action objectives and PRGs developed in the previous sections; the area and/or volume of each media used in the FS are presented in the table below. As presented previously, the media of concern (soil, sediment, waste, surface water and groundwater) have been organized based on their location (source area or non-source area [i.e. downgradient]). These areas and/or volumes have been used in the detailed analysis (Section 8) to evaluate the remedial alternatives and to develop order of magnitude cost estimates.

Table 3-11
Summary of Impacted Areas and Volumes

		Area		Volume	
Source Areas					
Landfill Lobes	Waste - Northern Lobe	30	acres	1.90E+06	cy
	Waste - Southern Lobe	10	acres	3.00E+05	cy
	Sediment - Sutton Brook	24,000	sq ft	900	cy
	Surface Water – Sutton Brook Site Channel	24,000	sq ft		
	Groundwater	32.2	acres	--	
FDDA	Soil	38,300	sq ft	8,900	cy
	Groundwater	1.6	acres	--	
GSA	Soil	8,150	sq ft	530	cy
Non-source Areas					
	Groundwater	16.8	acres	--	

TABLE 3-1
CHEMICAL SPECIFIC ARARs and TBCs
Sutton Brook Disposal Area Superfund Site, Tewksbury, Massachusetts

Media	Requirement	Status	Summary of Requirement
Groundwater	**Federal Regulatory Requirements**		
	Federal Safe Drinking Water Act (SDWA) Maximum Contaminant Levels (MCLs) (40 CFR Part 141)	Relevant and appropriate	MCLs are enforceable standards that regulate the concentration of specific organic and inorganic contaminants that have been determined to adversely affect human health in public drinking water supplies. MCLs may be relevant and appropriate for the groundwater at the Site because the aquifer is a potential source of drinking water.
	SDWA Maximum Contaminant Level Goals (MCLGs) (40 CFR 141.50-141.51)	Relevant and appropriate	Non-zero MCLGs are non-enforceable health goals set for certain organic and inorganic compounds for public water systems. MCLGs are set at levels that would result in no known or expected adverse health effects with an adequate margin of safety.
	EPA Risk Reference Doses (RfDs)	To be considered	RfDs are dose levels developed by EPA for use in estimating the non-carcinogenic risk resulting from exposure to toxic substances.
	EPA Human Health Assessment Cancer Slope Factors (CSFs)	To be considered	CSFs are developed by EPA for health effects assessments or evaluation by the Human Health Assessment Group. These values present the most up-to-date cancer risk potency information and are used to compute the individual incremental cancer risk resulting from exposure to carcinogens.
	Guidelines for Carcinogen Risk Assessment (EPA/630/P-03/001F, March 2005)	To be considered	Guidance values are to be used to evaluate the potential carcinogenic hazard caused by exposure to contaminants.
	Supplemental Guidance for Assessing Susceptibility from Early-Life Exposure to Carcinogens (EPA/630/R-03/003F, March 2005)	To be considered	Guidance values are to be used to evaluate the potential carcinogenic hazard to children caused by exposure to contaminants.
	EPA Office of Water, Drinking Water Health Advisories EPA 822-R-06-013	To be considered	Health Advisories (HAs) are estimates of acceptable drinking water levels for chemical substances based on health affects information; an HA is not a legally enforceable Federal standard, but serves as technical guidance to assist federal, state and local officials. HAs are used if a constituent does not have a promulgated MCL or MCP GW-1 Standard.
	State Regulatory Requirements		
	Massachusetts Groundwater Quality Standards (314 CMR 6.00)	Relevant and appropriate	These standards consist of ground water classifications, which designate and assign the uses for which the various ground waters of the Commonwealth shall be maintained and protected; water quality criteria necessary to sustain the designated uses; and regulations necessary to achieve the designated uses or maintain the existing ground water quality. The GWQSs set numeric limits for certain contaminants as well as a pH range. They are to be used when they are more stringent than Federal MCLs.
	Massachusetts Drinking Water Standards (310 CMR 22.00)	Relevant and appropriate	These standards establish State MCLs for organic and inorganic contaminants that have been determined to adversely affect human health in public drinking water systems. The aquifer on-site is not a public water system, but these requirements are R&A because the aquifer has the potential to be used as a source of drinking water. These requirements are to be used when they are more stringent than Federal MCLs.
	Massachusetts Contingency Plan (310 CMR 40.0000), Method 1 GW-1 Standards	Relevant and appropriate	The MCP Method 1 groundwater standards assume exposure to concentrations of oil and/or hazardous material in groundwater under current or foreseeable future conditions. These standards contain a list of numerical, risk-based limitations on particular contaminants in groundwater based on the groundwater classification.
	Massachusetts DEP Office of Research and Standards Guidelines (ORSG)	To be considered	Guidance values used for groundwater if a constituent does not have a promulgated MCL or MCP GW-1 standard.
Sediment/Soil	**State Regulatory Requirements**		
	Massachusetts Contingency Plan (310 CMR 40.0000), Method 1 Soil Standards	Relevant and appropriate	The MCP Method 1 soil standards assume exposure to concentrations of oil and/or hazardous material in soil under current or foreseeable future conditions. The Method 1 soil standards may be considered as remedial goals depending on the current and foreseeable future use of the site.
Surface Water	**Federal Regulatory Requirements**		
	Clean Water Act (CWA) Ambient Water Quality Criteria (AWQC) (33 USC 1251 *et seq*.) (40 CFR 122.44)	Relevant and appropriate	Federal AWQC are recommended (non-enforceable) criteria published by EPA and provided to the States. AWQC are listed for protection of ecological and human health for approximately 160 contaminants.

Notes:
ARAR - Applicable or Relevant and Appropriate Requirement
MCLs - Maximum Contaminant Levels
TBC - To Be Considered
USEPA - U.S. Environmental Protection Agency
MCLGs - Maximum Contaminant Level Goals

TABLE 3-2
LOCATION SPECIFIC ARARs and TBCs
Sutton Brook Disposal Area Superfund Site, Tewksbury, Massachusetts

Location	Requirement	Status	Summary of Requirement
Surface Water, Wetlands, Floodplains	**Federal Regulatory Requirements and Guidance**		
	Wetlands Executive Order (EO11990), 40 CFR 6.302(a), and 40 CFR Part 6, Appendix A	Applicable	The Wetlands Executive Order requires federal agencies to avoid undertaking or providing assistance for new construction located in wetlands unless there is no practicable alternative and the proposed action includes all practicable measures to minimize the destruction, loss, or degradation of wetlands, and preserve and enhance natural and beneficial values of wetlands.
	Clean Water Act Section 404 Dredge and Fill Regulations (40 CFR 230, 33 CFR 320-323)	Applicable	These regulations outline the requirements for the discharge of dredged or fill materials into surface waters including wetlands. No activity that impacts waters of the United States shall be permitted if a practicable alternative that has less adverse impact exists. If there is no other practicable alternative, the impacts must be mitigated.
	Rivers and Harbors Act Section 10 (33 USC 403, 33 CFR 320-323)	Applicable	Section 10 of the Rivers and Harbors Act prohibits unauthorized obstruction or alteration of navigable waters. No activity that impacts waters of the United States shall be permitted if a practicable alternative that has less adverse impact exists. If there is no other practicable alternative, the impacts must be mitigated.
	Floodplains Executive Order (EO11988), 40 CFR 6.302(b), and 40 CFR Part 6, Appendix A	Applicable	The Floodplains Executive Order requires federal agencies to avoid impacts associated with the occupancy and modification of a floodplain unless there is no practicable alternative and the proposed action includes all practicable measure to reduce the risk of flood loss, to minimize the impact of floods, and to restore and preserve the natural and beneficial values of floodplains.
	RCRA Floodplain Restrictions for Hazardous Waste Facilities (40 CFR 264.18(b))	Relevant and Appropriate	These regulations require that a hazardous waste facility located in a 100-year floodplain must be designed, constructed, operated, and maintained to prevent washout by a 100-year storm.
	Fish and Wildlife Coordination Act (16 USC 661 et seq, 40 CFR Part 6)	Applicable	The Fish and Wildlife Coordination Act requires action to protect fish and wildlife and requires consultation with the U.S. Fish and Wildlife Service and state wildlife agencies to mitigate losses of fish and wildlife that result from modification of a water body.
	State Regulatory Requirements		
	Massachusetts Wetlands Regulations (310 CMR 10.00; MGL c. 131, Section 40: Wetlands Protection Act)	Applicable	These regulations set performance standards for dredging, filling, and altering of any inland wetland, the buffer zone within 100 feet of a wetland, and the riverfront area (defined as the area between the river's mean annual high-water line and a line located 200 feet away). The requirement also defines wetlands based on vegetation type and requires that effects on wetlands be mitigated. Resource areas at the Site covered by the regulations include banks, bordering vegetated wetlands, land under bodies of water, land subject to flooding, riverfront and estimated habitats of rare wildlife. Under this requirement, available alternatives must be considered that minimize the extent of adverse impacts, and mitigation including restoration and/or replication is required.
	Massachusetts Water Quality Certification for Discharge of Dredged or Fill Material, Dredging, and Dredging Material Disposal in Waters of the U.S. within the Commonwealth (314 CMR 9.00)	Applicable	For discharges of dredged or fill material: there must be no practicable alternative with less adverse impact on the aquatic ecosystem; appropriate and practicable steps must be taken to avoid and minimize potential adverse impacts to wetlands and land under water; stormwater discharges must be controlled with BMPs; and there must not be substantial adverse impacts to the physical, chemical, or biological integrity of surface waters. For dredging and dredged material management: there must be no practicable alternative with less adverse impact on the aquatic ecosystem; and if avoidance is not possible then minimize, or if neither avoidance or minimization are possible, then mitigate potential adverse impacts.

TABLE 3-2
LOCATION SPECIFIC ARARs and TBCs
Sutton Brook Disposal Area Superfund Site, Tewksbury, Massachusetts

Location	Requirement	Status	Summary of Requirement
Surface Water, Wetlands, Floodplains	Massachusetts Waterways Regulations (310 CMR 9.00)	Applicable	These regulations set forth criteria for work within flowed and filled tidelands and other waterways. Waterways concerns focus on the long term viability of marine uses and protecting public rights in tidelands, including fishing and access.
	Massachusetts Hazardous Waste Rules, Facility Location Standards (310 CMR 30.700)	Applicable	These regulations set forth criteria for siting hazardous waste facilities within Land Subject to Flooding (as defined under the Massachusetts Wetlands Protection standards); surface water supplies; and actual, planned, or potential public water supplies
Other Natural Resources	**Federal Regulatory Requirements**		
	Endangered Species Act (16 USC 1531 et seq.; 40 CFR 6.302(h); 50 CFR 402)	Applicable if encountered	This statute requires that Federal agencies avoid activities which jeopardize threatened or endangered species or adversely modify habitats essential to their survival. Mitigation measures should be considered if a listed species or habitat may be jeopardized.
	National Historic Preservation Act (16 USC 470 et seq., 36 CFR 800)	Applicable if encountered	Pursuant to Sections 106 and 110(f) of the NHPA, as amended, CERCLA response actions are required to take into account the effects of the response activities on any historic property included or eligible for inclusion on the National Register of Historic Places.
	State Regulatory Requirements		
	Antiquities Act and Regulations; Massachusetts Historical Commission; Protection of Properties Included in the State Register of Historic Places (M.G.L. ch. 9, sec. 26-27; 950 CMR 70.00)	Applicable if encountered	These regulations require the adoption of all prudent and feasible means to eliminate, minimize or mitigate adverse effects to historic or archaeological properties, and require coordination with the Massachusetts Historical Commission.
	Massachusetts Endangered Species Act, 321 CMR 10.00, (MGL c. 131A)	Applicable if encountered	The Commonwealth of Massachusetts has the authority to research, list, and protect any species deemed endangered, threatened, or of other special concern. These species are listed as either endangered, threatened, or species of special concern in the regulations. Actions must be conducted in a manner that minimizes the effect on Massachusetts-listed endangered species and species listed by the Massachusetts Natural Heritage Program.

Notes:

ARAR - Applicable or Relevant and Appropriate Requirement
CWA - Clean Water Act
EPA - U.S. Environmental Protection Agency
CFR - Code of Federal Regulations
CMR - Code of Massachusetts Regulations
TBC - To Be Considered
CERCLA - Comprehensive Environmental Response, Compensation, and Liability Act
USC - U.S. Code
FS - Feasibility Study

TABLE 3-3
ACTION SPECIFIC ARARs and TBCs
Sutton Brook Disposal Area Superfund Site, Tewksbury, Massachusetts

Media	Requirement	Status	Summary of Requirement
Site Work	**State Regulatory Requirements**		
	Massachusetts Air Pollution Control Regulations (310 CMR 7.00)	Applicable	This regulation stipulates that during construction and/or demolition activities, air emissions (i.e. dust, particulates, etc.) must be controlled to prevent air pollution.
	MassDEP Stormwater Management Policy	To be considered	The goal of the policy is to improve water quality and address water quantity problems within Massachusetts through the implementation of performance standards for stormwater management.
Waste	**Federal Regulatory Requirements**		
	RCRA Subtitle C - Hazardous Waste Identification and Listing Regulations (40 CFR Parts 260-262 and 40 CFR 264.13)	Applicable	Massachusetts have been delegated the authority to administer these RCRA standards through its state hazardous waste management regulations. These provisions have been adopted by the State. These regulations include rules to identify hazardous waste and a requirement to obtain a detailed chemical and physical analysis of a representative sample of any hazardous wastes prior to treatment, storage, or disposal.
	RCRA Subtitle C - Closure and Post-Closure (40 CFR Subpart G, 264.111 and 264.117)	Applicable	Massachusetts have been delegated the authority to administer these RCRA standards through its state hazardous waste management regulations. These provisions have been adopted by the State. 40 CFR 264.111 identifies standards for closures of hazardous wastes facilities; 40 CFR 117 identifies post-closure standards for maintenance of facilities.
	RCRA Subtitle C - Landfills (40 CFR Subpart N, 264.310)	Applicable	Massachusetts have been delegated the authority to administer these RCRA standards through its state hazardous waste management regulations. These provisions have been adopted by the State. These regulations establish the minimum requirements for final covers of hazardous waste landfills.
	RCRA 40 CFR 264 Subpart I, Use and Management of Containers	Applicable if containers are used in the remedial action	Massachusetts have been delegated the authority to administer these RCRA standards through its state hazardous waste management regulations. These provisions have been adopted by the State. This regulation establishes requirements for the storage of containers of hazardous waste.
	RCRA 40 CFR 264 Subpart J, Tank Systems	Applicable if tank systems are used in the remedial action	Massachusetts have been delegated the authority to administer these RCRA standards through its state hazardous waste management regulations. These provisions have been adopted by the State. This regulation establishes requirements for the use of tank systems for storing or treating hazardous waste.
	RCRA 40 CFR 264 Subpart L, Waste Piles	Applicable if waste piles are used in the remedial action	Massachusetts have been delegated the authority to administer these RCRA standards through its state hazardous waste management regulations. These provisions have been adopted by the State. This regulation establishes requirements for the use of piles for storing or treating hazardous waste.
	RCRA 40 CFR 264 Subpart X, Miscellaneous Units	Applicable if miscellaneous units are used in the remedial action	Massachusetts have been delegated the authority to administer these RCRA standards through its state hazardous waste management regulations. These provisions have been adopted by the State. This regulation establishes requirements for the use of miscellaneous units for treating, storing, or disposing of hazardous waste.
	RCRA 40 CFR 264 Subpart AA, Air Emission Standards for Process Vents	Applicable if thresholds are met	This regulation establishes air emission standards for process vents, closed-vent systems, and control devices at hazardous waste facilities.

TABLE 3-3
ACTION SPECIFIC ARARs and TBCs
Sutton Brook Disposal Area Superfund Site, Tewksbury, Massachusetts

Media	Requirement	Status	Summary of Requirement
Waste (con't)	RCRA 40 CFR 264 Subpart BB, Air Emission Standards for Equipment Leaks	Applicable if thresholds are met	This regulation contains air pollutant emission standards for equipment leaks at hazardous waste TSD facilities. This subpart applies to equipment that contains or contacts hazardous wastes with organic concentrations of at least 10 percent by weight.
	RCRA 40 CFR 264 Subpart CC, Air Emission Standards for Tanks, Surface Impoundments and Containers	Applicable if thresholds are met	This regulation establishes air emission standards for facilities that treat, store, or dispose hazardous wastes in tanks, surface impoundments, or containers.
	RCRA 40 CFR 264 Subpart DD, Containment Buildings	Applicable	This regulation contains design, operating, closure and post-closure standards and requirements for the storage and treatment of hazardous waste in containment buildings.
	Technical Memorandum RE: Revised Alternative Cap Design Guidance Proposed for Unlined, Hazardous Waste Landfills in EPA Region 1 (February 5, 2001).	To be considered	This memo present an alternative cover design for hazardous waste landfills capped under CERCLA within Region 1.
	Presumptive Remedy for CERCLA Municipal Landfill Sites (OSWER Directive No. 9355.0-49F)	To be considered	This guidance outlines a streamlined approach to the scoping (planning) stages of the RI/FS in the process of closing municipal landfills under CERCLA, with containment as the presumptive remedy. This directive also provides guidance regarding the appropriate level of detail appropriate for risk assessment of source areas and characterization of hot spots.
	State Regulatory Requirements		
	Massachusetts Hazardous Waste Management Standards (310 CMR 30.500)	Applicable	These rules are used to identify, manage, and dispose of hazardous waste. Closure and post-closure standards are spelled out.
	Massachusetts Technical Standards for Hazardous Waste Facilities (310 CMR 30.600, 310 CMR 30.633, 310 CMR 30.640, 310 CMR 30.660, 310 CMR 30.680, 310 CMR 30.690)	Applicable	These rules set standards for the design, performance, operation, maintenance, and monitoring of hazardous waste facilities. For hazardous waste landfills, these rules establishes performance standards for low permeability covers, post-closure care, and groundwater monitoring. These rules also prescribe requirements for the use of containers and tanks to treat or store hazardous waste.
	MassDEP Landfill Technical Guidance, revised, May 1997	To be considered	This technical guidance outlines the closure process and design requirements for unlined landfills in Massachusetts.

TABLE 3-3
ACTION SPECIFIC ARARs and TBCs
Sutton Brook Disposal Area Superfund Site, Tewksbury, Massachusetts

Media	Requirement	Status	Summary of Requirement
Surface Water	**Federal Regulatory Requirements**		
	Clean Water Act Section 402 National Pollutant Discharge Elimination System (NPDES) (40 CFR Part 122-125 and 131)	Applicable	This act and regulations establish discharge limitations, monitoring requirements, and best management practices. Point-source discharges of effluent to surface water must comply with NPDES requirements (e.g., federal and state ambient water quality criteria (AWQC)).
	Clean Water Act (CWA) Ambient Water Quality Criteria (AWQC) (33 USC 1251 *et seq.*) (40 CFR 122.44)	Applicable	Federal AWQC are recommended (non-enforceable) criteria published by EPA and provided to the States. AWQC are listed for protection of ecological and human health for approximately 160 contaminants. If treated groundwater is discharged to surface water, it would be treated as needed to comply with this ARAR.
	State Regulatory Requirements		
	Mass. Clean Waters Act - MassDEP Surface Water Discharge Permit Program (314 CMR 3.00; MGL c. 21 Sections 26-53)	Applicable	This act and program establish the requirements intended to maintain the quality of surface waters by controlling the direct discharge of pollutants to surface waters. Direct discharge of wastewater to surface waters must meet effluent discharge limits established by this program.
	Massachusetts Surface Water Quality Standards (314 CMR 4.00)	Applicable	The Massachusetts Surface Water Quality Standards designate the most sensitive uses for which the various waters of the Commonwealth shall be enhanced, maintained and protected; which prescribe the minimum water quality criteria required to sustain the designated uses; and which contain regulations necessary to achieve the designated uses and maintain existing water quality including, where appropriate, the prohibition of discharges. These regulations limit or prohibit discharges of pollutants to surface waters to ensure that the surface water quality standards of the receiving waters are protected and maintained or attained.
	MassDEP Surface Water Discharge Permit Program (314 CMR 3.00)	Applicable	These regulations are intended to protect surface water bodies in the Commonwealth by regulating the discharge into them. Direct discharges of wastewater to surface waters must meet effluent discharge limits established by this program.
Groundwater	**Federal Regulatory Requirements**		
	RCRA Subtitle C - Releases from Solid Waste Management Units (40 CFR Subpart F, 264.95 and 264.96(a) and (c))	Applicable	These regulations identify specific monitoring requirements applicable to hazardous waste facilities, including specifying the point of compliance at which the groundwater protection standard applies and at which monitoring must be conducted, as well as specifying the compliance period during which the groundwater protection standard applies.
	Underground Injection (40 CFR Part 144)	Relevant and appropriate	These regulations provide regulatory compliance standards for treatment facilities that inject wastes underground. The use at wells to dispose of hazardous waste is prohibited.
	Final OSWER Directive "Use of Monitored Natural Attenuation at Superfund, RCRA Corrective Action, and Underground Storage Tank Sites (OSWER Dir. 9200.4-17P, 4/12/99)	To be considered	This guidance sets criteria for evaluating monitored natural attenuation as a remedy at, among others, Superfund sites.

TABLE 3-3
ACTION SPECIFIC ARARs and TBCs
Sutton Brook Disposal Area Superfund Site, Tewksbury, Massachusetts

Media	Requirement	Status	Summary of Requirement
Groundwater (con't)	State Regulatory Requirements		
	MassDEP Underground Injection Control Regulations (310 CMR 27.00)	Applicable	These regulations are intended to protect underground sources of drinking water by regulating the underground injection of hazardous wastes, fluids used for extraction of minerals, oil, and energy, and any other fluids having potential to contaminate groundwater.
	MassDEP Groundwater Discharge Permit Program (314 CMR 5.00)	Applicable	These regulations are intended to protect groundwater quality by controlling the discharge of pollutants to the ground waters of the Commonwealth to assure that these waters are protected for their highest potential use. These regulations set effluent limits for the discharge of pollutants to groundwater.
	Massachusetts Well Decommissioning Requirements (313 CMR 3.03)	Applicable	These regulations provide for certain notification requirements upon well abandonment.
Soils/Sediment	State Regulatory Requirements		
	Reuse and Disposal of Contaminated Soils at Massachusetts Landfills (COMM-97-001)	To be considered	This Policy provides information about the Massachusetts Department of Environmental Protection's requirements, standards, management practices and approvals for the testing, tracking, transport, and reuse or disposal of Contaminated Soil at Massachusetts landfills.
Air	Federal Regulatory Requirements		
	Clean Air Act National Emissions Standards for Hazardous Air Pollutants (NESHAPs), 40 CFR Part 61	Applicable	These regulations set standards for emissions of 189 Hazardous Air Pollutants that are listed in Section 112(b)(1) of the Clean Air Act.
	OSWER Directive 9355.0-28, Air Stripper Control Guidance, 7/12/89	To be considered	This OSWER directive establishes guidance on the control of air emissions from air strippers used at Superfund sites for groundwater treatment.
	State Regulatory Requirements		
	Massachusetts Ambient Air Quality Standards (310 CMR 6.00)	Applicable	These regulations set primary and secondary standards for emissions of sulfur oxides, particulate matter, carbon monoxide, ozone, nitrogen dioxide, and lead.
	MassDEP Revised Ambient Air Guidelines (December 6, 1995)	To be considered	This document presents MassDEP's revised ambient air guidelines, presenting the Threshold Effects Exposure Limits (TELs) and Allowable Ambient Limits (AALs).
	Massachusetts Air Pollution Control Regulations (310 CMR 7.00)	Applicable	This regulation stipulates that during construction and/or demolition activities, air emissions (i.e. dust, particulates, etc.) must be controlled to prevent air pollution.

EPA - U.S. Environmental Protection Agency
OSWER - Office of Solid Waste and Emergency Response
CFR - Code of Federal Regulations
CMR - Code of Massachusetts Regulations
TBC - To Be Considered
CERCLA - Comprehensive Environmental Response, Compensation, and Liability Act
USC - U.S. Code
FS - Feasibility Study
NPDES - National Pollutants Discharge Elimination System

Table 3-4
Summary of Findings - Human Health Risk Assessment
Remedial Investigation and Feasibility Study
Sutton Brook Disposal Area Superfund Site - Tewksbury, MA

Medium	Upland Soil	Groundwater	
Exposure Point	Group 4	Group 1/2 (Landfill Lobes)	Group 3-6
COPCs with ILCR > 10^{-6}	Arsenic; benzo(a)pyrene; benzo(a)anthracene; benzo(b)fluoranthene; benzo(k)fluoranthene; dibenzo(a,h)anthrancene; indeno(1,2,3,-cd)pyrene	1,4-Dichlorobenzene; n-nitroso-di-n-butylamine; n-nitrosopyrrolodine; o-toluidine; 1,2-DCA; 1,2-DCP; 1,4-dioxane, benzene, chloroform; methylene chloride, PCE, TCE, VC, arsenic	1,4-Dichlorobenzene; aroclor 1254; alpha-BHC; BEHP; 1,1,2-TCA; 1,2-DCA; 1,2-DCP; 1,4-dioxane, acrylonitrile, benzene, carbon tetrachloride; chloroform; methylene chloride, PCE, TCE, VC, arsenic
COPCs with HI >1	none	3/4-Methylphenol; naphthalene; pyridine; cis-1,2-DCE; 1,2-DCE; 2-butanone; 4-methyl-2-pentanone; acetone; benzene; ethylbenzene; methylene chloride; n-propylbenzene; THF; toluene; xylenes; arsenic; beryllium, cadmium, manganese; thallium	3/4-methylphenol; 2-methylphenol; aroclor 1254; BEHP; naphthalene; phenol; 1,1-DCA; 1,2-DCE; 1,4-dioxane; 2-butanone; 4-methyl-2-pentanone; acetone; acrylonitrile; benzene; carbon tetrachloride; cis-1,2-DCE; ethylbenzene; ethyl methacrylate; methylene chloride, n-propylbenzene; THF; toluene; VC; xylenes; antimony; arsenic; beryllium; cadmium; chromium; manganese; silver; thallium; zinc.

Notes:
*Based on human health risks calculated for the reasonable maximum exposure (RME) residential scenario.
ILCR = Incremental Lifetime Cancer Risk. For each medium, we identified only COPCs with cumulative ILCRs greater than $1x10^{-6}$ (rounded to one significant figure).
HI = Hazard Index. For each medium, we identified only COPCs with cumulative HIs greater than 1 (rounded to one significant figure).
Soil risks consider cumulative exposure resulting from dermal contact and incidental ingestion of those media. Groundwater risks consider cumulative exposures resulting from ingestion of and dermal contact with potable water and inhalation of volatiles while showering.
COPC = Chemical of Potential Concern
BEHP = bis(2-ethyl hexyl)phthalate; 1,1-DCA = 1,1,-dichloroethane; 1,2-DCA = 1,2-dichloroethane; 1,2-DCE = 1,2-dichloroethene; 1,2-DCP = 1,2-dichloropropane; PCE = tetrachloroethene;
TCE = trichloroethene; THF = tetrahydrofuran; VC = vinyl chloride; 1,1,2-TCA = 1,1,2-trichloroethane

TABLE 3-5
COMPARISON OF MAXIMUM CONCENTRATIONS IN GROUNDWATER TO ARARs and TBCs
Group 1-2 - Groundwater
Remedial Investigation and Feasibility Study
Sutton Brook Disposal Area Superfund Site - Tewksbury, MA

Exposure Point	CAS Number	Chemical	Maximum Concentration (1)		Units	ARAR or TBC Value	ARAR or TBC Source (2)
Group 1-2 Groundwater	57-12-5	Cyanide, Total	0.0053		mg/L	0.2	MCL
	7429-90-5	Aluminum, Total	2.5		mg/L	0.05	SDWR
	7440-36-0	Antimony, Total	0.0052		mg/L	0.006	MCL
	7440-38-2	Arsenic, Total	2		mg/L	0.01	MCL
	7440-39-3	Barium, Total	1.59		mg/L	2	MCL
	7440-41-7	Beryllium, Total	0.03		mg/L	0.004	MCL
	7440-43-9	Cadmium, Total	0.36		mg/L	0.005	MCL
	7440-70-2	Calcium, Total	501		mg/L	NA	NA
	7440-47-3	Chromium, Total	0.0082		mg/L	0.1	MCL
	7440-48-4	Cobalt, Total	0.0763		mg/L	NA	NA
	7440-50-8	Copper, Total	0.179		mg/L	1.3	MCL
	7439-89-6	Iron, Total	780	J	mg/L	0.3	SDWR
	7439-92-1	Lead, Total	0.24		mg/L	0.015	MCL
	7439-95-4	Magnesium, Total	153		mg/L	NA	NA
	7439-96-5	Manganese, Total	20.2	J	mg/L	0.3	HA
	7440-02-0	Nickel, Total	0.21		mg/L	0.1	HA
	7440-09-7	Potassium, Total	170	J	mg/L	NA	NA
	7782-49-2	Selenium, Total	0.07		mg/L	0.05	MCL
	7440-22-4	Silver, Total	0.009		mg/L	0.1	HA
	7440-23-5	Sodium, Total	414		mg/L	20	ORSG
	7440-28-0	Thallium, Total	0.0047	J	mg/L	0.002	MCL
	7440-62-2	Vanadium, Total	0.03	J	mg/L	NA	NA
	7440-66-6	Zinc, Total	0.35		mg/L	2	HA
	1031-07-8	Endosulfan sulfate	0.000031	J	mg/L	NA	NA
	95-50-1	1,2-Dichlorobenzene	0.005		mg/L	0.6	MCL
	106-46-7	1,4-Dichlorobenzene	0.011	J	mg/L	0.075	MCL
	105-67-9	2,4-Dimethylphenol	0.058	J	mg/L	NA	NA
	121-14-2	2,4-Dinitrotoluene	0.000586		mg/L	0.1	HA; DWEL
	91-57-6	2-Methylnaphthalene	0.00083		mg/L	NA	NA
	95-48-7	2-Methylphenol	0.18	J	mg/L	NA	NA
	108-39-4/106-44-5	3-Methylphenol/4-Methylphenol	10		mg/L	NA	NA
	106-44-5	4-Methylphenol	11		mg/L	NA	NA
	100-02-7	4-Nitrophenol	0.00118		mg/L	0.06	HA
	83-32-9	Acenaphthene	0.000714		mg/L	2	HA; DWEL
	98-86-2	Acetophenone	0.0308		mg/L	NA	NA
	65-85-0	Benzoic acid	12	J	mg/L	NA	NA
	84-66-2	Diethyl phthalate	0.163		mg/L	30	HA; DWEL
	84-74-2	Di-n-butylphthalate	0.00143		mg/L	4	HA; DWEL
	78-59-1	Isophorone	0.000549		mg/L	0.1	HA
	91-20-3	Naphthalene	0.24	J	mg/L	0.1	HA
	924-16-3	N-Nitrosodi-n-butylamine	0.00108		mg/L	NA	NA
	930-55-2	N-Nitrosopyrrolidine	0.00968		mg/L	NA	NA
	95-53-4	o-Toluidine	0.00316		mg/L	NA	NA
	108-95-2	Phenol	2.6		mg/L	2	HA
	110-86-1	Pyridine	0.042		mg/L	NA	NA
	71-55-6	1,1,1-Trichloroethane	0.13		mg/L	0.2	MCL
	75-34-3	1,1-Dichloroethane	0.53		mg/L	0.07	ORSG
	75-35-4	1,1-Dichloroethene	0.00024	J	mg/L	0.007	MCL
	95-63-6	1,2,4-Trimethylbenzene	2.6		mg/L	NA	NA
	107-06-2	1,2-Dichloroethane	0.0069	J	mg/L	0.005	MCL
	540-59-0	1,2-Dichloroethene (Total)	0.15		mg/L	0.07	MCL
	540-59-0	cis-1,2-Dichloroethene	0.45		mg/L	0.07	MCL
	540-59-0	trans-1,2-Dichloroethene	0.00057	J	mg/L	0.07	MCL

TABLE 3-5
COMPARISON OF MAXIMUM CONCENTRATIONS IN GROUNDWATER TO ARARs and TBCs
Group 1-2 - Groundwater
Remedial Investigation and Feasibility Study
Sutton Brook Disposal Area Superfund Site - Tewksbury, MA

Exposure Point	CAS Number	Chemical	Maximum Concentration (1)		Units	ARAR or TBC Value	ARAR or TBC Source (2)
	78-87-5	1,2-Dichloropropane	0.0034	J	mg/L	0.005	MCL
	108-67-8	1,3,5-Trimethylbenzene	0.64		mg/L	10	HA
	123-91-1	1,4-Dioxane	0.83		mg/L	0.003	ORSG
	78-93-3	2-Butanone	27	J	mg/L	4	HA
	591-78-6	2-Hexanone	0.45	J	mg/L	NA	NA
	108-10-1	4-Methyl-2-pentanone	13	J	mg/L	0.35	ORSG
	67-64-1	Acetone	21	J	mg/L	6.3	ORSG
	71-43-2	Benzene	0.038	J	mg/L	0.005	MCL
	75-15-0	Carbon disulfide	0.00037	J	mg/L	NA	NA
	108-90-7	Chlorobenzene	0.028		mg/L	0.1	MCL
	75-00-3	Chloroethane	4.3		mg/L	NA	NA
	67-66-3	Chloroform	0.0017		mg/L	0.08	MCL
	74-87-3	Chloromethane	0.002	J	mg/L	0.03	HA
	75-71-8	Dichlorodifluoromethane	0.095	J	mg/L	1	HA
	60-29-7	Ethyl Ether	0.3	J	mg/L	NA	NA
	100-41-4	Ethylbenzene	2		mg/L	0.7	MCL
	98-82-8	Isopropylbenzene	0.048	J	mg/L	4	HA
	1634-04-4	Methyl tert butyl ether	0.00056	J	mg/L	0.07	ORSG
	75-09-2	Methylene Chloride	2.14		mg/L	0.005	MCL
	103-65-1	n-Propylbenzene	0.26		mg/L	NA	NA
	99-87-6	p-Isopropyltoluene	0.015	J	mg/L	NA	NA
	100-42-5	Styrene	0.24		mg/L	0.1	MCL
	104-51-8	n-Butylbenzene	0.00918		mg/L	NA	NA
	98-06-6	tert-Butylbenzene	0.0228		mg/L	NA	NA
	127-18-4	Tetrachloroethene	0.017	J	mg/L	0.005	MCL
	109-99-9	Tetrahydrofuran	10		mg/L	1.3	ORSG
	108-88-3	Toluene	21		mg/L	1	MCL
	79-01-6	Trichloroethene	0.076	J	mg/L	0.005	MCL
	75-69-4	Trichlorofluoromethane	0.41	J	mg/L	2	HA
	75-01-4	Vinyl chloride	0.035	J	mg/L	0.002	MCL
	1330-20-7	Xylenes (total)	0.49		mg/L	10	MCL
	95-49-8	o-Chlorotoluene	0.0028	J	mg/L	0.1	HA
	106-46-7	1,2,4-Trichlorobenzene	0.0025	J	mg/L	0.075	MCL

Footnotes:

Shaded rows indicate maximum concentration greater than ARAR or TBC.

(1) Summary statistics were calculated from groundwater samples from monitoring wells in Groups 1-2 of the site.

(2) ARAR =Applicable or relevant and appropriate requirements. MCL = Maximum Contaminant Level. For compounds without MCLs, we used federal health advisories (HA) or MADEP Office of Research and Standards Guidelines (OSRG) as TBCs.

TBC = To be considered.

Health advisory values are the "Lifetime" values, unless otherwise noted. DWEL - Drinking Water Exposure Level; Cancer = 10^{-4} Cancer Risk level; 1-day = 1 day concentration for 10 kg child; SDWR = Secondary Drinking Water Regulation

TABLE 3-6
COMPARISON OF MAXIMUM CONCENTRATIONS IN GROUNDWATER TO ARARs and TBCs
Group 3-6 - Groundwater
Remedial Investigation and Feasibility Study
Sutton Brook Disposal Area Superfund Site - Tewksbury, MA

Exposure Point	CAS Number	Chemical	Maximum Concentration (1)		Units	ARAR or TBC Value	ARAR or TBC Source (2)
Group 3-6	57-12-5	Cyanide, Total	0.0104		mg/L	0.2	MCL
	7429-90-5	Aluminum, Total	5.9		mg/L	0.05	SDWR
	7440-36-0	Antimony, Total	0.1		mg/L	0.006	MCL
	7440-38-2	Arsenic, Total	2.32		mg/L	0.01	MCL
	7440-39-3	Barium, Total	0.37		mg/L	2	MCL
	7440-41-7	Beryllium, Total	0.56		mg/L	0.004	MCL
	7440-43-9	Cadmium, Total	0.06		mg/L	0.005	MCL
	7440-70-2	Calcium, Total	366		mg/L	NA	MCLG
	7440-47-3	Chromium, Total	0.03		mg/L	0.1	MCL
	7440-48-4	Cobalt, Total	0.14		mg/L	NA	NA
	7440-50-8	Copper, Total	0.1		mg/L	1.3	MCLG
	7439-89-6	Iron, Total	680		mg/L	0.3	SDWR
	7439-92-1	Lead, Total	0.06		mg/L	0.015	MCL
	7439-95-4	Magnesium, Total	56		mg/L	NA	NA
	7439-96-5	Manganese, Total	29		mg/L	0.3	HA
	7439-97-6	Mercury, Total	0.00007	J	mg/L	0.002	MCL
	7440-02-0	Nickel, Total	0.08		mg/L	0.1	HA
	7440-09-7	Potassium, Total	100		mg/L	NA	NA
	7782-49-2	Selenium, Total	0.012		mg/L	0.05	MCL
	7440-22-4	Silver, Total	0.8		mg/L	0.1	HA
	7440-23-5	Sodium, Total	310		mg/L	20	ORSG
	7440-28-0	Thallium, Total	0.0048		mg/L	0.002	MCL
	7440-62-2	Vanadium, Total	0.01		mg/L	NA	NA
	7440-66-6	Zinc, Total	55		mg/L	2	HA
	11097-69-1	Aroclor 1254	0.0012	J	mg/L	0.0005	MCL
	319-84-6	Alpha-BHC	0.000047	J	mg/L	NA	NA
	120-82-1	1,2,4-Trichlorobenzene	0.0004	J	mg/L	0.07	MMCL
	95-50-1	1,2-Dichlorobenzene	0.0012	J	mg/L	0.6	MCL
	106-46-7	1,4-Dichlorobenzene	0.0032	J	mg/L	0.075	MCL
	105-67-9	2,4-Dimethylphenol	0.18		mg/L	NA	NA
	95-48-7	2-Methylphenol	1	J	mg/L	NA	NA
	108-39-4/106-44-5	3-Methylphenol/4-Methylphenol	2.1		mg/L	NA	NA
	106-44-5	4-Methylphenol	0.27		mg/L	NA	NA
	65-85-0	Benzoic Acid	5.2	J	mg/L	NA	NA
	100-51-6	Benzyl Alcohol	0.0019	J	mg/L	NA	NA
	117-81-7	Bis(2-Ethylhexyl)phthalate	0.61		mg/L	0.006	MCL
	105-60-2	Caprolactam	0.01	J	mg/L	NA	NA
	84-66-2	Diethyl phthalate	0.0394		mg/L	30	HA; DWEL
	131-11-3	Dimethyl phthalate	0.08	J	mg/L	NA	NA
	84-74-2	Di-n-butylphthalate	0.011		mg/L	4	HA; DWEL
	91-20-3	Naphthalene	0.011	J	mg/L	0.1	HA
	108-95-2	Phenol	9.4		mg/L	2	HA
	71-55-6	1,1,1-Trichloroethane	0.49	J	mg/L	0.2	MCL
	79-00-5	1,1,2-Trichloroethane	0.00692		mg/L	0.005	MCL
	75-34-3	1,1-Dichloroethane	3.6	J	mg/L	0.07	ORSG
	75-35-4	1,1-Dichloroethene	0.13	J	mg/L	0.007	MCL
	95-63-6	1,2,4-Trimethylbenzene	1.4		mg/L	NA	NA
	107-06-2	1,2-Dichloroethane	0.0444		mg/L	0.005	MCL
	540-59-0	1,2-Dichloroethene (Total)	0.13		mg/L	0.07	MCL
	78-87-5	1,2-Dichloropropane	0.0036	J	mg/L	0.005	MCL
	108-67-8	1,3,5-Trimethylbenzene	1.2	J	mg/L	10	HA; 1-day
	123-91-1	1,4-Dioxane	3	J	mg/L	0.003	ORSG
	78-93-3	2-Butanone	77		mg/L	4	HA
	108-10-1	4-Methyl-2-pentanone	190		mg/L	0.35	ORSG

TABLE 3-6
COMPARISON OF MAXIMUM CONCENTRATIONS IN GROUNDWATER TO ARARs and TBCs
Group 3-6 - Groundwater
Remedial Investigation and Feasibility Study
Sutton Brook Disposal Area Superfund Site - Tewksbury, MA

Exposure Point	CAS Number	Chemical	Maximum Concentration (1)		Units	ARAR or TBC Value	ARAR or TBC Source (2)
	67-64-1	Acetone	73		mg/L	6.3	ORSG
	71-43-2	Benzene	0.045		mg/L	0.005	MCL
	75-27-4	Bromodichloromethane	0.00015	J	mg/L	0.08	MCL
	75-15-0	Carbon disulfide	0.00065	J	mg/L	NA	NA
	56-23-5	Carbon tetrachloride	0.052		mg/L	0.005	MCL
	108-90-7	Chlorobenzene	0.0042		mg/L	0.1	MMCL
	75-00-3	Chloroethane	2.5	J	mg/L	NA	NA
	67-66-3	Chloroform	0.0057		mg/L	0.08	MCL
	74-87-3	Chloromethane	0.006		mg/L	0.03	HA
	540-59-0	cis-1,2-Dichloroethene	0.22	J	mg/L	0.07	MCL
	75-71-8	Dichlorodifluoromethane	0.036	J	mg/L	1	HA
	60-29-7	Ethyl ether	0.076		mg/L	NA	NA
	100-41-4	Ethylbenzene	8.4		mg/L	0.7	MCL
	98-82-8	Isopropylbenzene	0.082		mg/L	4	HA; DWEL
	1634-04-4	Methyl tert butyl ether	0.005		mg/L	0.07	ORSG
	75-09-2	Methylene chloride	2.2		mg/L	0.005	MCL
	104-51-8	n-Butylbenzene	0.0899		mg/L	NA	NA
	103-65-1	n-Propylbenzene	0.092	J	mg/L	NA	NA
	99-87-6	p-Isopropyltoluene	0.096	J	mg/L	NA	NA
	135-98-8	sec-Butylbenzene	0.00066	J	mg/L	NA	NA
	100-42-5	Styrene	0.00005	J	mg/L	0.1	MCL
	98-06-6	tert-Butylbenzene	0.0668		mg/L	NA	NA
	127-18-4	Tetrachloroethene	0.006		mg/L	0.005	MCL
	109-99-9	Tetrahydrofuran	20	J	mg/L	1.3	ORSG
	108-88-3	Toluene	78		mg/L	1	MCL
	79-01-6	Trichloroethene	0.006		mg/L	0.005	MCL
	75-69-4	Trichlorofluoromethane	0.0345		mg/L	2	HA
	75-01-4	Vinyl chloride	0.071	J	mg/L	0.002	MCL
	1330-20-7	Xylenes (total)	28.2		mg/L	10	MCL
	107-13-1	Acrylonitrile	1.3	J	mg/L	0.006	HA; Cancer
	97-63-2	Ethyl Methacrylate	4	J	mg/L	NA	NA
	87-68-3	Hexachlorobutadiene	0.00049	J	mg/L	0.01	HA; DWEL
	156-60-5	trans-1,2-Dichloroethene	0.00097		mg/L	0.1	MCL

Footnotes:

Shaded rows indicate maximum concentration greater than ARAR or TBC.

(1) Summary statistics were calculated from groundwater samples from monitoring wells in Groups 3-6 of the site.

(2) ARAR =Applicable or relevant and appropriate requirements. MCL = Maximum Contaminant Level. MMCL = Massachusetts MCL. For compounds without MCLs, we used federal health advisories (HA) or MADEP Office of Research and Standards Guidelines (OSRG) as TBCs.

TBC = To be considered.

Health advisory values are the "Lifetime" values, unless otherwise noted. DWEL - Drinking Water Exposure Level; Cancer = 10^{-4} Cancer Risk level; 1-day = 1 day concentration for 10 kg child; SDWR = Secondary Drinking Water Regulation

Table 3-7
Derivation of Preliminary Remediation Goals (PRGs)
Residential Scenario
Remedial Investigation and Feasibility Study
Sutton Brook Disposal Area Superfund Site - Tewksbury, MA

UPLAND SOIL

COPC	Target cancer risk	Risk-Based Cleanup Goal (mg/kg)*			ARAR	Source	Reference	PQL	PRG	Basis
		Noncancer	*Cancer*	*Minimum RBCG*	(mg/kg)		(mg/kg)	(mg/kg)	(mg/kg)	
Benzo(a)pyrene	1×10^{-6}	--	0.04	0.04	2	MCP S-1/GW-1	0.415	0.5	2.0	ARAR
	1×10^{-5}	--	0.44	0.44			0.415	0.5		
Benzo(a)anthracene	1×10^{-6}	--	0.44	0.44	7	MCP S-1/GW-1	0.436	0.5	4.4	RBCG
	1×10^{-5}	--	4.37	4.37			0.436	0.5		
Benzo(b)fluoranthene	1×10^{-6}	--	0.44	0.44	7	MCP S-1/GW-1	0.45	0.5	4.4	RBCG
	1×10^{-5}	--	4.37	4.37			0.45	0.5		
Bis(2-ethylhexyl)phthalate	1×10^{-6}	2851.56	80.91	80.91	100	MCP S-1/GW-1	--	1	81	RBCG
	1×10^{-5}	--	809.14	809.14			--	1		
Tetrachloroethene	1×10^{-6}	1825.00	2.76	2.76	1	MCP S-1/GW-1	--	0.1	1.0	ARAR
	1×10^{-5}	--	27.60	27.60			--	0.1		
Benzo(k)fluoranthene	1×10^{-6}	--	4.37	4.37	70	MCP S-1/GW-1	0.394	1	4.4	RBCG
	1×10^{-5}	--	43.70	43.70			0.394	1		
Dibenzo(a,h)anthracene	1×10^{-6}	--	0.04	0.04	0.7	MCP S-1/GW-1	0.83	0.5	0.7	ARAR
	1×10^{-5}	--	0.44	0.44			0.83	0.5		
Indeno(1,2,3-cd)pyrene	1×10^{-6}	--	0.44	0.44	7	MCP S-1/GW-1	0.394	0.7	4.4	RBCG
	1×10^{-5}	--	4.37	4.37			0.394	0.7		

*Minimum concentration between noncancer and cancer-based RBCG for each receptor.

Table 3-7
Derivation of Preliminary Remediation Goals (PRGs)
Residential Scenario
Remedial Investigation and Feasibility Study
Sutton Brook Disposal Area Superfund Site - Tewksbury, MA

GROUNDWATER

COPC	Risk-Based Cleanup Goal (mg/L)			ARAR	Source	TBC	Source	Reference	PQL	PRG	Basis
	Noncancer	*Cancer*	*Lowest*	(mg/L)		(mg/L)		(mg/L)	(mg/L)	(mg/L)	ARAR
Inorganics											
Antimony	0.005	--	0.005	0.006	MCL	--	--	0.003	0.006	0.006	ARAR
Arsenic	0.004	0.00004	0.00004	0.01	MCL	--	--	0.0361	0.01	0.01	ARAR
Beryllium	0.014	--	0.014	0.004	MCL	--	--	0.002	0.004	0.004	ARAR
Cadmium	0.005	--	0.005	0.005	MCL	--	--	0.001	0.002	0.005	ARAR
Chromium	0.026	--	0.026	0.1	MCL	--	--	0.005	0.02	0.1	ARAR
Lead	--	--	--	0.015	MCL	--	--	0.005	0.005	0.015	ARAR
Manganese	0.5	--	0.5	--	--	0.3	HA	0.272	0.02	0.3	TBC
Nickel	--	--	--	--	--	0.1	HA	0.012	0.01	0.1	TBC
Selenium	--	--	--	0.05	MCL	--	--	0.003	0.01	0.05	ARAR
Silver	0.056	--	0.056	--	--	0.1	HA	0.0035	0.005	0.1	ARAR
Thallium	0.001	--	0.001	0.002	MCL	--	--	0.0025	0.01	0.002	ARAR
Zinc	3.599	--	3.599	--	--	2	HA	0.0274	0.02	2	TBC
Organics											
1,1 Dichloroethene	--	--	--	0.007	MCL	--	--	--	0.002	0.007	ARAR
1,4-Dichlorobenzene	0.387	0.002	0.002	0.075	MCL	--	--	--	0.002	0.075	ARAR
1,1,1-Trichloroethane	--	--	--	0.2	MCL	--	--	--	0.002	0.2	ARAR
1,1,2-Trichloroethane	0.012	0.0002	0.0002	0.005	MCL	--	--	--	0.002	0.005	ARAR
1,1-Dichloroethane	0.360	--	0.360	--	--	0.07	ORSG	--	0.002	0.36	RBCG
1,2-Dichloroethane	1.178	0.0001	0.0001	0.005	MCL	--	--	--	0.002	0.005	ARAR
1,2-Dichloroethene	0.034	--	0.034	0.1	MCL	--	--	--	0.002	0.1	ARAR
1,2-Dichloropropane	0.004	0.0008	0.0008	0.005	MCL	--	--	--	0.002	0.005	ARAR
1,4-Dioxane	1.185	0.004	0.004	--	--	0.003	ORSG	--	0.005	0.004	RBCG
2-Butanone	5.697	--	5.697	--	--	4	HA	--	0.01	4	TBC
2-Methylphenol	0.538	--	0.538	--	--	--	--	--	0.005	0.54	RBCG
3-Methylphenol/4-Methylphenol	0.469	--	0.469	--	--	--	--	--	0.005	0.47	RBCG
4-Methyl-2-pentanone	0.803	--	0.803	--	--	0.35	ORSG	--	0.01	0.8	RBCG
Acetone	5.623	--	5.623	--	--	6.3	ORSG	--	0.01	5.6	RBCG
Alpha-BHC	--	0.000008	0.000008	--	--	--	--	--	0.00004	0.000008	RBCG
Aroclor 1254	0.00007	0.00004	0.00004	0.0005	MCL	--	--	--	0.001	0.0005	ARAR
Benzene	0.015	0.0003	0.0003	0.005	MCL	--	--	--	0.002	0.005	ARAR
Bis(2-ethylhexyl)phthalate	0.115	0.002	0.002	0.006	MCL	--	--	--	0.01	0.006	ARAR
Carbon tetrachloride	0.002	0.0001	0.0001	0.005	MCL	--	--	--	0.002	0.005	ARAR
Chloroform	0.080	0.0001	0.0001	0.08	MCL	--	--	--	0.002	0.08	ARAR
cis-1,2-Dichloroethene	0.035	--	0.035	0.07	MCL	--	--	--	0.002	0.07	ARAR
Ethylbenzene	0.425	--	0.425	0.7	MCL	--	--	--	0.002	0.7	ARAR
Methylene chloride	0.550	0.004	0.004	0.005	MCL	--	--	--	0.005	0.005	ARAR
Naphthalene	0.004	--	0.004	--	--	0.14	ORSG	--	0.002	0.14	TBC
N-Nitrosodi-n-butylamine	--	0.000003	0.000003	--	--	--	--	--	0.01	0.000003	RBCG
N-Nitrosopyrrolidine	--	0.00003	0.00003	--	--	--	--	--	0.0025	0.00003	RBCG
n-Propylbenzene	0.052	--	0.052	--	--	--	--	--	0.002	0.052	RBCG
o-Toluidine	--	0.0002	0.0002	--	--	--	--	--	0.0005	0.0002	RBCG
Phenol	3.237	--	3.237	--	--	2	HA	--	0.007	2	TBC
Pyridine	0.009	--	0.009	--	--	--	--	--	0.05	0.009	RBCG
Styrene	--	--	--	0.1	MCL	--	--	--	0.002	0.1	ARAR
Tetrachloroethene	0.025	0.00007	0.00007	0.005	MCL	--	--	--	0.002	0.005	ARAR
Tetrahydrofuran	0.227	--	0.227	--	--	1.3	ORSG	--	0.002	1.3	TBC
Toluene	0.646	--	0.646	1	MCL	--	--	--	0.002	1	ARAR
Trichloroethene	0.562	0.00012	0.00012	0.005	MCL	--	--	--	0.002	0.005	ARAR
Vinyl chloride	0.023	0.00003	0.00003	0.002	MCL	--	--	--	0.002	0.002	ARAR
Xylenes (total)	0.082	--	0.082	10	MCL	--	--	--	0.002	10	ARAR
Acrylonitrile	0.004	0.00005	0.00005	--	--	--	--	--	0.002	0.00005	RBCG
Ethyl methacrylate	0.265	--	0.265	--	--	--	--	--	0.002	0.26	RBCG

Notes:
The backup tables for RBCG included in Appendix A.
Reference: 90th percentile concentration of reference dataset specific to medium (refer to Section 3.4.1 of the FS). A dash (--) indicates constituent not detected in reference dataset or reference concentration not determined. Refer to the May 2007 Human Health Risk Assessment and Appendix D of this document for additional information on the reference data set.
COPC = Chemical of Potential Concern
ARAR = Applicable or Relevant and Appropriate Requirement
TBC = criteria To Be Considered
RBCG = Risk-based cleanup goal
MCL = Maximum Contaminant Level (Federal Drinking Water Standard)
ORSG = Massachusetts Department of Environmental Protection Office of Research and Standards Guideline.
SDWR = secondary drinking water regulation
PQL = Project Quantitation Limit, as per the September 10, 2004 Sutton Brook Disposal Area Quality Assurance Project Plan (QAPP).
HA = EPA Health Advisory

Table 3-8
Derivation of Preliminary Remediation Goals (PRGs)
Facility Worker
Remedial Investigation and Feasibility Study
Sutton Brook Disposal Area Superfund Site - Tewksbury, MA

GROUNDWATER

COPC	Risk-Based Cleanup Goal (mg/L)			ARAR	Source	TBC	Source	Reference	PQL	PRG	Basis
	Noncancer	*Cancer*	*Lowest*	(mg/L)				(mg/L)	(mg/L)	(mg/L)	ARAR
Inorganics											
Antimony	0.036	--	0.036	0.006	MCL	--	--	0.003	0.006	0.006	ARAR
Arsenic	0.027	0.0002	0.0002	0.01	MCL	--	--	0.0361	0.01	0.01	ARAR
Beryllium	0.174	--	0.174	0.004	MCL	--	--	0.002	0.004	0.004	ARAR
Cadmium	0.044	--	0.044	0.005	MCL	--	--	0.001	0.002	0.005	ARAR
Chromium	0.263	--	0.263	0.1	MCL	--	--	0.005	0.02	0.1	ARAR
Lead	--	--	--	0.015	MCL	--	--	0.005	0.005	0.015	ARAR
Manganese	4.1	--	4.1	--	--	0.3	HA	0.272	0.02	0.3	TBC
Nickel	--	--	--	--	--	0.1	HA	0.012	0.01	0.1	TBC
Selenium	--	--	--	0.05	MCL	--	--	0.003	0.01	0.05	ARAR
Silver	0.443	--	0.443	--	--	0.1	HA	0.0035	0.005	0.44	RBCG-nc
Thallium	0.007	--	0.007	0.002	MCL	--	--	0.0025	0.01	0.002	ARAR
Zinc	26.658	--	26.66	--	--	2	HA	0.0274	0.02	2	TBC
Organics											
1.1 DCE	--	--	--	0.007	MCL	--	--	--	0.002	0.007	ARAR
1,4-Dichlorobenzene	6.606	0.003	0.003	0.075	MCL	--	--	--	0.002	0.075	ARAR
1,1,1-Trichloroethane	--	--	--	0.2	MCL	--	--	--	0.002	0.2	ARAR
1,1,2-Trichloroethane	0.345	0.003	0.003	0.005	MCL	--	--	--	0.002	0.005	ARAR
1,1-Dichloroethane	17.35	--	17.35	--	--	0.07	ORSG	--	0.002	17.3	RBCG
1,2-Dichloroethane	17.50	0.002	0.002	0.005	MCL	--	--	--	0.002	0.005	ARAR
1,2-Dichloroethene	0.778	--	0.778	0.1	MCL	--	--	--	0.002	0.1	ARAR
1,2-Dichloropropane	--	0.003	0.003	0.005	MCL	--	--	--	0.002	0.005	ARAR
1,4-Dioxane	8.88	0.022	0.022	--	--	0.003	ORSG	--	0.005	0.022	RBCG
2-Butanone	53.14	--	53.14	--	--	4	HA	--	0.01	4	TBC
2-Methylphenol	4.27	--	4.27	--	--	--	--	--	0.005	4.27	RBCG
3-Methylphenol/4-Methylphenol	4.31	--	4.31	--	--	--	--	--	0.005	4.31	RBCG
4-Methyl-2-pentanone	7.01	--	7.01	--	--	0.35	ORSG	--	0.01	7.01	RBCG
Acetone	79.74	--	79.74	--	--	6.3	ORSG	--	0.01	79.74	RBCG
Alpha-BHC	--	0.00002	0.00002	--	--	--	--	--	0.00004	0.00002	RBCG
Aroclor 1254	0.002	0.0006	0.0006	0.0005	MCL	--	--	--	0.001	0.0005	ARAR
Benzene	0.339	0.003	0.003	0.005	MCL	--	--	--	0.002	0.005	ARAR
Bis(2-ethylhexyl)phthalate	1.21	0.003	0.003	0.006	MCL	--	--	--	0.01	0.006	ARAR
Carbon tetrachloride	0.057	0.001	0.001	0.005	MCL	--	--	--	0.002	0.005	ARAR
Chloroform	0.864	0.006	0.006	0.08	MCL	--	--	--	0.002	0.08	ARAR
cis-1,2-Dichloroethene	0.865	--	0.865	0.07	MCL	--	--	--	0.002	0.07	ARAR
Ethylbenzene	7.47	--	7.47	0.7	MCL	--	--	--	0.002	0.7	ARAR
Methylene chloride	5.27	0.030	0.030	0.005	MCL	--	--	--	0.005	0.005	ARAR
Naphthalene	1.47	--	1.47	--	--	0.14	ORSG	--	0.002	0.14	TBC
N-Nitrosodi-n-butylamine	--	0.00004	0.00004	--	--	--	--	--	0.01	0.00004	RBCG
N-Nitrosopyrrolidine	--	0.0001	0.0001	--	--	--	--	--	0.0025	0.0001	RBCG
n-Propylbenzene	--	--	--	--	--	--	--	--	0.002	0.002	PQL
o-Toluidine	--	0.0009	0.0009	--	--	--	--	--	0.0005	0.0009	RBCG
Phenol	25.91	--	25.91	--	--	2	HA	--	0.007	2.0	TBC
Pyridine	0.088	--	0.088	--	--	--	--	--	0.05	0.088	RBCG
Styrene	--	--	--	0.1	MCL	--	--	--	0.002	0.1	ARAR
Tetrachloroethene	0.748	0.0002	0.0002	0.005	MCL	--	--	--	0.002	0.005	ARAR
Tetrahydrofuran	--	--	--	--	--	1.3	ORSG	--	0.002	1.3	TBC
Toluene	6.41	--	6.41	1	MCL	--	--	--	0.002	1	ARAR
Trichloroethene	--	0.0004	0.0004	0.005	MCL	--	--	--	0.002	0.005	ARAR
Vinyl chloride	0.262	0.0003	0.0003	0.002	MCL	--	--	--	0.002	0.002	ARAR
Xylenes (total)	13.98	--	13.98	10	MCL	--	--	--	0.002	10	ARAR
Acrylonitrile	0.089	0.0004	0.0004	--	--	--	--	--	0.002	0.0004	RBCG
Ethyl methacrylate	7.59	--	7.59	--		--	--	--	0.002	7.59	RBCG-nc

Notes:
The backup tables for RBCG included in Appendix A.
Reference: 90th percentile concentration of reference dataset specific to medium (refer to Section 3.4.1 of the FS). A dash (--) indicates constituent not detected in reference dataset or reference concentration not determined. Refer to the May 2007 Human Health Risk Assessment and Appendix D of this document for additional information on the reference data set.
COPC = Chemical of Potential Concern
ARAR = Applicable or Relevant and Appropriate Requirement
TBC = criteria To Be Considered
RBCG = Risk-based cleanup goal
MCL = Maximum Contaminant Level (Federal Drinking Water Standard)
SDWR - secondary drinking water regulation
ORSG = Massachusetts Department of Environmental Protection Office of Research and Standards Guideline.
PQL = Project Quantitation Limit, as per the September 10, 2004 Sutton Brook Disposal Area Quality Assurance Project Plan (QAPP).

TABLE 3-9
SUMMARY OF FINDINGS - BASELINE ECOLOGICAL RISK ASSESSMENT
Remedial Investigation and Feasibility Study
Sutton Brook Disposal Area Superfund Site – Tewksbury, MA

Location	Receptor and Assessment Endpoint	Basis
Upper Sutton Brook: Eastern Reach	Pelagic Invertebrates and Fish (surface water)	Iron exceeded chronic AWQC
Upper Sutton Brook: Site Channel	Pelagic Invertebrates and Fish (surface water)	DDT, ethylbenzene, toluene, xylenes, barium, and manganese exceeded NOAEL-based benchmarks in the SLERA. No further evaluation in the BERA.
	Benthic Invertebrates (sediment)	1,2,4-trimethylbenzene, 1,3,5-trimethylbenzene, 2-methylphenol, 3-methylphenol/4-methylphenol, 4-methyl-2-pentanone, acetone, carbon disulfide, chloroethane, ethylbenzene, xylenes, toluene, arsenic, and manganese exceeded NOAEL-based benchmarks in the SLERA. No further evaluation in the BERA.
Aquatic Wetland	Pelegic Invertebrates (surface water)	Iron exceeds chronic AWQC
	Amphibians (surface water)	Aluminum LOAEL-based HQ of 2.5
Former Drum Disposal Area	Plants	Bis(2-Ethylhexyl)phthalate, ethylbenzene, naphthalene, xylenes exceed NOAEL-based benchmarks in the SLERA, based on concentrations in SB-03(04). No further evaluation in the BERA.
	Soil Invertebrates	1,2,4-Trimethylbenzene, 1,3,5-trimethylbenzene, ethylbenzene, toluene, and xylenes exceed NOAEL-based benchmarks in the SLERA, based on concentrations in SB-03(04). No further evaluation in the BERA.
	Upland Carnivores: Robin	1,2,4-Trimethylbenzene, bis(2-ethylhexyl)phthalate, di-n-octylphthalate, and xylenes exceed NOAEL-based TRVs in the SLERA, based on concentrations in SB-03(04). No further evaluation in the BERA.
Upland Soils (Excluding Former Drum Disposal Area)	Invertebrates	Zinc LOAEL-based HQ is 2.0 at SO-07(99). Effects likely localized. Other COPCs show either low and infrequent NOAEL exceedances or were present below representative LOAEL toxicity values.,
	Carnivores : Robin	Average concentrations of lead and di-n-octylphthalate produce a LOAEL-based HQ of 1.1 Lead present at up to 233 mg/kg on-site. Concentrations over 65 mg/kg produce a LOAEL-based HQ >1.0. Di-n-octylphthales present up to 0.560 mg/kg on-site. Concentrations above 0.20 mg/kg cause LOAEL-based HQ > 1.0

TABLE 3-10
ECOLOGICAL PRELIMINARY REMEDIATION GOALS
Remedial Investigation and Feasibility Study
Sutton Brook Disposal Area Superfund Site - Tewksbury, MA

Compound	Habitat Area	Media	Receptor Potentially at Risk	PRG (mg/l or mg/kg)	Source	PQL, mg/l or mg/kg
4-4'-DDT	Upper Sutton Brook - Site Channel	surface water	pelagic invertebrates, fish	0.000001	AWQC/ARAR	0.00004
Ethylbenzene	Upper Sutton Brook - Site Channel	surface water	pelagic invertebrates, fish	0.0073	Appendix K of BERA	0.002
Toluene	Upper Sutton Brook - Site Channel	surface water	pelagic invertebrates, fish	0.0098	Appendix K of BERA	0.002
Xylenes	Upper Sutton Brook - Site Channel	surface water	pelagic invertebrates, fish	0.013	Appendix K of BERA	0.002
1,2,4-Trimethylbenzene	Upper Sutton Brook - Site Channel	sediment	benthic invertebrates	1.3	Appendix K of BERA	0.1
1,3,5-Trimethylbenzene	Upper Sutton Brook - Site Channel	sediment	benthic invertebrates	1.2	Appendix K of BERA	0.1
2-Methylphenol	Upper Sutton Brook - Site Channel	sediment	benthic invertebrates	0.1	Appendix K of BERA	1.2
3-Methylphenol/4-methylphenol	Upper Sutton Brook - Site Channel	sediment	benthic invertebrates	0.6	Appendix K of BERA	0.6
4-Methyl-2-pentanone	Upper Sutton Brook - Site Channel	sediment	benthic invertebrates	0.04	Appendix K of BERA	0.02
Acetone	Upper Sutton Brook - Site Channel	sediment	benthic invertebrates	0.07	Appendix K of BERA	0.01
Carbon Disulfide	Upper Sutton Brook - Site Channel	sediment	benthic invertebrates	0.001	Appendix K of BERA	0.01
Chloroethane	Upper Sutton Brook - Site Channel	sediment	benthic invertebrates	0.03	Appendix K of BERA	0.1
Ethylbenzene	Upper Sutton Brook - Site Channel	sediment	benthic invertebrates	0.09	Appendix K of BERA	0.01
Toluene	Upper Sutton Brook - Site Channel	sediment	benthic invertebrates	0.06	Appendix K of BERA	0.025
Xylenes	Upper Sutton Brook - Site Channel	sediment	benthic invertebrates	0.13	Appendix K of BERA	0.01
1,2,4-Trimethylbenzene	Former Drum Disposal Area	soil	soil invertebrates	1.1	Appendix K of BERA	0.1
1,2,4-Trimethylbenzene	Former Drum Disposal Area	soil	robin	80	1	0.1
1,3,5-Trimethylbenzene	Former Drum Disposal Area	soil	soil invertebrates	1.1	Appendix K of BERA	0.1
Bis(2-ethylhexyl)phthalate	Former Drum Disposal Area	soil	plants	100	Appendix K of BERA	1
Bis(2-ethylhexyl)phthalate	Former Drum Disposal Area	soil	robin	2.3	1	1
Di-n-octylphthalate	Former Drum Disposal Area	soil	robin	0.1	1	1
Ethylbenzene	Former Drum Disposal Area	soil	plants	3.2	Appendix K of BERA	0.1
Ethylbenzene	Former Drum Disposal Area	soil	soil invertebrate	1.1	Appendix K of BERA	0.1
Naphthalene	Former Drum Disposal Area	soil	plants	1	Appendix K of BERA	0.1
Toluene	Former Drum Disposal Area	soil	soil invertebrate	1.1	Appendix K of BERA	0.1
Xylenes	Former Drum Disposal Area	soil	plants	10	Appendix K of BERA	0.1
Xylenes	Former Drum Disposal Area	soil	soil invertebrate	1.1	Appendix K of BERA	0.1
Xylenes	Former Drum Disposal Area	soil	robin	50	1	0.1
Di-n-octylphthalate	Upland Soils	soil	robin	0.4	2	1
Lead	Upland Soils	soil	robin	65	2	4
Zinc	Upland Soils	soil	soil invertebrate	190	Table 4-6c	4

PRGs were based on the outcome of the ecological risk assessment prepared for the Site and developed for use in the Feasibility Study. Based on assumptions used in the ecological risk assessment, the PRGs developed for the Upper Sutton Brook and Former Drum Disposal Area were based on the screening level risk assessment and therefore, depending on their use, may not be applicable as numerical cleanup goals as typically used in remediation verification. For example, prior to sediment removal from the site channel, additional delineation data may be collected which could be used to refine the preliminary remediation goals as presented in the FS.

1. Back-calculated from robin exposure models in Chapter 4 of Baseline Ecological Risk Assessment, May 2007. Target value = HQ of 1.0. Value reflects area use factor of 1.0.
2. Value of lead reflects area use factor of 0.5 used in the BERA. The value for di-n-octylphthalate reflects area use value of 0.25. This compound was detected in only three samples (SO-07(99), SO-09 (99), and SO-10(99), located within approximately 250 ft of each other, and the area represented by these three samples is small relative to the home range of the robin. So for this compound only, an area use factor of 0.25 was used in the PRG calculation.

Table 4-6c refers to the table of LOAELs presented as BERA Table 4-6c (May 2007)

Appendix K refers to the NOAEL-based values presented in this appendix in the May 2007 BERA

4. SCREENING AND SELECTION OF POTENTIAL REMEDIAL TECHNOLOGIES AND PROCESS OPTIONS

The following section presents the general response actions, remedial technologies, and associated process options that are potentially applicable to the media, contaminants, and conditions present at the Site. These general response actions, remedial technologies and associated process options were evaluated based on their effectiveness, implementability and relative cost for the site specific media and conditions. The overall purpose of this evaluation is to develop a focused group of remedial technologies and process options that can be used to assemble and formulate site-wide remedial alternatives (in Section 5).

4.1 DEVELOPMENT OF GENERAL RESPONSE ACTIONS

General response actions are measures that may be implemented for a given media to address the RAOs. General response actions may include one or a combination of the following: institutional controls, access controls (e.g., fencing), containment, excavation, collection (groundwater), treatment, disposal, and discharge.

Tables 4-1 through 4-4 summarize the general response actions for the landfills, FDDA, garage and storage area, and downgradient groundwater (non-source areas), respectively. In addition, these tables present an identification of remedial technologies and process options consistent with each of the general response actions. Potential remedial technologies and process options were identified based on the types of contaminants, nature of media present, and the potential human health and ecological risks present on-site.

For the landfill lobes, the media is divided into soil/waste, air (landfill gas), leachate, brook sediment and surface water, and groundwater. Based on the assumptions carried through the RI and risk assessments, it has been presumed that the limits of the landfilled waste will be capped. Therefore, potential general response actions identified for the waste include no action, limited action, and containment. For landfill gas, potential general response actions include no action, limited action, collection and treatment; and for leachate, the potential general response actions include no action, limited action, collection, treatment, and discharge. These general response actions are intended to provide a selection of remedial technologies and process options to fulfill site RAOs.

Potential general response actions identified for soil impacts in the FDDA and Garage and Storage Area include no action; limited action (i.e., institutional controls, access restrictions), containment, excavation with disposal, excavation with ex-situ treatment and/or disposal, and in-situ remediation. These general response actions are intended to provide a selection of remedial technologies and process options to fulfill site soil RAOs.

Potential general response actions for sediment in the source area include no action, limited action (i.e., institutional controls, access restrictions, long-term surface water monitoring), restoration (excavation), restoration and containment, restoration with partial containment, and re-routing of portion of Sutton Brook in between the two landfill lobes. These general response actions are intended to provide a selection of remedial technologies and process options to fulfill site sediment and surface water RAOs.

Potential general response actions for site groundwater include no action, limited action (i.e., institutional controls, long term monitoring), containment with barriers or groundwater extraction, collection (source reduction), ex-situ treatment and discharge, and in-situ remediation. These general response actions are

intended to provide a relatively focused selection of remedial technologies and process options to fulfill site groundwater RAOs.

4.2 INITIAL SCREENING OF POTENTIAL REMEDIAL TECHNOLOGIES AND PROCESS OPTIONS

As discussed above, potential remedial technologies and process options were identified based on the types and nature of contaminants, media, and the potential human health and ecological risks present on-site. The goal of this initial screening is to identify the remedial technologies and process options that are the most effective, implementable, and cost effective. During this process, the number of potentially applicable remedial technologies is reduced by eliminating those which are not applicable or feasible given the site specific conditions.

For this initial evaluation and screening of remedial technologies and process options, the site media were organized into seven categories consisting of landfill waste, air (landfill gas), leachate, soil, sediment/wetland soil, groundwater, and surface water. These media were evaluated for both the source areas and non-source areas, where applicable.

During this initial screening, the remedial technologies and process options were evaluated based on the criteria of effectiveness, implementability, and cost. Descriptions of these criteria and how they are used in the evaluation of remedial technologies and process options are described below:

- Effectiveness – each remedial technology and process option is evaluated on: 1) its effectiveness in meeting the site RAOs; 2) its capability of treating or processing the estimated volume of impacted media; 3) the potential impacts to human health and the environment during the construction and implementation of the remedial approach; and 4) how proven and reliable the process is with the contaminants and hydrogeology at the Site.

- Implementability – under this criterion, both the technical and administrative feasibility of implementing a process option is evaluated. Technical implementability is the initial screening tool for remedial technologies and process options to eliminate those that are clearly infeasible, ineffective or impractical at the Site. The administrative implementability then evaluates the ability to actually implement the response action.

- Cost – during this screening evaluation of remedial technologies and process options, capital and operation and maintenance (O&M) costs are evaluated based on their relative cost to other processes in the same technology type (i.e. low, medium or high).

The technology screening and evaluation is provided in Tables 4-1 through 4-3 for the “Source Areas” (landfill lobes, FDDA, and garage and storage area, respectively) and Table 4-4 for the non-source areas (downgradient groundwater). Those process options that are retained for further evaluation are indicated on these tables by highlighting the appropriate option.

TABLE 4-1
INITIAL EVALUATION AND SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS --
SOURCE AREA - LANDFILL LOBES

GENERAL RESPONSE ACTION	REMEDIAL TECHNOLOGY	PROCESS OPTION	DESCRIPTION	EFFECTIVENESS	IMPLEMENTABILITY	RELATIVE COST	SCREENING COMMENTS
LANDFILL LOBES - SOIL AND WASTE							
No Action	None	Not applicable	No activities taken to address potential direct contact with and infiltration through the landfill waste beyond periodic site inspections and five-year reviews.	-Not an effective approach for controlling and mitigating any potential human health or ecological risks or future contaminant migration.	-Easily implementable.	-No capital cost -No O&M costs	This alternative is retained as a baseline for comparison to the remaining alternatives in accordance with the NCP.
Limited Action	Access Restrictions	Fencing and/or security guard service	Construction of a physical barrier (i.e. fencing) around the landfill lobes to prevent access and/or employ security guard service to discourage attempts at accessing the impacted area.	-Effective at preventing human access to the waste but does not prevent potential future leaching of waste (through infiltration) to groundwater, nor does it prevent ecological access to the waste.	-Services and materials readily available to implement.	-Low capital cost -Low O&M costs.	Eliminated due to the presumptions incorporated into the RI and HERA and it does not meet the RAOs.
	Institutional Controls	Land use restrictions	Through land use restrictions, zoning or other legal mechanisms, restrict the use of or exposure to the landfill.	-Effective at preventing human exposure to the waste but does not prevent potential future leaching of waste (through infiltration) to groundwater, nor does it prevent ecological exposure to the waste.	-Easily implementable.	-Low capital cost -No O&M costs.	Eliminated from being the only response action selected due to the presumptions incorporated into the RI and HERA; however, this option may be incorporated with other technologies.
Containment	Permeable Cover	Soil and vegetative cover	Impacted area is covered with permeable soil and vegetative layers to prevent exposure to, erosion and surface migration of impacted soil.	-Effective at preventing human and ecological exposure to impacted soil but does not prevent potential future leaching of waste to groundwater, nor prevent the generation of leachate.	-Services and materials readily available to implement.	-Low to Moderate capital cost -Low O&M costs	Eliminated due to the ineffectiveness of this technology to prevent or reduce the percolation of precipitation through the waste and the generation of leachate; other containment technologies (i.e. low permeability cap) provide additional benefits that this technology is unable to provide.
	Alternative Cover System	Evapotranspiration Cover	Cover system that relies on the properties of soil to store water until it is either transpired through vegetation or evaporated from the soil surface (to prevent percolation through the waste). Design of an evapotranspiration cover system is site specific and utilizes one or more vegetated soil layers.	-Effective technology to prevent human and ecological exposure to the waste; effective technology for areas with arid or semi-arid climates. Due to the annual precipitation rates of the area, this technology may have reduced effectiveness in preventing infiltration into the waste. In addition, due to the potential for a fair amount of snow melting while vegetation is dormant, the cover may not be effective in controlling percolation into the waste.	-Services and material readily available to implement.	-Low to moderate capital cost -Moderate O&M costs	Eliminated as a stand alone approach, but retained as a potential option in conjunction with a low permeability cap.
	Low Permeability Cover	Low permeability soil layer	Impacted area is covered with an engineered cap utilizing a low permeability layer ($1x10^{-5}$ cm/s) to prevent exposure to and reduce infiltration through and leaching of contaminants into groundwater.	-Highly effective technology to prevent human and ecological exposure and migration of waste landfilled in the past; however, it does not eliminate or detoxify the waste. -Effective means to reduce infiltration and leachate generation through a landfill.	-Services and materials readily available to implement. -Design and construction can be implemented in a manner that substantially complies with local, state and federal regulations. -Stormwater basins will likely be required to accommodate the loss in flood storage capacity with this alternative.	-Low to moderate capital cost -Low O&M costs	Potentially applicable. Retained for further evaluation.
		Low permeability single geomembrane cover	Impacted area is covered with an engineered cap utilizing a low permeability single geomambrane layer (40 to 60 mil) and drainage layer to prevent exposure to and reduce infiltration through and leaching of contaminants into groundwater.	-Highly effective technology to prevent human and ecological exposure and migration of waste landfilled in the past; however, it does not eliminate or detoxify the waste. -Effective means to reduce infiltration and leachate generation through a landfill.	-Services and materials readily available to implement. -Design and construction can be implemented in a manner that substantially complies with local, state and federal regulations. -Stormwater basins will likely be required to accommodate the loss in flood storage capacity with this alternative.	-Moderate capital cost -Low O&M costs	Potentially applicable. Retained for further evaluation.

TABLE 4-1
INITIAL EVALUATION AND SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS --
SOURCE AREA - LANDFILL LOBES

GENERAL RESPONSE ACTION	REMEDIAL TECHNOLOGY	PROCESS OPTION	DESCRIPTION	EFFECTIVENESS	IMPLEMENTABILITY	RELATIVE COST	SCREENING COMMENTS
		Low permeability two layer composite cover	Impacted area is covered with an engineered cap incorporating two low permeability layers (60-mil geomembrane and $1x10^{-4}$ cm/s soil) to prevent exposure to and reduce infiltration through and leaching of contaminants into groundwater.	- Highly effective technology to prevent human and ecological exposure and migration of waste landfilled in the past; however, it does not eliminate or detoxify the waste. - Effective means to reduce infiltration and leachate generation through a landfill.	- Services and materials readily available to implement. - Design and construction can be implemented in a manner that substantially complies with local, state and federal regulations. - Stormwater basins will likely be required to accommodate the loss in flood storage capacity with this alternative.	- High capital cost - Low O&M costs	Potentially applicable. Retained for further evaluation.
LANDFILL LOBES - AIR							
No Action	None	Not applicable	No activities taken to address potential gas migration from the landfill waste beyond periodic site inspections and five-year reviews.	-Not an effective approach for controlling and mitigating any potential risks to human and/or ecological receptors.	-Easily implementable.	-No capital cost -No O&M costs	This alternative is retained as a baseline for comparison to the remaining alternatives in accordance with the NCP.
Limited Action	Long Term Monitoring	Air monitoring	Periodic air monitoring is performed at the perimeter of the landfill lobes to evaluate gas migration from the landfill.	-Effective means to evaluate potential risks generated through landfill gas migration; however not an effective approach for controlling and/or mitigating any potential risks to human and/or ecological receptors.	-Services and materials readily available to implement.	-Low capital cost -Low O&M costs	Eliminated as this technology is not an effective means at controlling or mitigating any potential landfill gas migration; however it may be combined with another technology to evaluate its effectiveness.
Venting	Passive	Passive vent system	As gas is generated by the landfilled waste, it migrates to vents within the capped landfill.	-Effective technology to vent any potential landfill gas generated overtime. -Proven and reliable technology to collect landfill gas (depending on volume produced).	-Services and materials readily available to implement.	-Moderate capital cost -Low O&M costs	Potentially applicable. Retained for further evaluation.
Collection	Active	Active extraction of landfill gas beneath the cap	Landfill gas is actively extracted by mechanical means through a collection system within the capped landfill.	-Effective technology to vent any potential landfill gas generated overtime. -Proven and reliable technology to collect landfill gas.	-Services and materials readily available to implement. -Applicability for the site specific conditions will be dependent on the results of the landfill gas assessment (to be conducted as part of the Phase 2 FS).	-High capital cost -High O&M costs	Potentially applicable. Retained for further evaluation.
Treatment	Direct Discharge	Direct discharge without treatment	Extracted landfill gas is discharged to the atmosphere in a single or multiple discharge points.	-Effectiveness dependent on actual volume and concentration of landfill gas generated; applicability for the site specific conditions will be dependent on the results of the landfill gas assessment (to be conducted as part of the Phase 2 FS). -Proven and reliable technology for low volume and concentration landfill gas.	-Services and materials readily available to implement.	-Low capital cost -Low O&M costs	Potentially applicable. Retained for further evaluation.
	Physical	Carbon adsorption	Extracted landfill gas is passed through granular activated carbon unit(s) to remove contaminants (VOCs, hydrogen sulfide, etc) prior to discharge.	-Effective technology to remove select contaminants (hydrogen sulfide, VOCs); not an effective means for treating methane.	-Services and materials readily available to implement.	-Moderate capital cost -High O&M costs	Eliminated. Treatment for non-methane compounds is not required for either landfill lobe (per initial LandGEM evaluation).
	Thermal	Flares	Extracted landfill gas is heated through flares to burn off the methane.	- Effective technology to destroy methane gas; proven and reliable technology. -Applicability for the site specific conditions will be dependent on the results of the landfill gas assessment (to be conducted as part of the Phase 2 FS).	-Services and materials readily available to implement.	-Moderate to high capital cost -Moderate O&M costs	Potentially applicable. Retained for further evaluation.
		Gas to energy	Extracted landfill gas is heated to burn off the methane; if a large enough volume of landfill gas is generated, it can be converted to electricity.	-Effective technology to destroy methane gas.	-Services and materials readily available to implement. -Applicable approach if sufficient volume of landfill gas is generated; modeling during the Phase 2 Detailed Analysis will determine if the estimated future methane generation rate is sufficient to cost effectively implement this alternative.	-High capital cost -High O&M costs	Potentially applicable; dependent on Phase 2 modeling results. Retained for further evaluation.

TABLE 4-1
INITIAL EVALUATION AND SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS --
SOURCE AREA - LANDFILL LOBES

GENERAL RESPONSE ACTION	REMEDIAL TECHNOLOGY	PROCESS OPTION	DESCRIPTION	EFFECTIVENESS	IMPLEMENTABILITY	RELATIVE COST	SCREENING COMMENTS
LANDFILL LOBES - LEACHATE							
No Action	None	Not applicable	No activities taken to address potential leachate migration from the landfill waste beyond periodic site inspections and five-year reviews.	-Not an effective approach for controlling and mitigating any potential risks to human and/or ecological receptors.	-Easily implementable.	-No capital cost -No O&M costs	This alternative is retained as a baseline for comparison to the remaining alternatives in accordance with the NCP.
Limited Action	Long Term Monitoring	Leachate monitoring	Periodic leachate monitoring is performed at the perimeter of the landfill lobes to evaluate leachate generation and migration from the landfill.	-Effective means to evaluate if leachate is present and at what any potential risks exist (to human and/or ecological receptors) as a result of leachate generation; however not an effective approach for controlling and mitigating any potential risks.	-Services and materials readily available to implement.	-Low capital cost -Low O&M costs	Potentially applicable (dependent on rate of leachate generation). Retained for further evaluation during the remedy design phase.
Collection	Passive	Infiltration trench or vertical wells/sump	As leachate is generated, it migrates (via gravity) to a trench or vertical wells/sump within the capped landfill for extraction.	-Effective means of collection for low volume leachate generation. -Potential to collect groundwater in addition to leachate since waste is located near the water table.	-Services and materials readily available to implement.	-Moderate capital cost -Moderate O&M costs	Potentially applicable (dependent on rate of leachate generation). Retained for further evaluation during the remedy design phase.
	Active	Infiltration trench or vertical extraction wells	Leachate is actively extracted through mechanical means and a collection system (vertical injection wells or infiltration trench) within the capped landfill.	-Effective means to collect high volumes of leachate. -Could also potentially collect a high volume of groundwater in addition to leachate since waste is located near the water table.	-Services and materials readily available to implement.	-Moderate to high capital cost -Moderate to high O&M costs	Potentially applicable (dependent on rate of leachate generation). Retained for further evaluation during the remedy design phase.
Treatment	Physical/ Chemical/ Thermal	Various	Extracted leachate is treated on-site; one or more processes will be required to treat the leachate prior to on-site discharge or off-site disposal. The actual treatment processes incorporated is dependent on chemical composition of the leachate.	-Multiple technologies are available to treat leachate; actual technology(ies) dependent on chemical composition and volume of leachate generated. -Effective approach to reduce the toxicity of the leachate.	-Services and materials readily available to implement.	-High capital cost -Moderate to high O&M costs	Potentially applicable. Retained for further evaluation during the remedy design phase.
Discharge	Off-site	Disposal	Once extracted, the leachate is transported off-site for treatment and/or disposal.	-Effective approach at removing the leachate from the site, eliminating any potential risk to human and/or ecological receptors or migration. -Commonly used approach.	-Services and materials readily available to implement.	-Low capital cost -Moderate to high O&M costs	Potentially applicable. Retained for further evaluation during the remedy design phase.
	On-site	Discharge	Once treated on-site, the leachate is discharged into the subsurface or back into the landfill.	-Convenient, effective and feasible means to discharge treated leachate.	-Services and materials readily available to implement. -To implement, treatment of the leachate prior to discharge will be required. -To substantially comply with discharge regulations, frequent monitoring will be required.	-Moderate capital cost -Moderate O&M costs	Potentially applicable. Retained for further evaluation during the remedy design phase.

TABLE 4-1
INITIAL EVALUATION AND SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS --
SOURCE AREA - LANDFILL LOBES

GENERAL RESPONSE ACTION	REMEDIAL TECHNOLOGY	PROCESS OPTION	DESCRIPTION	EFFECTIVENESS	IMPLEMENTABILITY	RELATIVE COST	SCREENING COMMENTS
SEDIMENT AND SURFACE WATER (wetlands and brook adjacent to lobes)							
No Action	None	Not applicable	No activities taken to address impacted sediment and surface water beyond periodic site inspections and five-year reviews.	- Not an effective approach for remediating impacted sediment and surface water. - Does not prevent potential future impacts to the surface water in the brook, nor the downgradient migration and usage of impacted surface water. - Potentially lengthy timeframe to reduce residual concentrations in surface water.	- Easily implementable. - No disruption to the brook habitat and flow patterns.	Lowest cost option - no capital or O&M costs.	This alternative is retained as a baseline for comparison to the remaining alternatives in accordance with the NCP.
Limited Action	Access Restrictions	Fencing and/or security guard service	Construction of a physical barrier (i.e. fencing) around the brook to prevent access and/or employ security guard service to discourage attempts at accessing the impacted area.	- Technology is not effective in reducing risks associated with the impacted sediment nor at preventing the migration of impacted groundwater into the brook. - Prevents human access to impacted sediment, but does not prevent access to ecological receptors.	- Services and materials readily available to implement.	- Low capital cost - Low O&M costs.	Eliminated as this is not a feasible technology to meet the site remedial goals.
	Institutional Controls	Land use restrictions	Through land use restrictions, zoning or other legal mechanisms, restrict the use of or access to the brook.	- Technology is not effective in reducing risks associated with the impacted sediment nor at preventing the migration of impacted groundwater into the brook.	- Services and materials readily available to implement.	- Low capital cost - No O&M costs.	Eliminated as this is not a feasible technology to meet the site remedial goals.
	Long-term Monitoring	Surface water and/or sediment monitoring	Periodic monitoring to evaluate changes in surface water and/or sediment quality that could be attributable to contaminant migration, natural attenuation processes or active remediation.	- Technology is not effective in reducing risks associated with the impacted sediment nor at preventing the migration of impacted groundwater into the brook. - In conjunction with the capping of the landfill lobes, this alternative will aid in monitoring the effectiveness at reducing discharge.	- Services and materials readily available to implement. - No disruption to the brook and its habitat.	- Low capital cost - Low O&M costs.	Potentially applicable for surface water. Retained for further evaluation.
Restoration	Excavation	Excavated with on-site or off-site disposal	Excavate impacted sediment (with off-site or on-site disposal) and restore brook.	- Effective approach to eliminate impacted sediment; not an effective means to prevent discharge of impacted groundwater into the brook. - Removes impacted sediment from the brook, preventing future exposure to the existing impacted material. - Although flow will be diverted during excavation, upon restoration the natural hydrogeology patterns will be maintained. - If used in conjunction with other remedial approaches that address groundwater impacts (i.e. containment), this approach will effectively eliminate current and future risks. - Does not prevent further surface water or sediment impacts; may be controlled if performed with other technologies for the impacted groundwater.	- Services and materials readily available to implement - May result in the disruption of the ecological habitat in the vicinity of the excavation.	- Moderate to high capital cost - Low O&M costs	Potentially applicable. Retained for further evaluation.
Restoration and Containment	Excavation with Containment of the Brook	On-site or off-site disposal with containment around a portion of the brook that passes between the lobes	Excavate impacted sediment (with off-site or on-site disposal) and restore brook with containment around all sides (i.e. place in an impermeable culvert or place barriers (sheet piling) on both sides of the brook).	- Effective approach to eliminate impacted sediment and prevent migration of impacted groundwater from the source areas and/or landfill lobes into the brook. However, the potential exists for impacted groundwater to migrate along the contained brook and potentially discharge downgradient within the brook and/or wetlands. This may be controlled if performed with other technologies for the impacted groundwater.	- Services and materials readily available to implement - May result in the disruption of the ecological habitat in the vicinity of the excavation. - Will result in modification of the existing hydrogeological flow patterns.	- High capital cost - No O&M costs	Potentially applicable. Retained for further evaluation.

TABLE 4-1
INITIAL EVALUATION AND SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS --
SOURCE AREA - LANDFILL LOBES

GENERAL RESPONSE ACTION	REMEDIAL TECHNOLOGY	PROCESS OPTION	DESCRIPTION	EFFECTIVENESS	IMPLEMENTABILITY	RELATIVE COST	SCREENING COMMENTS
Restoration with Partial Containment	Excavation with Barrier along a portion of the brook	On-site or off-site disposal with vertical barrier along select portions of the brook	Excavate impacted sediment (with off-site or on-site disposal) and restore brook with containment along the southern landfill lobe side (i.e. place an impermeable barrier [e.g. hanging vertical barrier] along a portion of the brook to prevent contaminated groundwater discharge).	- Effective approach to eliminate impacted sediment and prevent discharge of impacted groundwater into the brook. - Prevents further impacts to sediment and surface water.	- Services and materials readily available to implement - May result in the disruption of the ecological habitat in the vicinity of the excavation. - Will result in modification of the existing hydrogeological flow patterns.	- Moderate to high capital cost - No O&M costs	Eliminated as a potential technology for the brook because containment has been retained as an option for groundwater (see below).
Re-route Brook	Re-route brook and containment of sediments	Re-route brook and extend cap over sediment in between landfill lobes	Re-route brook to the south of the southern lobe (or other location) and backfill and cap the area of the existing brook in between the two lobes.	- Effective approach to eliminate impacted sediment and prevent discharge of impacted groundwater into the brook. - Prevents further impacts to sediment and surface water. - May need containment in area of re-route (depending on location).	- Services and materials readily available to implement - Potential major disruption of the ecological habitat within the brook. - Implementation will result in modification of hydrogeological flow patterns on-site; hyrogeo modeling will be required to ensure this alternative is feasible. - Design and construction may not be able to be implemented in a manner that substantially complies with the extensive local, state and federal regulations. - May not be enough land to recreate the 100-year flood plain that would be destroyed during the re-routing	- Very high capital cost - No O&M costs	Potentially applicable. Retained for further evaluation.
LANDFILL LOBES - GROUNDWATER							
No Action	None	Not applicable	No activities taken to address impacted groundwater beyond periodic site inspections and five-year reviews.	- Does not prevent potential downgradient migration and usage of impacted groundwater. - Potentially lengthy timeframe to reduce residual concentrations in groundwater to MCLs.	- Easily implementable.	Lowest cost option - no capital or O&M costs.	This alternative is retained as a baseline for comparison to the remaining alternatives in accordance with the NCP.
Limited Action	Institutional Controls	Land use restrictions	Through land use restrictions, zoning or other legal mechanisms, restrict the use of or exposure to groundwater.	- Effective at preventing human exposure or consumption of impacted groundwater but does not prevent potential downgradient migration. - Potentially lengthy timeframe to reduce residual concentrations in groundwater to MCLs.	- Easily implementable.	- Low capital cost - No O&M costs.	Potentially applicable. Retained for further evaluation.
	Long-term Monitoring	Groundwater monitoring	Periodic groundwater monitoring to evaluate changes in groundwater quality that could be attributable to contaminant migration, natural attenuation processes or active remediation.	- Effective at monitoring contaminant trends over time. - Potentially lengthy timeframe to reduce residual concentrations in groundwater to MCLs.	- Easily implementable; services and materials readily available to implement.	- Low capital cost - Low O&M costs	Potentially applicable. Retained for further evaluation.
Containment with Barrier	Low Permeability Cap	Clay, concrete, and/or asphalt	Impacted area is covered with an engineered (low permeability) cover (i.e. compacted clay, concrete, asphalt, etc.) to prevent exposure to and reduce infiltration through and leaching of contaminants into groundwater.	- Effective at preventing exposure to impacted groundwater. - Although this technology does not prevent potential downgradient migration, it does limit the amount of future leaching of contaminants from the landfill into groundwater.	- Services and materials readily available to implement. - Design and construction can be implemented in a manner that substantially complies with local, state and federal regulations.	- Moderate capital cost - Low O&M costs	Eliminated as a potential technology for groundwater since it has been retained as a technology for the landfill lobes.
	Vertical Barriers	Slurry wall	Subsurface vertical wall, constructed with low permeable material (i.e. soil - bentonite), to contain or divert groundwater. The containment unit can be constructed for the entire plume or for a portion of the plume (i.e. restrict groundwater discharge from the southern landfill lobe into Sutton Brook).	- Effective at preventing migration of impacted groundwater; dependable and reliable in the long term.	- Services and materials available to implement.	- Moderate capital cost - Low O&M costs	Potentially applicable. Retained for further evaluation.
		Sheet pile wall	Subsurface vertical wall, constructed by driving vertical sheets of steel or comparable material into the ground to contain or divert groundwater. The containment unit can be constructed for the entire plume or for a portion of the plume (i.e. restrict groundwater discharge from the southern landfill lobe into a portion of Sutton Brook).	- Effective at preventing migration of impacted groundwater; dependable and reliable in the long term.	- Services and materials available to implement.	- Moderate capital cost - Low O&M costs	Potentially applicable. Retained for further evaluation. May be combined with interceptor trench.

TABLE 4-1
INITIAL EVALUATION AND SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS --
SOURCE AREA - LANDFILL LOBES

GENERAL RESPONSE ACTION	REMEDIAL TECHNOLOGY	PROCESS OPTION	DESCRIPTION	EFFECTIVENESS	IMPLEMENTABILITY	RELATIVE COST	SCREENING COMMENTS
		Grout curtain wall	Subsurface vertical wall, constructed by injecting a grout mixture into overburden soil pores under pressure to form an impermeable barrier to contain or divert groundwater. The containment unit can be constructed for the entire plume or for a portion of the plume (i.e. restrict groundwater discharge from the southern landfill lobe into Sutton Brook).	- Effective at preventing migration of impacted groundwater; dependable and reliable in the long term.	- Services and materials available to implement.	- Moderate capital cost - Low O&M costs	Potentially applicable. Retained for further evaluation.
Containment with Groundwater Extraction	Extraction	Vertical extraction wells	Strategically placed vertical wells are installed to hydraulically contain impacted groundwater.	- Effective means to collect and prevent migration of impacted groundwater. - Reliable and frequently used alternative.	- Services and materials readily available to implement.	- Moderate to high capital cost - Moderate to high O&M costs	Potentially applicable. Retained for further evaluation.
		Interceptor trench	Collection of groundwater from a subsurface trench that contains porous material to facilitate the flow of water. The trench acts as a means to cut off the flow of impacted water (i.e. containment on-site).	- Effective at preventing migration of impacted groundwater.	- Services and materials readily available to implement. - Potential issues with the placement of the trench in relation to the landfill waste.	- Moderate to high capital cost - Moderate to high O&M costs	Potentially applicable. Retained for further evaluation.
Collection (source reduction)	Extraction	Vertical extraction wells	Strategically placed vertical wells are installed to extract source zone groundwater.	- Effective means to collect and prevent migration of impacted groundwater. - Reliable and frequently used alternative.	- Services and materials readily available to implement.	- Moderate to high capital cost - Moderate to high O&M costs	Potentially applicable. Retained for further evaluation.
		Interceptor trench	Collection of groundwater from a subsurface trench that contains porous material to facilitate the flow of water.	- Effective at preventing migration of impacted groundwater.	- Services and materials readily available to implement. - Potential issues with the placement of the trench in relation to the landfill waste.	- Moderate to high capital cost - Moderate to high O&M costs	Potentially applicable. Retained for further evaluation.
		Vacuum enhanced/ multi-phase extraction	A vacuum is applied to an extraction wells to induce groundwater flow to the well without drawdown. This method allows for removal of multiple contaminant phases (water, LNAPL, and vapor). In addition to removing the vapor and groundwater from the well, the high vacuum applied to the well(s) enhances the groundwater recovery and maximizes vapor extraction effectiveness.	- Effective at treating and preventing migration of impacted groundwater.	- Services and materials readily available to implement. - Since LNAPL is not present on-site, nor are there vadose zone soil impacts in this area, this technology provides extra services not required.	- High capital cost - High O&M costs	Eliminated as this technology provides treatment to conditions (i.e. LNAPL) not present in site groundwater.
Ex-situ Treatment	Physical/ Chemical Treatment	Filtration/microfiltration/ultrafiltration	Separation of suspended particles form a fluid using a porous media or membrane to trap particles either within or on the surface of the media.	- Effective technology to remove suspended particles as a pretreatment step; not effective in removing other contaminants.	- Services and materials readily available to implement.	- Low capital cost - Low to moderate O&M costs	Potentially applicable. Retained for further evaluation as a possible pretreatment step in an ex-situ groundwater treatment system.
		Reverse osmosis	Removal of dissolved organic and inorganic compounds by passing the fluid through a semi-permeable membrane under pressure.	- Effective technology for treating the impacted groundwater; other technologies may be required to treat the entire waste stream.	- Services and materials available to implement for small scale systems; not in common use at this time for large scale treatment of groundwater.	- Moderate to high capital cost - Moderate O&M costs	Potentially applicable. Retained for further evaluation.
		Distillation	Separation process used to remove volatile components from a fluid. Heat is applied to the fluid to vaporize the volatile components; the vaporized components are subsequently cooled and condensed.	- Not a highly effective technology for remediating low concentrations of volatile components; other technologies will be required to treat the inorganic portion of the waste stream.	- Services and materials readily available to implement.	- High capital cost - Moderate to high O&M costs	Eliminated as this technology is not effective for the site specific conditions and other proven technologies are available.
		Air stripping	Removal of volatile compounds from the aqueous phase to the vapor phase through contact with air in a countercurrent manner (i.e. packed tower, tray, etc.). Resulting vapor phase is typically requires treatment.	- Effective technology for treating VOC impacted groundwater; other technologies will be required to treat the inorganic and 1,4-dioxane portion of the waste stream.	- Services and materials readily available to implement.	- Moderate capital cost - Moderate O&M costs	Potentially applicable as one of multiple treatment steps; retained for further evaluation.
		Steam stripping	Removal of volatile compounds from the aqueous phase to the vapor phase through contact with steam in an countercurrent manner. Volatiles are recovered by condensation of steam.	- Effective technology for treating VOC impacted groundwater; other technologies will be required to treat the inorganic and 1,4-dioxane portion of the waste stream.	- Services and materials readily available to implement.	- High capital cost - Moderate to high O&M costs	Eliminated as other technologies (i.e. air stripping) are more widely used and more cost effective.

TABLE 4-1
INITIAL EVALUATION AND SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS --
SOURCE AREA - LANDFILL LOBES

GENERAL RESPONSE ACTION	REMEDIAL TECHNOLOGY	PROCESS OPTION	DESCRIPTION	EFFECTIVENESS	IMPLEMENTABILITY	RELATIVE COST	SCREENING COMMENTS
		Aeration	Pre-treatment step utilized to remove dissolved metals (i.e. iron and manganese) through contact with air. Contact with air results in oxidation and formation of insoluble hydroxides that precipitate from water.	- Effective technology for removing dissolved metals from groundwater; other technologies will be required.	- Services and materials readily available to implement.	- Moderate capital cost - Moderate O&M costs	Potentially applicable. Retained for further evaluation as a possible pretreatment step in an ex-situ groundwater treatment system.
		Carbon adsorption	Removal of dissolved contaminants from groundwater by adsorption on activated carbon.	- Effective technology for removing dissolved organic compounds from groundwater; other technologies will be required.	- Services and materials readily available to implement.	- Moderate capital cost - Moderate to high O&M costs	Potentially applicable as one of multiple treatment steps; retained for further evaluation.
		Clarification	Separation of suspended particles from groundwater by gravity settling in a tank.	- Effective technology to remove suspended particles as a pretreatment step; not effective in removing other contaminants.	- Services and materials readily available to implement.	- Moderate capital cost - Moderate O&M costs	Potentially applicable. Retained for further evaluation as a possible pretreatment step in an ex-situ groundwater treatment system.
		Precipitation/ Flocculation	Chemical conversion of dissolved metals and/or other inorganic ions to an insoluble precipitate that can be removed by clarification and/or filtration. The process typically involves pH adjustment and the addition of chemical precipitants and flocculants to promote particle aggregation and increased settling efficiency.	- Effective technology to remove inorganics in groundwater; other technologies will be required to treat the remainder of the waste stream.	- Services and materials readily available to implement.	- Moderate to high capital cost - Moderate to high O&M costs	Potentially applicable as one of multiple treatment steps; retained for further evaluation.
		Advanced oxidation processes	Use of strong oxidizers (i.e. ozone or hydrogen peroxide), often in conjunction with UV light, to destroy dissolved organic contaminants.	- Effective technology for removing dissolved organic compounds, including 1,4-dioxane, from groundwater; other technologies may be required.	- Services and materials readily available to implement.	- Moderate to high capital cost - Moderate to high O&M costs	Potentially applicable as one of multiple treatment steps; retained for further evaluation.
		Ion exchange	Removal of dissolved inorganic compounds by passing groundwater through a granular solid or other porous media (i.e. impregnated resin) that exchanges sorbed ions for the contaminant ions.	- Effective technology to remove dissolved inorganics in groundwater; other technologies will be required to treat the remainder of the waste stream. This technology is commonly used as a pretreatment or polishing step.	- Services and materials readily available to implement.	- Moderate to high capital cost - Moderate to high O&M costs	Potentially applicable as a pretreatment or polishing step; retained for further evaluation.
	Biological Treatment	Aerobic reactor	Microorganisms and oxygen are utilized to convert organic compounds into innocuous end products.	- Potentially effective technology for degrading organic compounds from groundwater; other technologies will be required.	- Services and materials available to implement; however, other technologies have been proven to achieve similar results in a shorter timeframe.	- Moderate to high capital cost - Low to moderate O&M costs	Eliminated as other technologies (i.e. air stripping) are more widely used and more cost effective.
		Anaerobic reactor	Anaerobic microorganisms are utilized to degrade organic contaminants in an oxygen free environment.	- Performance data for full scale application is minimal; effectiveness not certain.	- Services and materials available to implement; however, performance data for full scale applications is minimal.	- Moderate to high capital cost - Moderate O&M costs	Eliminated as the effectiveness of this technology in a full scale application has not been proven.
Discharge	Surface Discharge	Direct	Discharge of treated groundwater to Sutton Brook.	- Convenient, effective and feasible means to discharge treated groundwater.	- Services and materials available to implement. - Discharge locations easily accessible. - Design and construction can be implemented in a manner that substantially complies with the multiple local, state and federal regulations. - More frequent discharge monitoring and more stringent discharge requirements may be required.	- Low to moderate capital cost - Low to moderate O&M costs	Potentially applicable. Retained for further evaluation.
		In-direct	Discharge of treated groundwater into a local Publicly Owned Treatment Works (POTW) for treatment and disposal.	- Effective means to discharge treated groundwater; treatment system requirements (i.e. standards to meet) may be reduced in comparison to direct surface water discharge. - Commonly used discharge alternative; groundwater passes through multiple treatment processes prior to final discharge.	- The public sewer system pipeline was recently installed along South Street in the vicinity of the site. Recent discussions with the Town Engineer have indicated that the capacity of the system may be able to accommodate groundwater (range of 15 to 200 gpm) from the site. However, an evaluation would be required to confirm that the existing pipeline can accommodate the load from the site as well as the current and anticipated future usage from the area. Concerns were raised that additional upgrades to this line would likely present opposition by the town and residents.	- High capital cost (due to distance) - Moderate O&M costs	Potentially applicable. Retained for further evaluation.

TABLE 4-1
INITIAL EVALUATION AND SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS --
SOURCE AREA - LANDFILL LOBES

GENERAL RESPONSE ACTION	REMEDIAL TECHNOLOGY	PROCESS OPTION	DESCRIPTION	EFFECTIVENESS	IMPLEMENTABILITY	RELATIVE COST	SCREENING COMMENTS
	Subsurface Discharge	Injection wells	Pressurized discharge of treated groundwater to the subsurface using injection wells.	-Effective means to discharge treated groundwater. -Commonly used discharge alternative.	- Services and materials available to implement. - Groundwater modeling and pump tests may be required to confirm the feasibility of this technology. - Potential to modify existing groundwater chemistry and flow patterns; modeling will be required to demonstrate no adverse effect.	- Moderate capital cost - Low to moderate O&M costs	Potentially applicable. Retained for further evaluation.
		Infiltration gallery/ leach field	Discharge of treated groundwater to an on-site subsurface location utilizing a buried infiltration gallery or leach field.	-Effective means to discharge treated groundwater; groundwater modeling to confirm the feasibility of this method may be required. -Commonly used discharge alternative.	- Services and materials available to implement. - Groundwater modeling and pump tests may be required to confirm the feasibility of this technology. - Potential to modify existing groundwater chemistry and flow patterns; modeling will be required to demonstrate no adverse effect.	- Moderate capital cost - Low to moderate O&M costs	Potentially applicable. Retained for further evaluation.
		Infiltration wells (gravity drain)	Discharge of treated groundwater to an on-site subsurface location utilizing vertical, large diameter passive infiltration wells.	-Effective means to discharge treated groundwater; groundwater modeling to confirm the feasibility of this method will be required.	- Services and materials available to implement. - Groundwater modeling and pump tests may be required to confirm the feasibility of this technology. - Potential to modify existing groundwater chemistry and flow patterns; modeling will be required to demonstrate no adverse effect.	- Moderate capital cost - Low to moderate O&M costs	Potentially applicable. Retained for further evaluation.
In-situ Treatment/ Remedial Action	Physical/ Chemical Treatment	Air sparging/ soil vapor extraction	Air sparging involves injection of air under pressure below the water table, introducing air to soil pore spaces by displacing the water in the soil matrix. Air sparging contributes to the physical removal of organic compounds (liquid, adsorbed and dissolved phases) through volatilization from subsurface soils and groundwater. In addition, air sparging facilitates aerobic biodegradation processes by assisting with oxygen transfers in the soil and groundwater. The resulting soil vapor is collected via SVE wells.	-Effective technology for remediating VOCs in groundwater; however, it is not an effective means for treating inorganics or 1,4-dioxane. -Limited ability to collect soil vapor due to the high water table.	- Services and materials available to implement. - In-situ approach; discharge of treated water not required.	- Moderate capital cost - Moderate to high O&M costs	Eliminated as this alternative is not feasible given the site specific conditions (i.e. high water table and limited unsaturated thickness in the wetlands) and does not effectively treat all the contaminants present.
		In-well air stripping	Air is injected into the bottom of a dual level screened well to lift groundwater in the well causing it to flow out the upper screen while groundwater enters the well through the lower screen. Volatile contaminants are stripped from groundwater, drawn off by a vacuum extraction system and treated. The discharge of water through the lower screen establishes a circular in-situ flow path through which groundwater is repeatedly treated.	-Effective technology for remediating VOCs in groundwater; however, it is not an effective means for treating inorganics or 1,4-dioxane. -Effectiveness has been shown to be reduced in shallow aquifers.	- Services and materials available to implement. - In-situ approach; discharge of treated water not required. - With treatment zones confined to a relatively small radius around each well, numerous treatment wells may be required to effectively treat the plume. - Fouling of wells is a common maintenance concern.	- Moderate capital cost - Moderate to high O&M costs	Eliminated since this technology does not effectively treat all the contaminants present and other technologies are more effective for the site specific conditions.
		Chemical oxidation	Oxidants (i.e. ozone, hydrogen peroxide, permanganate) are injected into the impacted area to destroy organic contaminants in-situ. The contaminants are degraded into innocuous end products (i.e. carbon dioxide).	-Effective technology for remediating VOCs in groundwater; however, it is not an effective means for treating inorganics. -Implementation may modify the existing geochemistry that is effectively naturally attenuating impacted groundwater.	- Services and materials available to implement. - In-situ approach; discharge of treated water not required.	- Moderate capital cost - Moderate O&M costs	Potentially applicable to reduce the concentration of some compounds amenable to this treatment. If implemented, it may be used in conjunction with another technology(s). Retained for further evaluation.
		Permeable reactive barrier	An in-situ treatment zone of reactive material that degrades or immobilizes contaminants as groundwater flows through it. PRBs are installed as permanent, semi-permanent or replaceable units across the flow path of a contaminated plume. Natural gradients transport contaminants through strategically placed media. The media degrade, sorb, precipitate, or otherwise remove groundwater contaminants.	-Effective technology for treating and/or preventing migration of inorganics and select VOCs; only limited effectiveness in treating fuel hydrocarbons. -Regeneration of reactive material may be required over time to provide effective treatment/containment. -Potentially lengthy timeframe; may require multiple regenerations over time.	- Services and materials available to implement. - Disruptive technology during installation and regeneration(s).	- High capital cost - Low O&M costs	Potentially applicable to reduce the concentration of some compounds amenable to this treatment. If implemented, it may be used in conjunction with another technology(s). Retained for further evaluation.

TABLE 4-1
INITIAL EVALUATION AND SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS --
SOURCE AREA - LANDFILL LOBES

GENERAL RESPONSE ACTION	REMEDIAL TECHNOLOGY	PROCESS OPTION	DESCRIPTION	EFFECTIVENESS	IMPLEMENTABILITY	RELATIVE COST	SCREENING COMMENTS
		Phytoremediation	Plants are utilized to remove, transfer, stabilize and/or destroy contaminants in soil and groundwater. Phytoremediation mechanisms include enhanced biodegradation in the root zone; uptake of contaminants by roots and accumulation in plant mass; metabolism of contaminants within plant tissues; immobilization of contaminants in root zones; and uptake and release of volatile contaminants through plant leaves.	- Potentially effective technology for removing contaminants from shallow impacted groundwater; plants removing the contaminants may require removal and disposal upon completion of contaminant uptake. - Not an effective technology for groundwater below root depth. - Potentially lengthy timeframe. - Use of this alternative to treat groundwater in a 'phytobed' may be effective for low flow/volume; however this alternative has had limited use to date in full scale implementation.	- Services and materials available to implement. - Upon completion of contaminant uptake, plants may require removal and disposal; potentially disrupting the wetland area and existing habitat. - Use of this alternative as a 'phytobed' to treat groundwater (i.e. groundwater routed from behind a vertical barrier, etc.) will likely only be feasible for low flow/volumes.	- Low capital cost - Low O&M	Eliminated as a stand alone approach; however, the technology may be incorporated in conjunction with other remedial options (i.e. partial containment of landfill groundwater, etc.).
	Biological Treatment/ Remedial Action	Enhanced biodegradation	Enhanced in-situ bioremediation in groundwater involves the input of an organic carbon source, nutrients, electron acceptors, and/or microbial cultures to stimulate biodegradation.	- Effective technology for promoting biodegradation of contaminants in-situ. - Existing site data demonstrates that natural attenuation processes are currently reducing contaminant levels in-situ in some areas. - Technology may take a longer timeframe than other alternatives evaluated.	- Services and materials available to implement.	- Low to moderate capital cost - Low to moderate O&M costs	Potentially applicable to reduce the concentration of some compounds amenable to this treatment. If implemented, it may be used in conjunction with another technology(s). Retained for further evaluation.
		Engineered Treatment Wetland	- Engineered wetlands are designed to utilize natural biogeochemical reactions (i.e. reduction/oxidation transformations), phytoremediation (i.e. plant uptake of contaminants), bioremediation (i.e. microbial degradation), and physical processes (i.e. sedimentation) to treat impacted groundwater or surface water within a more controlled environment.	- Potentially effective technology for removing contaminants from shallow impacted groundwater or redirected flow. - Potentially lengthy timeframe. - Use of this alternative to treat groundwater may be effective for low flow/volume; however, this alternative has had limited use to date in full scale implementation.	- Services and materials available to implement. - Use of this alternative to treat groundwater (i.e. groundwater routed from behind a vertical barrier, etc.) will likely only be feasible for low flow/volumes.	- Low to moderate capital cost - Low to moderate O&M costs	Eliminated as a stand alone approach; however, the technology may be incorporated in conjunction with other remedial options that incorporate low flow/volume groundwater options.
		Monitored natural attenuation	MNA involves the monitoring and documentation of naturally-occurring processes in soil and groundwater environments that act without human intervention to reduce the mass, toxicity, mobility, volume, or concentration of contaminants in those media to acceptable levels. These in-situ processes include biodegradation, dispersion, dilution, adsorption, volatilization, and chemical or biological stabilization or destruction of contaminants.	- Effective technology for reducing contaminant levels in-situ; current data demonstrates natural attenuation processes are currently reducing contaminants levels. - Technology may take a longer timeframe than other alternatives evaluated.	- Services and materials available to implement.	- Low capital cost - Low O&M costs	Potentially applicable. Retained for further evaluation.

TABLE 4-2

INITIAL EVALUATION AND SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS --

SOURCE AREA - FORMER DRUM DISPOSAL AREA

GENERAL RESPONSE ACTION	REMEDIAL TECHNOLOGY	PROCESS OPTION	DESCRIPTION	EFFECTIVENESS	IMPLEMENTABILITY	RELATIVE COST	SCREENING COMMENTS
SOIL							
No Action	None	Not applicable	No activities taken to address impacted soil within the FDDA beyond periodic site inspections and five-year reviews.	-Technology does not re-use, detoxify or destroy contaminants through treatment. -Potentially lengthy timeframe to reduce residual concentrations in soil.	- Easily implementable.	- Lowest cost option - no capital or O&M costs.	This alternative is retained as a baseline for comparison to the remaining alternatives in accordance with the NCP.
Limited Action	Access Restrictions	Fencing and/or security guard service	Construction of a physical barrier (i.e. fencing) around the FDDA to prevent access and/or employ security guard service to discourage attempts at accessing impacted area.	-Effective at preventing human access to impacted soil but does not prevent potential future leaching of impacted soil to groundwater or prevent access of ecological receptors to the impacted material. -Technology does not re-use, detoxify or destroy contaminants though treatment. -Potentially lengthy timeframe to reduce residual concentrations in soil through natural attenuation. -This option does not provide the confirmation that these processes are occurring or at what rate.	- Services and materials readily available to implement.	- Low capital cost - Low O&M costs.	Potentially applicable. Retained for further evaluation.
	Institutional Controls	Land use restrictions	Through land use restrictions, zoning or other legal mechanisms, restrict the use of or exposure to the FDDA soil.	-Effective at preventing human exposure to impacted soil but does not prevent potential future leaching of impacted soil to groundwater or prevent exposure of ecological receptors to the impacted material. -Technology does not re-use, detoxify or destroy contaminants through treatment. -Potentially lengthy timeframe to reduce residual concentrations in soil through natural attenuation. -This option does not provide the confirmation that these processes are occurring or at what rate.	- Easily implementable.	- Low capital cost - No O&M costs.	Potentially applicable. Retained for further evaluation.
	Long Term Monitoring	Soil monitoring	Conduct soil sampling to assess changes that could be attributable to surface infiltration, natural attenuation processes, or active remediation.	-Effective at monitoring contaminant trends over time. -Does not prevent exposure to or prevent potential future leaching of impacted soil to groundwater. -Potentially lengthy timeframe to reduce residual concentrations.	- Services and materials readily available to implement.	- Low capital costs - Low O&M costs.	Eliminated as other technologies are more protective against existing and potential future risks.
Containment	Permeable Cover	Soil and vegetative cover	Impacted area is covered with permeable soil and vegetative layers to prevent exposure to, erosion and ground surface migration of impacted soil.	- Effective at preventing human exposure to impacted soil but does not prevent potential future leaching of impacted soil to groundwater or prevent exposure of ecological receptors to the impacted material. - Potentially lengthy timeframe to reduce residual concentrations in soil through natural attenuation. - This option does not provide confirmation that these processes are occurring or at what rate.	- Services and materials readily available to implement.	- Moderate capital cost - Low O&M costs	Eliminated as other containment technologies (i.e. low permeability cap) provide additional benefits for comparable disruption to the area.

TABLE 4-2
INITIAL EVALUATION AND SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS --
SOURCE AREA - FORMER DRUM DISPOSAL AREA

GENERAL RESPONSE ACTION	REMEDIAL TECHNOLOGY	PROCESS OPTION	DESCRIPTION	EFFECTIVENESS	IMPLEMENTABILITY	RELATIVE COST	SCREENING COMMENTS
	Low Permeability Cap	Clay, geomembrane, concrete, and/or asphalt	Impacted area is covered with a low permeability cover (i.e. compacted clay, geomembrane, concrete, asphalt, etc.) to prevent exposure to, erosion and surface migration of impacted soil and reduce infiltration through and leaching of contaminants into groundwater.	- Effective at preventing human and ecological exposure to impacted soil and reduces the potential for future leaching of impacted unsaturated soil to groundwater. - Potentially lengthy timeframe to reduce residual concentrations in soil through natural attenuation. - This option does not provide confirmation that these processes are occurring or at what rate.	- Services and materials readily available to implement.	- High capital cost - Low O&M costs	Potentially applicable. Retained for further evaluation.
Excavation with Disposal	Landfill	On-site disposal	The impacted soil is physically removed from the subsurface and disposed of on-site in the Southern Lobe (Southern Lobe selected due to similar groundwater contamination as the FDDA).	- Highly effective at eliminating human and ecological exposure to impacted material and preventing potential future leaching to groundwater as the material is removed from this area. - Quick timeframe to reach soil remedial goals.	- Services and materials readily available to implement. - Resulting area could be incorporated into the landfill cover stormwater plan (i.e. retention or detention pond).	- High capital cost - No O&M costs	Potentially applicable. Retained for further evaluation.
		Off-site disposal	The impacted soil is physically removed from the subsurface and disposed off-site at an appropriate disposal facility.	- Highly effective at eliminating human and ecological exposure to impacted material and preventing potential future leaching to groundwater as the material is removed. - Quick timeframe to reach soil remedial goals.	- Services and materials readily available to implement. - Resulting area could be incorporated into the landfill cover stormwater plan (i.e. retention or detention pond).	- High capital cost - No O&M costs	Potentially applicable. Retained for further evaluation.
Excavation with Ex-situ Treatment	Physical/ Chemical Treatment	Asphalt batching	Excavated soils are utilized in the production of asphalt. The contaminants present in the soil become bound up/ encapsulated in the asphalt mixture.	- Removes impacted material from the area, thereby eliminating future exposure risks to human and ecological receptors. - Quick timeframe to reach site remedial goals. - Effective technology for petroleum impacted material; Not an approved technology for phthalates and chlorinated VOCs at the concentrations present on-site.	- Services and materials available to implement. - Not a demonstrated technology for phthalates and chlorinated VOCs at the concentrations present on-site.	- High capital cost - No O&M costs	Eliminated as other ex-situ treatment technologies are more effective for the site COCs.
		Solidification/ Stabilization	Contaminants are physically bound or enclosed within a stabilized matrix (solidification), or chemical reactions are induced between the stabilizing agent and the contaminants to reduce their mobility (stabilization).	- Removes impacted material from the area, thereby eliminating future human and ecological exposure. - Prevents future exposure to any inorganics present in the material. - Effective approach for material impacted with inorganics; potentially effective technology in treating VOC and SVOC impacted material.	- Services and materials available to implement.	- High capital cost - No O&M costs	Eliminated as this technology has not been proven to be sufficiently effective for VOCs and SVOCs; other treatment alternatives (i.e. thermal) are more effective and reliable.
		Soil venting	The excavated material is placed in piles containing perforated pipes connected to a vacuum blower to induce air flow through the soil and removal of volatile contaminants. Extracted vapors are typically treated via carbon adsorption or oxidation.	- Removes impacted material from the area, thereby eliminating future human and ecological exposure. - Effective technology for treating VOCs; potentially effective technology for treating SVOCs.	- Services and materials available to implement.	- High capital costs - Moderate O&M costs.	Potentially applicable to reduce the concentration of some compounds amenable to this treatment prior to disposal. Retained for further evaluation.

TABLE 4-2
INITIAL EVALUATION AND SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS --
SOURCE AREA - FORMER DRUM DISPOSAL AREA

GENERAL RESPONSE ACTION	REMEDIAL TECHNOLOGY	PROCESS OPTION	DESCRIPTION	EFFECTIVENESS	IMPLEMENTABILITY	RELATIVE COST	SCREENING COMMENTS
		Soil washing	The excavated soils undergo a water and surfactant based process of screening and separation which removes contaminants by dissolving them in the wash solution and by concentrating them into a smaller volume of fine grained particles.	- Removes impacted material from the area, thereby eliminating future human and ecological exposure. - Destroys contaminants, allowing the treated material to be re-used on-site or disposed of off-site. - Effectiveness in treating VOC impacted material not proven. - Complex mixture of contaminants in the soil (i.e. mixture of metals, volatile organics, and SVOCs) and heterogeneous contaminant compositions throughout the soil mixture make it difficult to formulate a single suitable washing solution that will consistently and reliably remove all of the different types of contaminants.	- Services and materials available to implement.	- High capital cost - No O&M costs	Eliminated as other ex-situ treatment technologies are more effective for the site COCs.
		Dehalogenation	Excavated soil is screened, mixed with reagents and heated to dehalogenate the contaminants (through replacement of the halogen molecules or the decomposition and partial volatilization of the contaminants).	- Removes impacted material from the area, thereby eliminating future human and ecological exposure. - Destroys contaminants, allowing the treated material to be re-used on-site or disposed of off-site. - Effective technology for halogenated SVOCs, but reduced effectiveness for VOCs.	- Technology is not widely used, but services and materials are available to implement.	- High capital cost - No O&M costs	Eliminated as other ex-situ treatment technologies are more effective for the site COCs.
		Chemical Oxidation	Oxidants (i.e. ozone, hydrogen peroxide, permanganate) are mixed with the impacted material to degrade organic contaminants into innocuous end products (i.e. carbon dioxide).	- Removes impacted material from the area, thereby eliminating future human and ecological exposure. - Effective technology for treating VOCs; however, not a proven technology for treating SVOCs (i.e. phthalates).	- Services and materials available to implement.	- Moderate to high capital cost - Low O&M costs	Potentially applicable to reduce the concentration of some compounds amenable to this treatment prior to disposal. Retained for further evaluation.
	Thermal Treatment	Thermal desorption	Excavated soils are heated to separate (desorb) contaminants from soil by volatilization. The volatized contaminants are contained and treated.	- Proven technology to treat VOC and SVOC impacted material. - Removes impacted material from the area, thereby eliminating future human and ecological exposure. - Destroys contaminants, allowing the treated material to be re-used on-site or disposed of off-site.	- Services and materials available to implement. - Previously excavated soils from this area by EPA were treated off-site by this technology.	- High capital cost - No O&M costs	Potentially applicable. Retained for further evaluation.
		Incineration	Excavated soil is heated at high temperatures (1,400 to 2,200 ^{o}F) in a combustion chamber to volatilize and combust contaminants. Off-gases and combustion residuals generally require treatment.	- Proven technology to treat VOC and SVOC impacted material. - Removes impacted material from the area, thereby eliminating future human and ecological exposure. - Destroys contaminants, allowing the treated material to be re-used on-site or disposed of off-site.	- Services and materials available to implement.	- High capital cost - No O&M costs	Potentially applicable. Retained for further evaluation.
	Biological Treatment	Landfarming	Excavated soil is spread out and periodically tilled, fertilized and irrigated to stimulate natural degradation ex-situ.	- Effective technology for treating VOCs; potentially effective technology for treating SVOCs. - Removes impacted material from the area, thereby eliminating future human and ecological exposure. - Destroys contaminants, allowing the treated material to be re-used on-site or disposed of off-site.	- Services and materials available to implement.	- Moderate capital costs - Moderate O&M costs	Eliminated as other technologies are more effective for the material on-site.

TABLE 4-2
INITIAL EVALUATION AND SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS --
SOURCE AREA - FORMER DRUM DISPOSAL AREA

GENERAL RESPONSE ACTION	REMEDIAL TECHNOLOGY	PROCESS OPTION	DESCRIPTION	EFFECTIVENESS	IMPLEMENTABILITY	RELATIVE COST	SCREENING COMMENTS
		Biopiles	Excavated soil is mixed with soil amendments and placed in an engineered treatment cell. Moisture, heat, nutrients, oxygen and pH are controlled to enhance biodegradation.	- Effective technology for treating VOCs; potentially effective technology for treating SVOCs. - Removes impacted material from the area, thereby eliminating future human and ecological exposure. - Destroys contaminants, allowing the treated material to be re-used on-site or disposed of off-site.	- Services and materials available to implement.	- Moderate capital costs - Moderate O&M costs	Eliminated as other technologies are more effective for the material on-site.
		Bioslurry reactor	Excavated soil is mixed with water, microorganisms, nutrients, and oxygen and maintained in suspension in a reactor vessel to promote biodegradation of contaminants. Treated soil then undergoes dewatering.	- Effective technology for treating VOCs; potentially effective technology for treating SVOCs. - Removes impacted material from the area, thereby eliminating future human and ecological exposure. - Destroys contaminants, allowing the treated material to be re-used on-site or disposed of off-site.	- Services and materials available to implement.	- Moderate capital costs - Moderate O&M costs	Eliminated as other technologies are more effective for the material on-site.
In-situ Treatment/ Remedial Action	Physical/ Chemical Treatment	Solidification/ Stabilization	Utilizing auger/caisson or other injector head systems, solidification or stabilization treatment agents are applied into the impacted area to physically and/or chemically immobilize the contaminants in place.	- Effective approach for material impacted with inorganics; potentially effective technology in treating VOC and SVOC impacted material.	- Services and materials available to implement. - Implementation may modify existing hydrogeology flow patterns.	- High capital cost - Low O&M costs	Eliminated as this technology has not been proven to be sufficiently effective for VOCs and SVOCs; other treatment alternatives are more effective and reliable.
		Chemical Oxidation	Oxidants are introduced into the impacted area to destroy organic contaminants in-situ. The contaminants are degraded to non-toxic byproducts (i.e. carbon dioxide).	- Effective technology for treating VOCs; however, not a proven technology for treating SVOCs (i.e. phthalates).	- Services and materials available to implement. - Implementation may modify existing geochemistry in the subsurface.	- Moderate to high capital cost - Low O&M costs	Potentially applicable to reduce the concentration of some compounds amenable to this treatment. If implemented, it may be used in conjunction with another technology(s). Retained for further evaluation.
		Soil vapor extraction	Contaminants are removed from unsaturated soils by inducing air flow through the contaminated zone via horizontal or vertical extraction wells. Extracted soil vapor is typically treated via carbon adsorption or oxidation.	- Effective technology for treating VOCs; however, not a reliable technology for treating SVOCs (i.e. phthalates).	- Services and materials available to implement.	- Moderate to high capital cost - Moderate O&M cost	Eliminated as this technology is not effective given the site specific conditions (e.g. high water table and limited unsaturated thickness).
		Soil flushing	A solution containing surfactants/cosolvents to enhance contaminant solubility is applied to soil to leach contaminants into groundwater, which is then extracted and treated.	- Effective technology for treating VOCs; however, not a proven technology for treating SVOCs (i.e. phthalates). - Approach mobilizes contaminants making them more bioavailable to the existing habitat and potentially may result in the further spread of impacted material.	- Services and materials available to implement.	- Moderate to high capital cost - Moderate to high O&M cost since it requires groundwater extraction and treatment.	Eliminated as this technology is not effective given the site specific conditions.
		Electrokinetic Separation	Electrochemical and electrokinetic processes are utilized to desorb and extract metals and polar organics from low permeability formations.	- Not an overly effective technology for non-halogenated SVOCs.	- Not a commonly used alternative; however, services and materials are available to implement.	- Moderate to high capital cost - Moderate O&M cost	Eliminated as this technology is not effective given the site specific conditions.
	Thermal Treatment	Thermal desorption	Heat is applied to the impacted area to facilitate volatilization via electrical resistance, electromagnetic, or radio frequency heating or by hot air/ stream. Volatized contaminants are collected via SVE and treated with carbon adsorption or oxidation.	- Effective technology to treat VOC and SVOC impacted material.	- Services and materials available to implement. - Implementation may result in disruption to the existing subsurface geochemistry.	- High capital cost - Moderate to high O&M cost	Potentially applicable. Retained for further evaluation.

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SOURCE AREA - FORMER DRUM DISPOSAL AREA

GENERAL RESPONSE ACTION	REMEDIAL TECHNOLOGY	PROCESS OPTION	DESCRIPTION	EFFECTIVENESS	IMPLEMENTABILITY	RELATIVE COST	SCREENING COMMENTS
		Pyrolysis	Soil is heated under pressure without oxygen to transform contaminants into gaseous components, liquid, and a solid residue (coke) containing fixed carbon and ash. The pyrolysis gases, including carbon monoxide, hydrogen, and methane, require further treatment.	- Effective technology to treat VOC and SVOC impacted material.	- Not a commonly used alternative; however, services and materials are available to implement. - Implementation may result in disruption to the existing subsurface geochemistry.	- High capital cost - Moderate to high O&M cost	Eliminated since other treatment alternatives (i.e. thermal) are more widely used and reliable for the variety of contaminants in the FDDA.
	Biological Treatment/ Remedial Action	Bio venting	Oxygen is injected into the impacted area to stimulate natural in-situ biodegradation of aerobically degradable compounds.	- Effective technology for treating VOCs; potentially effective technology for treating SVOCs.	- Services and materials available to implement.	- Moderate to high capital cost - Moderate O&M cost	Eliminated as other technologies are more widely used and more effective.
		Composting	Impacted soil is excavated and mixed with bulking agents and organic amendments (i.e. wood chips, hay, manure, and vegetative wastes) in a controlled process to promote the biodegradation of organic contaminants into innocuous byproducts.	- Effective technology to treat VOC and SVOC impacted material; however, other treatment technologies are more effective at treating SVOCs.	- Services and materials available to implement.	- Moderate capital cost - Moderate O&M cost	Eliminated as other technologies are more widely used and more effective.
		Enhanced biodegradation	Water mixed with nutrients, oxygen or other amendments is percolated or injected into the impacted area to stimulate indigenous microorganisms to degrade organic contaminants to innocuous end products.	- Effective technology to treat VOC and SVOC impacted material; however, other treatment technologies are more effective at treating SVOCs.	- Services and materials available to implement.	- Moderate capital cost - Moderate O&M cost	Eliminated as other technologies are more widely used and more effective for the variety of contaminants present in the FDDA.
		Phytoremediation	Plants are utilized to remove, transfer, stabilize and/or destroy contaminants in soil. Phytoremediation mechanisms include enhanced biodegradation in the root zone; uptake of contaminants by roots and accumulation in plant mass; metabolism of contaminants within plant tissues; immobilization of contaminants in root zones; and uptake and release of volatile contaminants through plant leaves.	- Potentially effective technology to remove inorganic impacts, but not a highly effective technology for reducing VOC or SVOC levels. - Depth of impacted material exceeds the length that roots will reach.	- Services and materials available to implement. - Upon completion of contaminant removal by the plants, the plants may require excavation and off-site disposal.	- Moderate capital cost - Low to moderate O&M cost	Eliminated as this technology is not effective given the site specific conditions.
		Monitored natural attenuation	MNA involves the monitoring and documentation of naturally-occurring processes in soil and groundwater environments that act without human intervention to reduce the mass, toxicity, mobility, volume, or concentration of contaminants in those media to acceptable levels. These in-situ processes include biodegradation, dispersion, dilution, adsorption, volatilization, and chemical or biological stabilization or destruction of contaminants.	- Effective technology for treating VOCs; potentially effective technology for treating SVOCs. Confirmation of the specific MNA processes at work may be difficult to document. - Does not disrupt the existing subsurface geochemistry or hydrogeology. - Potentially lengthy timeframe to reach site remedial goals. - Confirmation of the specific MNA processes at work may be difficult to document.	- Services and materials available to implement.	- Low capital cost - Low O&M cost	Potentially applicable. Retained for further evaluation.
GROUNDWATER							
No Action	None	Not applicable	No activities taken to address impacted groundwater within the FDDA beyond periodic site inspections and five-year reviews.	-Does not prevent potential downgradient migration and usage of impacted groundwater. -Potentially lengthy timeframe to reduce residual concentrations in groundwater to remedial goals.	-Easily implementable.	Lowest cost option - no capital or O&M costs.	This alternative is retained as a baseline for comparison to the remaining alternatives in accordance with the NCP.
Limited Action	Institutional Controls	Land use restrictions	Through land use restrictions, zoning or other legal mechanisms, restrict the use of or exposure to groundwater in the FDDA	-Effective at preventing human exposure or consumption of impacted groundwater but does not prevent potential migration. -Potentially lengthy timeframe to reduce residual concentrations in groundwater to remedial goals.	-Easily implementable.	- Low capital cost -No O&M costs.	Potentially applicable. Retained for further evaluation.
	Long-term Monitoring	Groundwater monitoring	Periodic groundwater monitoring to evaluate changes in groundwater quality that could be attributable to contaminant migration, natural attenuation processes or active remediation.	-Effective at monitoring contaminant trends over time. -Potentially lengthy timeframe to reduce residual concentrations in groundwater to remedial goals.	-Easily implementable; services and materials readily available to implement.	- Low capital cost - Low O&M costs	Potentially applicable. Retained for further evaluation.

TABLE 4-2

INITIAL EVALUATION AND SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS --

SOURCE AREA - FORMER DRUM DISPOSAL AREA

GENERAL RESPONSE ACTION	REMEDIAL TECHNOLOGY	PROCESS OPTION	DESCRIPTION	EFFECTIVENESS	IMPLEMENTABILITY	RELATIVE COST	SCREENING COMMENTS
Containment with Barrier	Low Permeability Cap	Clay, concrete, and/or asphalt	Impacted area is covered with an engineered (low permeability) cover (i.e. compacted clay, concrete, asphalt, etc.) to prevent exposure to and reduce infiltration through and leaching of contaminants into groundwater.	- Effective at preventing exposure to impacted groundwater. - Although this technology does not prevent potential migration, it does limit the amount of future leaching of contaminants from the impacted soil into groundwater.	- Services and materials available to implement.	- Moderate capital cost - Low O&M costs	Eliminated as a potential technology for groundwater since it has been retained as a technology for FDDA soil.
	Vertical Barriers	Slurry wall	Subsurface vertical wall, constructed with low permeable material (i.e. soil - bentonite), to contain or divert groundwater.	- Effective at preventing migration of impacted groundwater; dependable and reliable in the long term.	- Services and materials available to implement.	- Moderate capital cost - Low O&M costs	Potentially applicable. Retained for further evaluation.
		Sheet pile wall	Subsurface vertical wall, constructed by driving vertical sheets of steel into the ground to contain or divert groundwater.	- Effective at preventing migration of impacted groundwater; dependable and reliable in the long term.	- Services and materials available to implement.	- Moderate capital cost - Low O&M costs	Potentially applicable. Retained for further evaluation.
		Grout curtain wall	Subsurface vertical wall, constructed by injecting a grout mixture into overburden soil pores under pressure to form an impermeable barrier to contain or divert groundwater.	- Effective at preventing migration of impacted groundwater; dependable and reliable in the long term.	- Services and materials available to implement.	- Moderate capital cost - Low O&M costs	Potentially applicable. Retained for further evaluation.
Containment with Groundwater Extraction	Extraction	Vertical extraction wells	Strategically placed vertical wells are installed to hydraulically contain impacted groundwater.	- Effective means to collect and prevent migration of impacted groundwater. - Reliable and frequently used alternative.	- Services and materials readily available to implement.	- Moderate to high capital cost - Moderate to high O&M costs	Potentially applicable. Retained for further evaluation.
		Interceptor trench	Collection of groundwater from a subsurface trench that contains porous material to facilitate the flow of water. The trench acts as a means to cut off the flow of impacted water (i.e. containment on-site).	- Effective at treating and preventing migration of impacted groundwater.	- Services and materials readily available to implement. - Potential site access issues with the placement of the trench in relation to adjacent wetland areas.	- Moderate to high capital cost - Moderate to high O&M costs	Potentially applicable. Retained for further evaluation.
Collection for source reduction	Extraction	Vertical extraction wells	Strategically placed vertical wells are installed to extract source zone groundwater.	- Effective means to collect and prevent migration of impacted groundwater. - Reliable and frequently used alternative.	- Services and materials readily available to implement.	- Moderate to high capital cost - Moderate to high O&M costs	Potentially applicable. Retained for further evaluation.
		Interceptor trench	Collection of groundwater from a subsurface trench that contains porous material to facilitate the flow of water.	- Effective at treating and preventing migration of impacted groundwater.	- Services and materials readily available to implement. - Potential site access issues with the placement of the trench in relation to adjacent wetland areas.	- Moderate to high capital cost - Moderate to high O&M costs	Potentially applicable. Retained for further evaluation.
		Vacuum enhanced/ multi-phase extraction	A vacuum is applied to an extraction wells to induce groundwater flow to the well without drawdown. This method allows for removal of multiple contaminant phases (water, LNAPL, and vapor). In addition to removing the vapor and groundwater from the well, the high vacuum applied to the well(s) enhances the groundwater recovery and maximizes vapor extraction effectiveness.	- Effective at treating and preventing migration of impacted groundwater.	- Services and materials readily available to implement. - Since LNAPL is not present on-site, nor are there vadose zone soil impacts in this area, this technology provides extra services not required.	- High capital cost - High O&M costs	Eliminated as this technology provides treatment to conditions (i.e. LNAPL) not present in site groundwater.
Ex-situ Treatment	Physical/ Chemical Treatment	Filtration/ microfiltration/ ultrafiltration	Separation of suspended particles form a fluid using a porous media or membrane to trap particles either within or on the surface of the media.	- Effective technology to remove suspended particles as a pretreatment step; not effective in removing other contaminants.	- Services and materials readily available to implement.	- Low capital cost - Low to moderate O&M costs	Potentially applicable. Retained for further evaluation as a possible pretreatment step in an ex-situ groundwater treatment system.
		Reverse osmosis	Removal of dissolved organic and inorganic compounds by passing the fluid through a semi-permeable membrane under pressure.	- Effective technology for treating the impacted groundwater; other technologies may be required to treat the entire waste stream.	- Services and materials available to implement for small scale systems; not in common use at this time for large scale treatment of groundwater.	- Moderate to high capital cost - Moderate O&M costs	Potentially applicable. Retained for further evaluation.

TABLE 4-2
INITIAL EVALUATION AND SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS --
SOURCE AREA - FORMER DRUM DISPOSAL AREA

GENERAL RESPONSE ACTION	REMEDIAL TECHNOLOGY	PROCESS OPTION	DESCRIPTION	EFFECTIVENESS	IMPLEMENTABILITY	RELATIVE COST	SCREENING COMMENTS
		Distillation	Separation process used to remove volatile components from a fluid. Heat is applied to the fluid to vaporize the volatile components; the vaporized components are subsequently cooled and condensed.	- Not a highly effective technology for remediating low concentrations of volatile components; other technologies will be required to treat the inorganic portion of the waste stream.	- Services and materials readily available to implement.	- High capital cost - Moderate to high O&M costs	Eliminated as this technology is not effective for the site specific conditions and other proven technologies are available.
		Air stripping	Removal of volatile compounds from the aqueous phase to the vapor phase through contact with air in a countercurrent manner (i.e. packed tower, tray, etc.). Resulting vapor phase is typically treated with carbon adsorption.	- Effective technology for treating VOC impacted groundwater; other technologies will be required to treat the inorganic and 1,4-dioxane portion of the waste stream.	- Services and materials readily available to implement.	- Moderate capital cost - Moderate O&M costs	Potentially applicable as one of multiple treatment steps; retained for further evaluation.
		Steam stripping	Removal of volatile compounds from the aqueous phase to the vapor phase through contact with steam in an countercurrent manner. Volatiles are recovered by condensation of steam.	- Effective technology for treating VOC impacted groundwater; other technologies will be required to treat the inorganic and 1,4-dioxane portion of the waste stream.	- Services and materials readily available to implement.	- High capital cost - Moderate to high O&M costs	Eliminated as other technologies (i.e. air stripping) are more widely used and more cost effective.
		Aeration	Pre-treatment step utilized to remove dissolved metals (i.e. iron and manganese) through contact with air. Contact with air results in oxidation and formation of insoluble hydroxides that precipitate from water.	- Effective technology for removing dissolved metals from groundwater; other technologies will be required.	- Services and materials readily available to implement.	- Moderate capital cost - Moderate O&M costs	Potentially applicable. Retained for further evaluation as a possible pretreatment step in an ex-situ groundwater treatment system.
		Carbon adsorption	Removal of dissolved contaminants from groundwater by adsorption on activated carbon.	- Effective technology for removing dissolved organic compounds from groundwater; other technologies will be required.	- Services and materials readily available to implement.	- Moderate capital cost - Moderate to high O&M costs	Potentially applicable as one of multiple treatment steps; retained for further evaluation.
		Clarification	Separation of suspended particles from groundwater by gravity settling in a tank.	- Effective technology to remove suspended particles as a pretreatment step; not effective in removing other contaminants.	- Services and materials readily available to implement.	- Moderate capital cost - Moderate O&M costs	Potentially applicable. Retained for further evaluation as a possible pretreatment step in an ex-situ groundwater treatment system.
		Precipitation/ Flocculation	Chemical conversion of dissolved metals and/or other inorganic ions to an insoluble precipitate that can be removed by clarification and/or filtration. The process typically involves pH adjustment and the addition of chemical precipitants and flocculants to promote particle aggregation and increased settling efficiency.	- Effective technology to remove inorganics in groundwater; other technologies will be required to treat the remainder of the waste stream.	- Services and materials readily available to implement.	- Moderate to high capital cost - Moderate to high O&M costs	Potentially applicable as one of multiple treatment steps; retained for further evaluation.
		Advanced oxidation processes	Use of strong oxidizers (i.e. ozone or hydrogen peroxide), often in conjunction with UV light, to destroy dissolved organic contaminants.	- Effective technology for removing dissolved organic compounds, including 1,4-dioxane, from groundwater; other technologies may be required.	- Services and materials readily available to implement.	- Moderate to high capital cost - Moderate to high O&M costs	Potentially applicable as one of multiple treatment steps; retained for further evaluation.
		Ion exchange	Removal of dissolved inorganic compounds by passing groundwater through a granular solid or other porous media (i.e. impregnated resin) that exchanges sorbed ions for the contaminant ions.	- Effective technology to remove dissolved inorganics in groundwater; other technologies will be required to treat the remainder of the waste stream. This technology is commonly used as a pretreatment or polishing step.	- Services and materials readily available to implement.	- Moderate to high capital cost - Moderate to high O&M costs	Potentially applicable as a pretreatment or polishing step; retained for further evaluation.
	Biological Treatment	Aerobic reactor	Microorganisms and oxygen are utilized to convert organic compounds into innocuous end products.	- Potentially effective technology for degrading organic compounds from groundwater; other technologies will be required.	- Services and materials available to implement; however, other technologies have been proven to achieve similar results in a shorter timeframe.	- Moderate to high capital cost - Low to moderate O&M costs	Eliminated as other technologies (i.e. air stripping) are more widely used and more cost effective.
		Anaerobic reactor	Anaerobic microorganisms are utilized to degrade organic contaminants in a n oxygen free environment.	- Performance data for full scale application is minimal; effectiveness not certain.	- Services and materials available to implement; however, performance data for full scale applications is minimal.	- Moderate to high capital cost - Moderate O&M costs	Eliminated as the effectiveness of this technology in a full scale application has not been proven.

TABLE 4-2
INITIAL EVALUATION AND SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS --
SOURCE AREA - FORMER DRUM DISPOSAL AREA

GENERAL RESPONSE ACTION	REMEDIAL TECHNOLOGY	PROCESS OPTION	DESCRIPTION	EFFECTIVENESS	IMPLEMENTABILITY	RELATIVE COST	SCREENING COMMENTS
Discharge	Surface Discharge	Direct	Discharge of treated groundwater to Sutton Brook.	-Convenient, effective and feasible means to discharge treated groundwater.	-Services and materials available to implement. -Discharge locations easily accessible. -More frequent discharge monitoring and more stringent discharge requirements may be required.	-Low to moderate capital cost -Low to moderate O&M costs	Potentially applicable. Retained for further evaluation.
		In-direct	Discharge of treated groundwater into a local Publicly Owned Treatment Works (POTW) for treatment and disposal.	-Effective means to discharge treated groundwater; treatment system requirements (i.e. standards to meet) may be reduced in comparison to direct surface water discharge. -Commonly used discharge alternative; groundwater passes through multiple treatment processes prior to final discharge.	-The public sewer system pipeline was recently installed along South Street in the vicinity of the site. Recent discussions with the Town Engineer have indicated that the capacity of the system may be able to accommodate groundwater (range of 15 to 200 gpm) from the site. However, an evaluation would be required to confirm that the existing pipeline can accommodate the load from the site as well as the current and anticipated future usage from the area. Concerns were raised that additional upgrades to this line would likely present opposition by the town and residents.	-High capital cost (due to distance) -Moderate O&M costs	Potentially applicable. Retained for further evaluation.
	Subsurface Discharge	Injection wells	Pressurized discharge of treated groundwater to the subsurface using injection wells.	-Effective means to discharge treated groundwater; groundwater modeling to confirm the feasibility of this method may be required. -Commonly used discharge alternative.	-Services and materials available to implement. -Groundwater modeling and pump tests may be required to confirm the feasibility of this technology. -Potential to modify existing groundwater chemistry and flow patterns; modeling will be required to demonstrate no adverse effect.	-Moderate capital cost -Low to moderate O&M costs	Potentially applicable. Retained for further evaluation.
		Infiltration gallery/ leach field	Discharge of treated groundwater to an on-site subsurface location utilizing a buried infiltration gallery or leach field.	-Effective means to discharge treated groundwater; groundwater modeling to confirm the feasibility of this method may be required. -Commonly used discharge alternative.	-Services and materials available to implement. -Groundwater modeling and pump tests may be required to confirm the feasibility of this technology. -Potential to modify existing groundwater chemistry and flow patterns; modeling will be required to demonstrate no adverse effect.	-Moderate capital cost -Low to moderate O&M costs	Potentially applicable. Retained for further evaluation.
		Infiltration wells (gravity drain)	Discharge of treated groundwater to an on-site subsurface location utilizing vertical, large diameter passive infiltration wells.	-Effective means to discharge treated groundwater; groundwater modeling to confirm the feasibility of this method will be required.	-Services and materials available to implement. -Groundwater modeling and pump tests may be required to confirm the feasibility of this technology. -Potential to modify existing groundwater chemistry and flow patterns; modeling will be required to demonstrate no adverse effect.	-Moderate capital cost -Low to moderate O&M costs	Potentially applicable. Retained for further evaluation.
In-situ Treatment/ Remedial Action	Physical/ Chemical Treatment	Air sparging/ soil vapor extraction	Air sparging involves injection of air under pressure below the water table, introducing air to soil pore spaces by displacing the water in the soil matrix. Air sparging contributes to the physical removal of organic compounds (liquid, adsorbed and dissolved phases) through volatilization from subsurface soils and groundwater. In addition, air sparging facilitates aerobic biodegradation processes by assisting with oxygen transfers in the soil and groundwater. The resulting soil vapor is collected via SVE wells.	-Effective technology for remediating VOCs in groundwater; however, it is not an effective means for treating inorganics or 1,4-dioxane. -Limited ability to collect soil vapor due to the high water table and frequent flooding in this area.	-Services and materials available to implement. -In-situ approach; discharge of treated water not required. -The SVE portion of this technology would be difficult to implement in this area given the elevated water table and the frequent flooding.	-Moderate capital cost -Moderate to high O&M costs	Eliminated as this technology is not effective for the site specific conditions (i.e. COCs, elevated water table, etc.).
		In-well air stripping	Air is injected into the bottom of a dual level screened well to lift groundwater in the well causing it to flow out the upper screen while groundwater enters the well through the lower screen. Volatile contaminants are stripped from groundwater, drawn off by a vacuum extraction system and treated. The discharge of water through the lower screen establishes a circular in-situ flow path through which groundwater is repeatedly treated.	-Effective technology for remediating VOCs in groundwater; however, it is not an effective means for treating inorganics or 1,4-dioxane.	-Services and materials available to implement. -In-situ approach; discharge of treated water not required. -Difficult to implement the SVE portion of this technology due to the elevated water table elevation and the frequent flooding in the area.	-Moderate capital cost -Moderate to high O&M costs	Eliminated as this technology is not effective for the site specific conditions.

TABLE 4-2

INITIAL EVALUATION AND SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS --

SOURCE AREA - FORMER DRUM DISPOSAL AREA

GENERAL RESPONSE ACTION	REMEDIAL TECHNOLOGY	PROCESS OPTION	DESCRIPTION	EFFECTIVENESS	IMPLEMENTABILITY	RELATIVE COST	SCREENING COMMENTS
		Chemical oxidation	Oxidants (i.e. ozone, hydrogen peroxide, permanganate) are injected into the impacted area to destroy organic contaminants in-situ. The contaminants are degraded into innocuous end products (i.e. carbon dioxide).	-Effective technology for remediating VOCs in groundwater; however, it is not an effective means for treating inorganics. -Implementation may modify the existing geochemistry that is effectively naturally attenuating impacted groundwater.	- Services and materials available to implement. - In-situ approach; discharge of treated water not required.	- Moderate capital cost - Moderate O&M costs	Potentially applicable to reduce the concentration of some compounds amenable to this treatment. If implemented, it may be used in conjunction with another technology(s). Retained for further evaluation.
		Permeable reactive barrier	An in-situ treatment zone of reactive material that degrades or immobilizes contaminants as groundwater flows through it. PRBs are installed as permanent, semi-permanent or replaceable units across the flow path of a contaminated plume. Natural gradients transport contaminants through strategically placed media. The media degrade, sorb, precipitate, or otherwise remove groundwater contaminants.	-Effective technology for treating and/or preventing migration of inorganics and select VOCs; only limited effectiveness in treating fuel hydrocarbons. -Regeneration of reactive material may be required over time to provide effective treatment/containment. -Potentially lengthy timeframe; may require multiple regenerations over time.	- Services and materials available to implement. - Disruptive technology during installation and regeneration.	- High capital cost - Low O&M costs	Potentially applicable to reduce the concentrations of some compounds amenable to this treatment. If implemented, it may be used in conjunction with another technology(ies). Retained for further evaluation.
		Phytoremediation	Plants are utilized to remove, transfer, stabilize and/or destroy contaminants in soil. Phytoremediation mechanisms include enhanced biodegradation in the root zone; uptake of contaminants by roots and accumulation in plant mass; metabolism of contaminants within plant tissues; immobilization of contaminants in root zones; and uptake and release of volatile contaminants through plant leaves.	-Potentially effective technology for removing contaminants from shallow impacted groundwater; plants removing the contaminants may require removal and disposal upon completion of contaminant uptake. -Not an effective technology for groundwater below root depth. -Potentially lengthy timeframe.	- Services and materials available to implement. - Upon completion of contaminant uptake, plants may require removal and disposal; potentially disrupting the wetland area and existing habitat.	- Low capital cost - Low O&M	Eliminated as this technology is not effective for the site specific conditions (i.e. depth to impacted groundwater exceeds effectiveness of plant root depth).
	Biological Treatment/ Remedial Action	Enhanced biodegradation	Enhanced in-situ bioremediation in groundwater involves the input of an organic carbon source, nutrients, electron acceptors, and/or microbial cultures to stimulate biodegradation.	-Effective technology for promoting biodegradation of contaminants in-situ. -Existing site data demonstrates that natural attenuation processes are currently reducing contaminant levels in-situ. -Technology may take a longer timeframe than other alternatives evaluated.	- Services and materials available to implement.	- Low to moderate capital cost - Low to moderate O&M costs	Potentially applicable to reduce the concentration of some compounds amenable to this treatment. If implemented, it may be used in conjunction with another technology(s). Retained for further evaluation.
		Monitored natural attenuation	MNA involves the monitoring and documentation of naturally-occurring processes in soil and groundwater environments that act without human intervention to reduce the mass, toxicity, mobility, volume, or concentration of contaminants in those media to acceptable levels. These in-situ processes include biodegradation, dispersion, dilution, adsorption, volatilization, and chemical or biological stabilization or destruction of contaminants.	-Effective technology for reducing contaminant levels in-situ; current data demonstrates natural attenuation processes are currently reducing contaminants levels. -Technology may take a longer timeframe than other alternatives evaluated.	- Services and materials available to implement.	- Low capital cost - Low O&M costs	Potentially applicable. Retained for further evaluation.

TABLE 4-3
INITIAL EVALUATION AND SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS --
SOURCE AREA - GARAGE AND STORAGE AREA

GENERAL RESPONSE ACTION	REMEDIAL TECHNOLOGY	PROCESS OPTION	DESCRIPTION	EFFECTIVENESS	IMPLEMENTABILITY	RELATIVE COST	SCREENING COMMENTS
SOIL							
No Action	None	Not applicable	No activities taken to address impacted soil beyond periodic site inspections and five-year reviews.	- Technology does not re-use, detoxify or destroy contaminants through treatment. - Potentially lengthy timeframe to reduce residual concentrations in soil.	- Easily implementable.	- Lowest cost option - no capital or O&M costs.	This alternative is retained as a baseline for comparison to the remaining alternatives in accordance with the NCP.
Limited Action	Access Restrictions	Fencing and/or security guard service	Construction of a physical barrier (i.e. fencing) around impacted soil to prevent access and/or employ security guard service to discourage attempts at access impacted area.	- Effective at preventing human access to impacted soil but does not prevent potential ecological access. - Technology does not re-use, detoxify or destroy contaminants through treatment. - Potentially lengthy timeframe to reduce residual concentrations in soil.	- Services and materials readily available to implement.	- Low capital cost - Low O&M costs.	Potentially applicable. Retained for further evaluation.
	Institutional Controls	Land use restrictions	Through land use restrictions, zoning or other legal mechanisms, restrict the use of or exposure to the impacted soil.	- Effective at preventing human exposure to impacted soil but does not prevent potential ecological exposure. - Technology does not re-use, detoxify or destroy contaminants through treatment. - Potentially lengthy timeframe to reduce residual concentrations in soil.	- Easily implementable.	- Low capital cost - No O&M costs.	Potentially applicable. Retained for further evaluation.
	Long Term Monitoring	Soil monitoring	Conduct soil sampling to assess changes that could be attributable to surface infiltration, natural attenuation processes, or active remediation.	- Effective at monitoring contaminant trends over time. - Does not prevent human or ecological exposure to impacted soils. - Potentially lengthy timeframe to reduce residual concentrations.	- Services and materials readily available to implement.	- Low capital costs - Low O&M costs.	Eliminated as other technologies are more protective against existing and potential future risks.
Containment	Permeable Cover	Soil and vegetative cover	Impacted area is covered with permeable soil and vegetative layers to prevent exposure to, erosion and surface migration of impacted soil.	- Effective at preventing human exposure to impacted soil but does not prevent potential ecological exposure.	- Services and materials readily available to implement.	- Moderate capital cost - Low O&M costs	Eliminated as other containment technologies (i.e. low permeability cap) provide additional benefits for comparable disruption to the area.
	Low Permeability Cap	Clay, geomembrane, concrete, and/or asphalt	Impacted area is covered with a low permeability cover (i.e. compacted clay, geomembrane, concrete, asphalt, etc.) to prevent exposure to, erosion and surface migration of impacted soil and reduce infiltration through and leaching of contaminants into groundwater.	- Effective at preventing human and ecological exposure to impacted soil and reduces the potential for future leaching of impacted soil to groundwater.	- Services and materials readily available to implement.	- High capital cost - Low O&M costs	Potentially applicable. Retained for further evaluation.
Excavation with Disposal	Landfill	On-site disposal	The impacted soil is physically removed from the subsurface and disposed of on-site at one of the landfill lobes.	- Highly effective at eliminating human and ecological exposure to impacted material and preventing potential future leaching to groundwater as the material is removed from the site. - Quick timeframe to reach soil remedial goals.	- Services and materials readily available to implement.	- Moderate capital cost - No O&M costs	Potentially applicable. Retained for further evaluation.
		Off-site disposal	The impacted soil is physically removed from the subsurface and disposed off-site at an appropriate disposal facility.	- Highly effective at eliminating human and ecological exposure to impacted material and preventing potential future leaching to groundwater as the material is removed. - Quick timeframe to reach soil remedial goals	- Services and materials readily available to implement.	- Moderate capital cost - No O&M costs	Potentially applicable. Retained for further evaluation.
Ex-situ Treatment	Physical/ Chemical Treatment	Asphalt batching	Excavated soils are utilized in the production of asphalt. The contaminants present in the soil become bound up/ encapsulated in the asphalt mixture.	- Removes impacted material from the area, thereby eliminating future exposure risks to human and ecological receptors. - Quick timeframe to reach soil remedial goals. - Effective technology for petroleum impacted material and low levels of metals.	- Services and materials available to implement.	- Moderate capital cost - No O&M costs	Potentially applicable. Retained for further evaluation.

TABLE 4-3
INITIAL EVALUATION AND SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS --
SOURCE AREA - GARAGE AND STORAGE AREA

GENERAL RESPONSE ACTION	REMEDIAL TECHNOLOGY	PROCESS OPTION	DESCRIPTION	EFFECTIVENESS	IMPLEMENTABILITY	RELATIVE COST	SCREENING COMMENTS
		Solidification/ Stabilization	Contaminants are physically bound or enclosed within a stabilized matrix (solidification), or chemical reactions are induced between the stabilizing agent and the contaminants to reduce their mobility (stabilization).	- Removes impacted material from the area, thereby eliminating future exposure to human and ecological receptors. - Prevents future exposure to any inorganics present in the material. - Effective approach for material impacted with inorganics; potentially effective technology in treating SVOC impacted material.	- Services and materials available to implement.	- High capital cost - No O&M costs	Eliminated as this technology has not been proven to be sufficiently effective for VOCs and SVOCs; other treatment alternatives (i.e. thermal) are more effective and reliable.
		Soil venting	The excavated material is placed in piles containing perforated pipes connected to a vacuum blower to induce air flow through the soil and removal of volatile contaminants. Extracted vapors are typically treated via carbon adsorption or oxidation.	- Removes impacted material from the area, thereby eliminating future exposure to human and ecological receptors. - Potentially effective technology for treating SVOCs; not effective for inorganics.	- Services and materials available to implement.	- High capital costs - Moderate O&M costs.	Eliminated as other alternative are more commonly used and more effective given the COCs present.
		Soil washing	The excavated soils undergo a water and surfactant based process of screening and separation which removes contaminants by dissolving them i the wash solution and by concentrating them into a smaller volume of fine grained particles.	- Removes impacted material from the area, thereby eliminating future exposure to human and ecological receptors. - Destroys contaminants, allowing the treated material to be re-used on-site or disposed of off-site. - Complex mixture of contaminants in the soil (i.e. mixture of metals, petroleum fractions, and PAHs) and heterogeneous contaminant compositions throughout the soil mixture make it difficult to formulate a single suitable washing solution that will consistently and reliably remove all of the different types of contaminants.	- Services and materials available to implement.	- High capital cost - No O&M costs	Eliminated as this technology is not effective given the site specific conditions.
		Dehalogenation	Excavated soil is screened, mixed with reagents and heated to dehalogenate the contaminants (through replacement of the halogen molecules or the decomposition and partial volatilization of the contaminants).	- Removes impacted material from the area, thereby eliminating future exposure to human and ecological receptors. - Destroys contaminants, allowing the treated material to be re-used on-site or disposed of off-site. - Effective technology for SVOCs, but not effective for inorganics.	- Technology is not widely used, but services and materials are available to implement.	- High capital cost - No O&M costs	Eliminated as other alternative are more commonly used and more effective given the COCs present.
		Chemical Oxidation	Oxidants (i.e. ozone, hydrogen peroxide, permanganate) are mixed with the impacted material to degrade organic contaminants into innocuous end products (i.e. carbon dioxide).	- Removes impacted material from the area, thereby eliminating future exposure to human and ecological receptors. - Not a proven technology for treating SVOCs and/or inorganics.	- Services and materials available to implement.	- Moderate to high capital cost - Low O&M costs	Eliminated as other alternative are more commonly used and more effective given the COCs present.
	Thermal Treatment	Thermal desorption	Excavated soils are heated to separate (desorb) contaminants from soil by volatilization. The volatized contaminants are contained and treated.	- Proven technology to treat SVOC impacted material. - Removes impacted material from the area, thereby eliminating future exposure to human and ecological receptors. - Destroys contaminants, allowing the treated material to be re-used on-site or disposed of off-site.	- Services and materials available to implement.	- High capital cost - No O&M costs	Potentially applicable. Retained for further evaluation.
		Incineration	Excavated soil is heated at high temperatures (1,400 to 2,200^{o}F) in a combustion chamber to volatilize and combust contaminants. Off-gases anc combustion residuals generally require treatment.	- Proven technology to treat SVOC impacted material. - Removes impacted material from the area, thereby eliminating future exposure to human and ecological receptors. - Destroys contaminants, allowing the treated material to be re-used on-site or disposed of off-site.	- Services and materials available to implement.	- High capital cost - No O&M costs	Potentially applicable. Retained for further evaluation.

TABLE 4-3
INITIAL EVALUATION AND SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS --
SOURCE AREA - GARAGE AND STORAGE AREA

GENERAL RESPONSE ACTION	REMEDIAL TECHNOLOGY	PROCESS OPTION	DESCRIPTION	EFFECTIVENESS	IMPLEMENTABILITY	RELATIVE COST	SCREENING COMMENTS
	Biological Treatment	Landfarming	Excavated soil is spread out and periodically tilled, fertilized and irrigated to stimulate natural degradation ex-situ.	- Potentially effective technology for treating SVOCs; not effective for inorganics. - Removes impacted material from the area, thereby eliminating future exposure to human and ecological receptors. - Destroys contaminants, allowing the treated material to be re-used on-site or disposed of off-site.	- Services and materials available to implement.	- Moderate capital costs - Moderate O&M costs	Eliminated as other technologies are more effective for the material on-site.
		Biopiles	Excavated soil is mixed with soil amendments and placed in an engineered treatment cell. Moisture, heat, nutrients, oxygen and pH are controlled to enhance biodegradation.	- Potentially effective technology for treating SVOCs; not effective for inorganics. - Removes impacted material from the area, thereby eliminating future exposure to human and ecological receptors. - Destroys contaminants, allowing the treated material to be re-used on-site or disposed of off-site.	- Services and materials available to implement.	- Moderate capital costs - Moderate O&M costs	Eliminated as other technologies are more effective for the material on-site.
		Bioslurry reactor	Excavated soil is mixed with water, microorganisms, nutrients, and oxygen and maintained in suspension in a reactor vessel to promote biodegradation of contaminants. Treated soil then undergoes dewatering.	- Potentially effective technology for treating SVOCs; not effective for inorganics. - Removes impacted material from the area, thereby eliminating future exposure to human and ecological receptors. - Destroys contaminants, allowing the treated material to be re-used on-site or disposed of off-site.	- Services and materials available to implement.	- Moderate capital costs - Moderate O&M costs	Eliminated as other technologies are more effective for the material on-site.
In-situ Treatment/ Remedial Action	Physical/ Chemical Treatment	Solidification/ Stabilization	Utilizing auger/caisson or other injector head systems, solidification or stabilization treatment agents are applied into the impacted area to physically and/or chemically immobilize the contaminants in place.	- Effective approach for material impacted with inorganics; potentially effective technology in treating SVOC impacted material.	- Services and materials available to implement.	- High capital cost - Low O&M costs	Eliminated since the solidification process was retained as the asphalt batching option.
		Chemical Oxidation	Oxidants are introduced into the impacted area to destroy organic contaminants in-situ. The contaminants are degraded to non-toxic byproducts (i.e. carbon dioxide).	- Effective technology for treating VOCs; however, not a proven technology for treating SVOCs and inorganics.	- Services and materials available to implement. - Due to the location of the impacted soil at the surface, this alternative would be infeasible to implement.	- Moderate to high capital cost - Low O&M costs	Eliminated as this technology is not effective given the site specific conditions.
		Soil vapor extraction	Contaminants are removed from unsaturated soils by inducing air flow through the contaminated zone via horizontal or vertical extraction wells. Extracted soil vapor is typically treated via carbon adsorption or oxidation.	- Not an effective technology for treating SVOCs or inorganics.	- Services and materials available to implement. - Due to the depth of the impacted material (at the surface), this alternative would be infeasible to implement effectively.	- Moderate to high capital cost - Moderate O&M cost	Eliminated as this technology is not effective given the site specific conditions.
		Soil flushing	A solution containing surfactants/cosolvents to enhance contaminant solubility is applied to soil to leach contaminants into groundwater, which is then extracted and treated.	- Not an effective technology for treating PAHs. - Approach mobilizes contaminants making them more bioavailable to the existing habitat and potentially may result in the further spread of impacted material.	- Services and materials available to implement.	- Moderate to high capital cost - Moderate to high O&M cost since it requires groundwater extraction and treatment.	Eliminated as this technology is not effective given the site specific conditions.
		Electrokinetic Separation	Electrochemical and electrokinetic processes are utilized to desorb and extract metals and polar organics from low permeability formations.	- Not an overly effective technology for SVOCs.	- Not a commonly used alternative; however, services and materials are available to implement.	- Moderate to high capital cost - Moderate O&M cost	Eliminated as this technology is not effective given the site specific conditions.
	Thermal Treatment	Thermal desorption	Heat is applied to the impacted area to facilitate volatilization via electrical resistance, electromagnetic, or radio frequency heating or by hot air/ stream. Volatized contaminants are collected via SVE and treated with carbon adsorption or oxidation.	- Effective technology to treat SVOC impacted material; not effective for inorganics.	- Services and materials available to implement. - Due to the depth of the impacted soil at the surface, this alternative would be infeasible to implement effectively and safely.	- High capital cost - Moderate to high O&M cost	Eliminated as this technology is not technically feasible given the site specific conditions.
		Pyrolysis	Excavated material is heated under pressure without oxygen to transform contaminants into gaseous components, liquid, and a solid residue (coke) containing fixed carbon and ash. The pyrolysis gases, including carbon monoxide, hydrogen, and methane, require further treatment.	- Effective technology to treat SVOC impacted material; not effective for inorganics.	- Not a commonly used alternative; however, services and materials are available to implement. - Due to the depth of the impacted soil at the surface, this alternative would be infeasible to implement effectively and safely.	- High capital cost - Moderate to high O&M cost	Eliminated since other treatment alternatives are more widely used and reliable for the contaminants present at the residence.

TABLE 4-3
INITIAL EVALUATION AND SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS --
SOURCE AREA - GARAGE AND STORAGE AREA

GENERAL RESPONSE ACTION	REMEDIAL TECHNOLOGY	PROCESS OPTION	DESCRIPTION	EFFECTIVENESS	IMPLEMENTABILITY	RELATIVE COST	SCREENING COMMENTS
	Biological Treatment/ Remedial Action	Bio venting	Oxygen is injected into the impacted area to stimulate natural in-situ biodegradation of aerobically degradable compounds.	- Potentially effective technology for treating SVOCs; not effective for inorganics.	- Services and materials available to implement.	- Moderate to high capital cost - Moderate O&M cost	Eliminated as other technologies are more widely used and more effective.
		Composting	Impacted soil is excavated and mixed with bulking agents and organic amendments (i.e. wood chips, hay, manure, and vegetative wastes) in a controlled process to promote the biodegradation of organic contaminants into innocuous byproducts.	- Potentially effective technology to treat SVOC impacted material; not effective for inorganics. Other treatment technologies are more effective at treating SVOCs.	- Services and materials available to implement.	- Moderate capital cost - Moderate O&M cost	Eliminated as other technologies are more widely used and more effective.
		Enhanced biodegradation	Water mixed with nutrients, oxygen or other amendments is percolated or injected into the impacted area to stimulate indigenous microorganisms to degrade organic contaminants to innocuous end products.	- Potentially effective technology to treat SVOC impacted material; not effective for inorganics. Other treatment technologies are more effective at treating SVOCs.	- Services and materials available to implement.	- Moderate capital cost - Moderate O&M cost	Eliminated as other technologies are more widely used and more effective for the variety of contaminants present at the former residence.
		Phytoremediation	Plants are utilized to remove, transfer, stabilize and/or destroy contaminants in soil. Phytoremediation mechanisms include enhanced biodegradation in the root zone; uptake of contaminants by roots and accumulation in plant mass; metabolism of contaminants within plant tissues; immobilization of contaminants in root zones; and uptake and release of volatile contaminants through plant leaves.	- Potentially effective technology to remove inorganic impacts, but not a highly effective technology for reducing SVOC levels.	- Services and materials available to implement. - Upon completion of contaminant removal by the plants, the plants may require excavation and off-site disposal.	- Moderate capital cost - Low to moderate O&M cost	Eliminated as this technology is not effective given the site specific conditions.
		Monitored natural attenuation	MNA involves the monitoring and documentation of naturally-occurring processes in soil and groundwater environments that act without human intervention to reduce the mass, toxicity, mobility, volume, or concentration of contaminants in those media to acceptable levels. These in-situ processes include biodegradation, dispersion, dilution, adsorption, volatilization, and chemical or biological stabilization or destruction of contaminants.	- Potentially effective technology for treating SVOCs. - Does not disrupt the existing subsurface geochemistry or hydrogeology. - Potentially lengthy timeframe to reach site remedial goals.	- Services and materials available to implement.	- Low capital cost - Low O&M cost	Eliminated as other technologies are more widely used and more effective.

TABLE 4-4
INITIAL EVALUATION AND SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS --
NON-SOURCE AREAS DOWNGRADIENT

GENERAL RESPONSE ACTION	REMEDIAL TECHNOLOGY	PROCESS OPTION	DESCRIPTION	EFFECTIVENESS	IMPLEMENTABILITY	RELATIVE COST	SCREENING COMMENTS
DOWNGRADIENT GROUNDWATER							
No Action	None	Not applicable	No activities taken to address downgradient impacted groundwater beyond periodic site inspections and five-year reviews.	- Does not prevent potential migration of impacted groundwater. - Potentially lengthy timeframe to reduce residual concentrations in groundwater to remedial goals.	- Easily implementable.	Lowest cost option - no capital or O&M costs.	This alternative is retained as a baseline for comparison to the remaining alternatives in accordance with the NCP.
Limited Action	Institutional Controls	Land use restrictions	Through land use restrictions, zoning or other legal mechanisms, restrict the use of or exposure to downgradient groundwater.	- Effective at preventing human exposure or consumption of impacted groundwater but does not prevent potential downgradient migration and usage. - Potentially lengthy timeframe to reduce residual concentrations in groundwater to remedial goals.	- Easily implementable.	- Low capital cost - No O&M costs.	Potentially applicable. Retained for further evaluation.
	Long-term Monitoring	Groundwater monitoring	Periodic groundwater monitoring to evaluate changes in groundwater quality that could be attributable to contaminant migration, natural attenuation processes or active remediation.	- Effective at monitoring contaminant trends over time. - Potentially lengthy timeframe to reduce residual concentrations in groundwater to remedial goals.	- Easily implementable; services and materials readily available to implement.	- Low to no capital costs - Low O&M costs.	Potentially applicable. Retained for further evaluation.
	Alternate Water Supply	Individual residential water treatment units	Installation of in-home point of source treatment units or connection to the local water supply.	- Effective at preventing human consumption of impacted groundwater but does not prevent potential migration.	- Services and materials to install point of source treatment systems in individual residences are available to implement.	- Moderate capital costs - Low to moderate O&M costs	Eliminated as the local public water supply is available to all residences.
		Public water supply	Connection to the local water supply.	- Effective at preventing human consumption of impacted groundwater but does not prevent potential migration.	- Services and materials to connect to the public water supply are available to implement.	- Moderate capital costs - Low to moderate O&M costs	Eliminated as there are local public water supply available to all residences..
Containment with Barrier	Low Permeability Cap	Clay, concrete, and/or asphalt	Impacted area is covered with an engineered (low permeability) cover (i.e. compacted clay, concrete, asphalt, etc.) to prevent exposure to and reduce infiltration through and leaching of contaminants into groundwater.	- Effective at preventing exposure to impacted groundwater. - Does not prevent potential migration.	- Services and materials readily available to implement. - Implementation of the cap is technically infeasible without filling in a large portion of the wetland area.	- High capital cost - Low O&M costs	Eliminated due to the major disturbance that this technology presents to the existing wetland area.
	Vertical Barriers	Slurry, sheet pile or grout curtain wall	Subsurface vertical wall constructed to contain or divert groundwater.	- Effective at preventing migration of impacted groundwater; dependable and reliable in the long term.	- Services and materials readily available to implement. - Implementation may cause disruption to the existing wetlands during installation. - Without additional measures (i.e. extraction), groundwater will likely mound behind the barrier, causing modifications to existing flow, potentially causing adverse effects to the existing wetlands and habitat.	- Moderate to high capital cost - Low O&M costs	Eliminated due to the potential implementation issues.
Containment with Groundwater Extraction	Extraction	Vertical extraction wells	Strategically placed vertical wells are installed to hydraulically contain impacted groundwater.	- Effective means to collect and prevent migration of impacted groundwater. - Reliable and frequently used alternative.	- Services and materials readily available to implement.	- Moderate to high capital cost - Moderate to high O&M costs	Potentially applicable. Retained for further evaluation.
		Interceptor trench	Collection of groundwater from a subsurface trench that contains porous material to facilitate the flow of water. The trench acts as a means to cut off the flow of impacted water (i.e. containment on-site).	- Effective at treating and preventing migration of impacted groundwater.	- Services and materials readily available to implement. - Implementation may cause disruption to the existing ecological habitat during installation.	- Moderate to high capital cost - Moderate to high O&M costs	Potentially applicable. Retained for further evaluation.
Collection (for contaminant reduction)	Extraction	Vertical extraction wells	Strategically placed vertical wells are installed to extract impacted groundwater.	- Effective means to collect and reduce contaminant concentrations in groundwater. - Reliable and frequently used alternative.	- Services and materials readily available to implement.	- Moderate to high capital cost - Moderate to high O&M costs	Potentially applicable. Retained for further evaluation.
		Interceptor trench	Collection of groundwater from a subsurface trench that contains porous material to facilitate the flow of water.	- Effective means to collect and reduce contaminant concentrations in groundwater.	- Services and materials readily available to implement. -Implementation may cause disruption to the existing wetlands during installation.	- Moderate to high capital cost - Moderate to high O&M costs	Potentially applicable. Retained for further evaluation.
		Vacuum enhanced/ multi-phase extraction	A vacuum is applied to an extraction wells to induce groundwater flow to the well without drawdown. This method allows for removal of multiple contaminant phases (water, LNAPL, and vapor). In addition to removing the vapor and groundwater from the well, the high vacuum applied to the well(s) enhances the groundwater recovery and maximizes vapor extraction effectiveness.	- Effective at treating and preventing migration of impacted groundwater.	- Services and materials readily available to implement. - Since LNAPL is not present on-site, nor are there vadose zone soil impacts in this area, this technology provides extra services not required.	- High capital cost - High O&M costs	Eliminated as this technology provides treatment to conditions (i.e. LNAPL) not present in downgradient groundwater.

TABLE 4-4
INITIAL EVALUATION AND SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS --
NON-SOURCE AREAS DOWNGRADIENT

GENERAL RESPONSE ACTION	REMEDIAL TECHNOLOGY	PROCESS OPTION	DESCRIPTION	EFFECTIVENESS	IMPLEMENTABILITY	RELATIVE COST	SCREENING COMMENTS
Ex-situ Treatment	Physical treatment	Filtration/microfiltration/ultrafiltration	Separation of suspended particles form a fluid using a porous media or membrane to trap particles either within or on the surface of the media.	- Effective technology to remove suspended particles as a pretreatment step; not effective in removing other contaminants.	- Services and materials readily available to implement.	- Low capital cost - Low to moderate O&M costs	Potentially applicable. Retained for further evaluation as a possible pretreatment step in an ex-situ groundwater treatment system.
		Reverse osmosis	Removal of dissolved organic and inorganic compounds by passing the fluid through a semi-permeable membrane under pressure.	- Effective technology for treating the impacted groundwater; other technologies may be required to treat the entire waste stream.	- Services and materials available to implement for small scale systems; not in common use at this time for large scale treatment of groundwater.	- Moderate to high capital cost - Moderate O&M costs	Potentially applicable. Retained for further evaluation as a possible pretreatment step in an ex-situ groundwater treatment system.
		Distillation	Separation process used to remove volatile components from a fluid. Heat is applied to the fluid to vaporize the volatile components; the vaporized components are subsequently cooled and condensed.	- Not a highly effective technology for remediating low concentrations of volatile components; other technologies will be required to treat the inorganic portion of the waste stream.	- Services and materials readily available to implement.	- High capital cost - Moderate to high O&M costs	Eliminated as this technology is not effective for the site specific conditions.
		Air stripping	Removal of volatile compounds from the aqueous phase to the vapor phase through contact with air in a countercurrent manner (i.e. packed tower, tray, etc.). Resulting vapor phase is typically treated with carbon adsorption.	- Effective technology for treating VOC impacted groundwater; other technologies will be required to treat the inorganic and 1,4-dioxane portion of the waste stream.	- Services and materials readily available to implement.	- Moderate capital cost - Moderate O&M costs	Potentially applicable as one of multiple treatment steps; retained for further evaluation.
		Steam stripping	Removal of volatile compounds from the aqueous phase to the vapor phase through contact with steam in an countercurrent manner. Volatiles are recovered by condensation of steam.	- Effective technology for treating VOC impacted groundwater; other technologies will be required to treat the inorganic and 1,4-dioxane portion of the waste stream.	- Services and materials readily available to implement.	- High capital cost - Moderate to high O&M costs	Eliminated as other technologies (i.e. air stripping) are more widely used and more cost effective.
		Aeration	Pre-treatment step utilized to remove dissolved metals (i.e. iron and manganese) through contact with air. Contact with air results in oxidation and formation of insoluble hydroxides that precipitate from water.	- Effective technology for removing dissolved metals from groundwater; other technologies will be required.	- Services and materials readily available to implement.	- Moderate capital cost - Moderate O&M costs	Potentially applicable. Retained for further evaluation as a possible pretreatment step in an ex-situ groundwater treatment system.
		Carbon adsorption	Removal of dissolved contaminants from groundwater by adsorption on activated carbon.	- Effective technology for removing dissolved organic compounds from groundwater; other technologies will be required.	- Services and materials readily available to implement.	- Moderate capital cost - Moderate to high O&M costs	Potentially applicable as one of multiple treatment steps; retained for further evaluation.
		Clarification	Separation of suspended particles from groundwater by gravity settling in a tank.	- Effective technology to remove suspended particles as a pretreatment step; not effective in removing other contaminants.	- Services and materials readily available to implement.	- Moderate capital cost - Moderate O&M costs	Potentially applicable. Retained for further evaluation as a possible pretreatment step in an ex-situ groundwater treatment system.
	Chemical Treatment	Precipitation/ Flocculation	Chemical conversion of dissolved metals and/or other inorganic ions to an insoluble precipitate that can be removed by clarification and/or filtration. The process typically involves pH adjustment and the addition of chemical precipitants and flocculants to promote particle aggregation and increased settling efficiency.	- Effective technology to remove inorganics in groundwater; other technologies will be required to treat the remainder of the waste stream.	- Services and materials readily available to implement.	- Moderate to high capital cost - Moderate to high O&M costs	Potentially applicable as one of multiple treatment steps; retained for further evaluation.
		Advanced oxidation processes	Use of strong oxidizers (i.e. ozone or hydrogen peroxide), often in conjunction with UV light, to destroy dissolved organic contaminants.	- Effective technology for removing dissolved organic compounds, including 1,4-dioxane, from groundwater; other technologies may be required.	- Services and materials readily available to implement.	- Moderate to high capital cost - Moderate to high O&M costs	Potentially applicable as one of multiple treatment steps; retained for further evaluation.
		Ion exchange	Removal of dissolved inorganic compounds by passing groundwater through a granular solid or other porous media (i.e. impregnated resin) that exchanges sorbed ions for the contaminant ions.	- Effective technology to remove dissolved inorganics in groundwater; other technologies will be required to treat the remainder of the waste stream. This technology is commonly used as a pretreatment or polishing step.	- Services and materials readily available to implement.	- Moderate to high capital cost - Moderate to high O&M costs	Potentially applicable as a pretreatment or polishing step; retained for further evaluation.
	Biological Treatment	Aerobic reactor	Microorganisms and oxygen are utilized to convert organic compounds into innocuous end products.	- Potentially effective technology for degrading organic compounds from groundwater; other technologies will be required.	- Services and materials available to implement.	- Moderate to high capital cost - Low to moderate O&M costs	Eliminated as other technologies (i.e. air stripping) are more widely used and more cost effective.
		Anaerobic reactor	Anaerobic microorganisms are utilized to degrade organic contaminants in a n oxygen free environment.	- Performance data for full scale application is minimal; effectiveness not certain.	- Services and materials available to implement; however, performance data for full scale applications is minimal.	- Moderate to high capital cost - Moderate O&M costs	Eliminated as the effectiveness of this technology in a full scale application has not been proven.
Discharge	Surface Discharge	Direct (Sutton Brook)	Discharge of treated groundwater to Sutton Brook.	- Convenient, effective and feasible means to discharge treated groundwater.	- Services and materials available to implement. - Discharge locations easily accessible. - More frequent discharge monitoring and more stringent discharge requirements may be required.	- Low to moderate capital cost - Low to moderate O&M costs	Potentially applicable. Retained for further evaluation.

TABLE 4-4
INITIAL EVALUATION AND SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS --
NON-SOURCE AREAS DOWNGRADIENT

GENERAL RESPONSE ACTION	REMEDIAL TECHNOLOGY	PROCESS OPTION	DESCRIPTION	EFFECTIVENESS	IMPLEMENTABILITY	RELATIVE COST	SCREENING COMMENTS
		In-direct (POTW)	Discharge of treated groundwater into a local Publicly Owned Treatment Works (POTW) for treatment and disposal.	-Effective means to discharge treated groundwater; treatment system requirements (i.e. standards to meet) may be reduced in comparison to direct surface water discharge. -Commonly used discharge alternative; groundwater passes through multiple treatment processes prior to final discharge.	-The public sewer system pipeline was recently installed along South Street in the vicinity of the site. Recent discussions with the Town Engineer have indicated that the capacity of the system may be able to accommodate groundwater (range of 15 to 200 gpm) from the site. However, an evaluation would be required to confirm that the existing pipeline can accommodate the load from the site as well as the current and anticipated future usage from the area. Concerns were raised that additional upgrades to this line would likely present opposition by the town and residents.	-High capital cost (due to distance) -Moderate O&M costs	Potentially applicable. Retained for further evaluation.
	Subsurface Discharge	Injection wells	Pressurized discharge of treated groundwater to the subsurface using injection wells.	-Effective means to discharge treated groundwater; groundwater modeling to confirm the feasibility of this method may be required. -Commonly used discharge alternative.	-Services and materials available to implement. -Groundwater modeling and pump tests may be required to confirm the feasibility of this technology. -Potential to modify existing groundwater chemistry and flow patterns; modeling will be required to demonstrate no adverse effect.	-Moderate capital cost -Low to moderate O&M costs	Potentially applicable. Retained for further evaluation.
		Infiltration gallery/ leach field	Discharge of treated groundwater to an on-site subsurface location utilizing a buried infiltration gallery or leach field.	-Effective means to discharge treated groundwater; groundwater modeling to confirm the feasibility of this method may be required. -Commonly used discharge alternative.	-Services and materials available to implement. -Groundwater modeling and pump tests may be required to confirm the feasibility of this technology. -Potential to modify existing groundwater chemistry and flow patterns; modeling will be required to demonstrate no adverse effect.	-Moderate capital cost -Low to moderate O&M costs	Potentially applicable. Retained for further evaluation.
		Infiltration wells (gravity drain)	Discharge of treated groundwater to an on-site subsurface location utilizing vertical, large diameter passive infiltration wells.	-Effective means to discharge treated groundwater; groundwater modeling to confirm the feasibility of this method will be required.	-Services and materials available to implement. -Groundwater modeling and pump tests may be required to confirm the feasibility of this technology.	-Moderate capital cost -Low to moderate O&M costs	Potentially applicable. Retained for further evaluation.
In-situ Treatment/ Remedial Action	Physical Treatment	Air sparging/ soil vapor extraction	Air sparging involves injection of air under pressure below the water table, introducing air to soil pore spaces by displacing the water in the soil matrix. Air sparging contributes to the physical removal of organic compounds (liquid, adsorbed and dissolved phases) through volatilization from subsurface soils and groundwater. In addition, air sparging facilitates aerobic biodegradation processes by assisting with oxygen transfers in the soil and groundwater. The resulting soil vapor is collected via SVE wells.	-Effective technology for remediating VOCs in groundwater; however, it is not an effective means for treating inorganics or 1,4-dioxane. -Limited ability to collect soil vapor due to the high water table and frequent flooding in this area.	-Services and materials available to implement. -Due to the elevated water table within the downgradient wetland portion of the site, limited vadose zone would be available to extract the VOCs. -During installation, the ecological habitat and wetland areas may be disrupted.	-Moderate capital cost -Moderate to high O&M costs	Eliminated as this technology is not effective for the site specific conditions.
		In-well air stripping	Air is injected into the bottom of a dual level screened well to lift groundwater in the well causing it to flow out the upper screen while groundwater enters the well through the lower screen. Volatile contaminants are stripped from groundwater, drawn off by a vacuum extraction system and treated. The discharge of water through the lower screen establishes a circular in-situ flow path through which groundwater is repeatedly treated.	-Effective technology for remediating VOCs in groundwater; however, it is not an effective means for treating inorganics or 1,4-dioxane.	-Services and materials available to implement. -During installation, the ecological habitat and wetland areas may be disrupted.	-Moderate capital cost -Moderate to high O&M costs	Eliminated as this technology is not effective for the site specific conditions.
	Chemical Treatment	Chemical oxidation	Oxidants (i.e. ozone, hydrogen peroxide, permanganate) are injected into the impacted area to destroy organic contaminants in-situ. The contaminants are degraded into innocuous end products (i.e. carbon dioxide).	-Effective technology for remediating VOCs in groundwater; however, it is not an effective means for treating inorganics. -Implementation may modify the existing geochemistry that is effectively naturally attenuating impacted groundwater.	-Services and materials available to implement. -During implementation, the ecological habitat and wetland areas may be disrupted.	-Moderate capital cost -Moderate O&M costs	Potentially applicable to reduce the concentration of some compounds amenable to this treatment. If implemented, it may be used in conjunction with another technology(s). Retained for further evaluation.

TABLE 4-4
INITIAL EVALUATION AND SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS --
NON-SOURCE AREAS DOWNGRADIENT

GENERAL RESPONSE ACTION	REMEDIAL TECHNOLOGY	PROCESS OPTION	DESCRIPTION	EFFECTIVENESS	IMPLEMENTABILITY	RELATIVE COST	SCREENING COMMENTS
		Permeable Reactive Barrier	An in-situ treatment zone of reactive material that degrades or immobilizes contaminants as groundwater flows through it. PRBs are installed as permanent, semi-permanent or replaceable units across the flow path of a contaminated plume. Natural gradients transport contaminants through strategically placed media. The media degrade, sorb, precipitate, or otherwise remove groundwater contaminants.	- Effective technology for treating and/or preventing migration of inorganics and select VOCs; only limited effectiveness in treating fuel hydrocarbons and limited data on effectiveness of treating 1,4-dioxane. - Regeneration of reactive material may be required over time to provide effective treatment/containment. - Potentially lengthy timeframe; may require multiple regenerations over time.	- Services and materials available to implement. - During implementation, the ecological habitat and wetland areas may be disrupted.	- High capital cost - Low O&M costs	Eliminated as this technology is not effective for the site specific conditions.
		Phytoremedation	Plants are utilized to remove, transfer, stabilize and/or destroy contaminants in soil. Phytoremediation mechanisms include enhanced biodegradation in the root zone; uptake of contaminants by roots and accumulation in plant mass; metabolism of contaminants within plant tissues; immobilization of contaminants in root zones; and uptake and release of volatile contaminants through plant leaves.	- Potentially effective technology for removing contaminants from shallow impacted soil and groundwater; plants removing the contaminants may require removal and disposal upon completion of contaminant uptake. - Not an effective technology for groundwater below root depth.	- Services and materials available to implement. - Upon completion of contaminant uptake, plants may require removal and disposal; potentially disrupting the wetland area and existing habitat.	- Low capital cost - Moderate O&M (restoration of wetland upon removal of plants)	Eliminated as this technology is not effective for the site specific conditions (i.e. depth to impacted groundwater exceeds effectiveness of plant root depth).
	Biological Treatment/ Remedial Action	Enhanced biodegradation	Enhanced in-situ bioremediation in groundwater involves the input of an organic carbon source, nutrients, electron acceptors, and/or microbial cultures to stimulate biodegradation.	- Effective technology for promoting biodegradation of contaminants in-situ. - Existing site data demonstrates that natural attenuation processes are currently effectively reducing contaminant levels in-situ.	- Services and materials available to implement.	- Low to moderate capital cost - Low to moderate O&M costs	Potentially applicable to reduce the concentration of some compounds amenable to this treatment. If implemented, it may be used in conjunction with another technology(s). Retained for further evaluation.
		Engineered Treatment Wetland	Engineered wetlands are designed to utilize natural biogeochemical reactions (i.e. reduction/oxidation transformations), phytoremediation (i.e. plant uptake of contaminants), bioremediation (i.e. microbial degradation), and physical processes (i.e. sedimentation) to treat impacted groundwater or surface water within a more controlled environment.	- Potentially effective technology for removing contaminants from shallow impacted groundwater or redirected flow. - Potentially lengthy timeframe. - Use of this alternative to treat groundwater may be effective for low flow/volume; however this alternative has had limited use to date in full scale implementation.	- Services and materials available to implement. - Use of this alternative to treat groundwater will likely only be feasible for low flow/volumes.	- Low to moderate capital cost - Low to moderate O&M costs	Eliminated as a stand alone approach; however, the technology may be incorporated in conjunction with other remedial options.
		Monitored natural attenuation	MNA involves the monitoring and documentation of naturally-occurring processes in soil and groundwater environments that act without human intervention to reduce the mass, toxicity, mobility, volume, or concentration of contaminants in those media to acceptable levels. These in-situ processes include biodegradation, dispersion, dilution, adsorption, volatilization, and chemical or biological stabilization or destruction of contaminants.	- Effective technology for promoting biodegradation of contaminants in-situ. - Existing site data demonstrates that natural attenuation processes are reducing contaminant levels in-situ. - Technology may take a longer timeframe than other alternatives evaluated.	- Services and materials available to implement. - No adverse impacts to surrounding wetland and its habitat during implementation.	- Low capital cost - Low O&M costs	Potentially applicable. Retained for further evaluation.

5. DEVELOPMENT AND INITIAL SCREENING OF REMEDIAL ALTERNATIVES

General response actions, remedial technologies, and process options retained from Section 4 are combined in this section to form area-based remedial alternatives, which are then screened to select alternatives to carry forward into the detailed analysis.

5.1 DEVELOPMENT OF REMEDIAL ALTERNATIVES

The alternatives represent various conceptual approaches to address site contaminants. The alternatives for each media and site location provide various degrees of risk reduction through different levels and/or methods of remediation, ranging from no action, to limited action, to a number of containment/treatment/removal alternatives which vary in the degree to which the toxicity, mobility, or volume of contaminants and wastes are reduced.

In accordance with the *Sutton Brook Disposal Area Superfund Site Statement of Work* and *September 2004 RI/FS Workplan*, alternatives were developed that:

a. protect human health and the environment by recycling waste or by, eliminating, reducing and/or controlling risks to human health and the environment posed through each pathway at the Site;

b. consider the long-term uncertainties associated with land disposal;

c. consider the goals, objectives and requirements of the Solid Waste Disposal Act;

d. consider the persistence, toxicity, mobility, and propensity to bioaccumulate of hazardous substances and their constituents;

e. consider the short and long term potential for human exposure;

f. consider the potential threat to human health and the environment if the remedial alternative proposed were to fail;

g. consider the threat to human health and the environment associated with the excavation, transportation, and re-disposal or containment of contaminated substances and/or media; and

h. consider potential impacts to wetlands and wetland biota.

Using these criteria and the general response actions, remedial technologies and process options retained from the initial screening, a series of area specific remedial alternatives were developed. These alternatives are presented in Tables 5-1a (landfill lobes), 5-2a (FDDA), 5-3a (garage and storage area), and 5-4a (downgradient groundwater).

These tables indicate which retained general response actions are being applied to each remedial alternative. For select alternatives, a generalized response action may have been selected (i.e. in-situ remediation or excavation), but the specific type of remedial action (MNA, chemical oxidation, etc.) will be determined in the remedial design stage.

5.2 INITIAL SCREENING OF REMEDIAL ALTERNATIVES

The multiple remedial alternatives developed for each area were evaluated based on effectiveness, implementability and cost with the objective of reducing the number of alternatives that will undergo a more thorough and extensive evaluation in the detailed analysis. This initial screening resulted in a series

of retained remedial alternatives that represent viable options while preserving the range of containment and treatment alternatives initially developed.

In accordance with the *Sutton Brook Disposal Area Superfund Site Statement of Work* (*Appendix B of Administrative Order by Consent for RI/FS*) and *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA, Interim Final*, the initial screening process for the site-wide alternatives consider the short and long term aspects of the following three criteria:

- Effectiveness: This criterion focuses on the degree to which an alternative reduces toxicity, mobility, or volume through treatment; minimizes residual risks and affords long term protection; complies with ARARs; and minimizes short-term impacts. It also focuses on how quickly the alternative achieves protection with a minimum of short term impact in comparison to how quickly the protection shall be achieved.

- Implementability: This criterion focuses on the technical feasibility and availability of the technologies that each alternative would employ and the administrative feasibility of implementing the alternative.

- Cost: The costs of construction and any long term costs to operate and maintain the alternatives shall be considered.

Each of the remedial alternatives was evaluated based on these criteria and the alternatives were either retained for the detailed analysis or eliminated from further consideration. Refer to Tables 5-1b (landfill lobes), 5-2b (FDDA), 5-3b (garage and storage area), and 5-4b (downgradient groundwater) for the details and results of the initial screening of remedial alternatives. A summary description of each of the retained alternatives is presented in Section 6.

TABLE 5-1a
DEVELOPMENT OF REMEDIAL ALTERNATIVES - Landfill Lobes

Media of Concern	Retained General Response Action (see Table 4-1)	Retained Remedial Technology/ Process Option (see Table 4-1)	ALTERNATIVE						
			No Action	Limited Action	Containment of waste, vent landfill gas, excavate impacted sediment, contain brook (i.e. culvert), in-situ treatment of groundwater	Containment of waste, vent landfill gas, restoration of wetlands and brook, partial containment of groundwater with a vertical barrier and groundwater treatment [1] [2]	Containment of waste, vent landfill gas, excavate impacted sediment, restore brook, hydraulically contain groundwater	Containment of waste, vent landfill gas, restoration of wetlands and brook, and contaminated groundwater collection and treatment	Containment of waste, vent landfill gas, re-routing of the brook, excavation of impacted sediment hot spots, partial containment of groundwater (vertical barrier) with groundwater treatment. [1]
LANDFILL LOBES - SOIL/ WASTE, LEACH ATE and AIR	No Action	Site Inspections	X						
	Limited Action	Institutional Controls and Monitoring		X	X	X	X	X	X
	Containment	Low Permeability Soil Layer							
		Low Permeability single geomembrane cover							
		Low Permeability two layer composite cover							
	Venting	Passive vent system (landfill gas)		X[a,b,c]	X[a,b,c]	X[a,b,c]	X[a,b,c]	X[a,b,c]	X[a,b,c]
	Collection, Treatment, Discharge	Landfill gas and/or leachate							
SEDIMENT AND SURFACE WATER (wetlands and brook adjacent to lobes)	No Action	Site Inspections	X						
	Limited Action	Long-term Monitoring of Surface Water and/or Sediment		X					
	Restoration	Excavation of sediment with disposal on-site or off-site				X[d]	X[d]	X[d]	
	Restoration and Containment	Excavation with full containment of the Brook (in between the lobes)			X[d]				
	Re-route Brook	Re-route brook and containment of sediments							X
LANDFILL LOBES - GROUNDWATER	No Action	Site Inspections	X						
	Limited Action	Institutional Controls		X	X	X	X	X	X
		Post-landfill closure groundwater monitoring		X	X	X	X	X	X
	Containment with Barrier	Slurry wall							
		Sheet pile wall				X[e]			X[f]
		Grout curtain wall							
	Containment with Groundwater Extraction	Vertical extraction wells							
		Interceptor trench					X[g]		
	Collection (source reduction)	Vertical extraction wells							
		Interceptor trench				X[g]		X[g]	X[g]
	Ex-situ Treatment - Physical/ Chemical	Filtration/microfiltration/ultrafiltration				X[h]	X[g]	X[h]	X[h]
		Reverse osmosis				X[h]	X[g]	X[h]	X[h]
		Air stripping				X[h]	X[g]	X[h]	X[h]
		Aeration				X[h]	X[g]	X[h]	X[h]
		Carbon adsorption				X[h]	X[g]	X[h]	X[h]
		Clarification				X[h]	X[g]	X[h]	X[h]
		Precipitation/ Flocculation				X[h]	X[g]	X[h]	X[h]
		Advanced oxidation processes				X[h]	X[g]	X[h]	X[h]
		Ion exchange				X[h]	X[g]	X[h]	X[h]
	Discharge	Discharge to surface water							
		Injection wells							
		Infiltration gallery/ leach field				X[g]	X[g]	X[g]	X[g]
		Infiltration wells (gravity drain)							
		In-direct discharge (to POTW)							
	In-situ Treatment or Remedial Action	Chemical Oxidation			X[i]	X[i]			X[i]
		Permeable Reactive Barrier			X[i]	X[i]			X[i]
		Phytoremediation (i.e. phytobed)			X[i]	X[i]			X[i]
		Enhanced Biodegradation			X[i]	X[i]			X[i]
		Engineered treatment wetland			X[i]	X[i]			X[i]
		Monitored Natural Attenuation			X[i]	X[i]			X[i]

Notes:

[1] - Selection of the groundwater remedial technology (i.e. containment with extraction and ex-situ treatment or in-situ treatment) will be determined during the Detailed Analysis. If groundwater extraction, treatment and discharge is selected, it is anticipated to be low volume - rate to be determined based on collection/ drainage of groundwater behind the containment unit.

[2] - Groundwater containment unit proposed to extend along a portion of the southern lobe only, between the edge of the waste/cap and the brook.

[a] - Selection of the specific type of cap for each of the landfill lobes will be determined in the detailed analysis.

[b] - It is anticipated (based on the data evaluation performed to date) that passive venting will be sufficient at this Site. However, the need for active collection of landfill gas will be determined during the sampling and assessment conducted as part of the Phase 2 FS with the subsequent detailed analysis to demonstrate compliance with the applicable regulations.

[c] - The need for and type of leachate or landfill gas treatment prior to discharge will be determined based on the need for active collection (see Note b).

[d] - Selection of the sediment disposal option to be determined in the detailed analysis and/or design phase.

[e] - Type of vertical containment wall to be determined in design stage.

[f] - Location of a potential vertical barrier is assumed to extend along a portion of the southern landfill lobe, between the southern edge of the waste and the newly re-routed brook.

[g] - Selection of the specific extraction and discharge method will be dependent on groundwater modeling performed for the detailed analysis.

[h] - Actual selection of treatment type will be dependent on the detailed analysis.

[i] - Selection of the specific in-situ treatment or remedial action option will be determined in the detailed analysis.

TABLE 5-1b
INITIAL SCREENING OF REMEDIAL ALTERNATIVES --
SOURCE AREA - LANDFILL LOBES

REMEDIAL ALTERNATIVE	APPROACH FOR MEDIA					EFFECTIVENESS	IMPLEMENTABILITY	RELATIVE COST	SCREENING COMMENTS
	LANDFILL LOBES			SEDIMENT AND SURFACE WATER	GROUNDWATER				
	SOIL AND WASTE	LEACHATE	AIR						
No Action	- No Action	- No Action	- No Action	- No Action	- No Action	- Alternative does not eliminate the current or potential future risks to human and/or ecological receptors. - Will not achieve RAOs. - Does not provide long-term protection.	- Technically feasible to implement.	- No capital costs - Low O&M costs (site inspections)	In accordance with the NCP, the No Action remedial alternative is **retained as alternative LF-1** as a comparison to the remaining alternatives.
Limited Action	- Institutional Controls - Containment of waste with low permeability cap	- Long term monitoring and/or passive/active recovery (selection to be determined during remedy design phase).	- Passive vent system (unless Phase 2 analysis demonstrates that an active collection and/or treatment system is required)	- Long term monitoring of surface water and/or sediment.	- Institutional Controls - Post landfill closure groundwater monitoring (min. 5 years)	- Containment of landfilled waste will eliminate human and ecological exposure risks associated with the waste. - Through institutional controls of the landfills and groundwater, it is an effective alternative to prevent human exposure to the waste; however this alternative does not eliminate risks to ecological receptors with the brook sediment and surface water. - Alternative does not reduce the toxicity, mobility or volume of impacted media through treatment. - Lengthy timeframe to meet RAOs. - Provides long-term protection for human exposure to the waste and groundwater, but does not provide protection in the short or long term to ecological receptors.	- Technically feasible to implement. - Services and materials readily available to implement.	- Moderate capital costs - Moderate O&M costs	This alternative has been eliminated since it does not reduce the toxicity, mobility or volume of impacted media through treatment and does not reduce or eliminate risks to ecological receptors.
Containment of waste, vent landfill gas, excavate impacted sediment, contain brook (i.e. culvert), in-situ treatment of groundwater	- Institutional Controls - Containment of waste with low permeability cap	- Long term monitoring and/or passive/active recovery (selection to be determined during remedy design phase).	- Passive vent system (unless Phase 2 analysis demonstrates that an active collection and/or treatment system is required)	- Excavation of impacted sediment and full containment of brook (in between lobes)	- Institutional Controls - Post landfill closure groundwater monitoring - In-situ treatment	- Containment of landfilled waste and the brook will eliminate human and ecological exposure risks. Containment of brook will also prevent any future re-contamination of the brook sediment or surface water by impacted groundwater. - Through institutional controls of the landfills and groundwater, it is an effective alternative to prevent human exposure to and use of the waste and groundwater. - This alternative utilizes natural attenuation processes and/or other in-situ groundwater remediation processes to reduce the toxicity, mobility or volume of impacted groundwater. - Provides long-term protection for exposure to the waste, brook and groundwater.	- Technically feasible to implement and services and materials readily available to implement; however, due to regulatory requirements associated with re-creating the bank after containerizing the brook (i.e., culvert, etc.), it may be infeasible to implement this alternative. Specific provisions include bordering land subject to flooding, inland bank, land under water, river front area, and bordering vegetated wetlands.	- Moderate capital costs - Moderate O&M costs	Although this alternative provides a reduction of risk to human and ecological receptors, it was eliminated as it may be infeasible due to substantial compliance with regulatory requirements in comparison to the other alternatives.
Containment of waste, vent landfill gas, restoration of wetlands and brook, partial containment of groundwater with a vertical barrier and groundwater remediation	- Institutional Controls - Containment of waste with low permeability cap	- Long term monitoring and/or passive/active recovery (selection to be determined during remedy design phase).	- Passive vent system (unless Phase 2 analysis demonstrates that an active collection and/or treatment system is required)	- Excavation of impacted sediment and restoration of brook	- Institutional Controls - Post landfill closure groundwater monitoring - Partial containment of groundwater with barrier - Groundwater remediation at downgradient end of containment barrier with in-situ or low volume extraction and ex-situ methods	- This alternative will effectively eliminate human and ecological exposure risks. Partial containment of the brook with groundwater treatment will also prevent any future re-contamination of the brook sediment or surface water by discharging groundwater. - This alternative utilizes groundwater remediation processes to reduce the toxicity, mobility or volume of impacted groundwater. - Provides long-term protection for exposure to the waste, brook and groundwater.	- Technically feasible to implement. - Services and materials readily available to implement.	- Moderate to high capital costs - Moderate to high O&M costs	This alternative was **retained as alternative LF-2** since it eliminates current and potential future risks to human and ecological receptors and reduces the toxicity, mobility and volume of impacted media through treatment.
Containment of waste, vent landfill gas, excavate impacted sediment, restore brook, hydraulically contain groundwater	- Institutional Controls - Containment of waste with low permeability cap	- Long term monitoring and/or passive/active recovery (selection to be determined during remedy design phase).	- Passive vent system (unless Phase 2 analysis demonstrates that an active collection and/or treatment system is required)	- Excavation of impacted sediment and restoration of brook	- Institutional Controls - Post landfill closure groundwater monitoring - Hydraulic containment of groundwater with extraction and ex-situ treatment	- This alternative will effectively eliminate human and ecological exposure risks. Hydraulic containment of the impacted groundwater will also strive to prevent any future re-contamination of the brook sediment or surface water. - Alternative effectively reduces the toxicity and volume of contaminants in groundwater through extraction and ex-situ treatment and reduces the mobility through the pumping design to contain the impacted material on-site. - Extraction and treatment of an extensive volume of groundwater may be required to effectively contain the groundwater on-site. - With institutional controls, this is an effective alternative to prevent human exposure to and use of the waste and impacted groundwater. - Provides short-term and long-term protection for human and ecological exposure, assuming no operational issues with the groundwater extraction and treatment system.	- Technically feasible to implement; however, extraction and treatment of an extensive volume of groundwater (and potentially surface water) may be required to effectively contain the groundwater. - Services and materials readily available to implement.	- High capital costs - High to very high O&M costs	This alternative was eliminated since other alternatives provide similar benefits but with a greater level of reliability and reduced cost (i.e. physical vertical barrier vs. constantly operating extraction wells).

TABLE 5-1b
INITIAL SCREENING OF REMEDIAL ALTERNATIVES --
SOURCE AREA - LANDFILL LOBES

REMEDIAL ALTERNATIVE	APPROACH FOR MEDIA					EFFECTIVENESS	IMPLEMENTABILITY	RELATIVE COST	SCREENING COMMENTS
	LANDFILL LOBES			SEDIMENT AND SURFACE WATER	GROUNDWATER				
	SOIL AND WASTE	LEACHATE	AIR						
Containment of waste, vent landfill gas, restoration of wetlands and brook, and contaminated groundwater collection and treatment	- Institutional Controls - Containment of waste with low permeability cap	- Long term monitoring and/or passive/active recovery (selection to be determined during remedy design phase).	- Passive vent system (unless Phase 2 analysis demonstrates that an active collection and/or treatment system is required)	- Excavation of impacted sediment and restoration of brook	- Institutional Controls - Post landfill closure groundwater monitoring - Contaminant mass reduction with extraction and ex-situ treatment	- This alternative will effectively eliminate human and ecological exposure risks. Hydraulic containment of the impacted groundwater will also strive to prevent any future re-contamination of the brook sediment or surface water. - Alternative effectively reduces the toxicity and volume of contaminants in groundwater through extraction and ex-situ treatment and reduces the mobility through the pumping design to contain the impacted material on-site. - Extraction and treatment of an extensive volume of groundwater may be required to effectively treat impacted groundwater. - With institutional controls, this is an effective alternative to prevent human exposure to and use of the impacted groundwater. - Provides short-term and long-term protection for human and ecological exposure; assuming no operational issues with the groundwater extraction and treatment system.	- Technically feasible to implement; however, extraction and treatment of an extensive volume of groundwater (and potentially surface water) may be required to effectively reduce contaminant concentrations in groundwater and prevent re-contamination of the brook. - Services and materials readily available to implement.	- High capital costs - High to very high O&M costs	This alternative was **retained as alternative LF-3** since it eliminates current and potential future risks to human and ecological receptors and reduces the toxicity, mobility and volume of impacted media in the most aggressive manner and potentially in the quickest timeframe.
Containment of waste, vent landfill gas, re-routing of the brook, excavation of impacted sediment hot spots, partial containment of groundwater (vertical barrier) with groundwater remediation.	- Institutional Controls - Containment of waste with low permeability cap	- Long term monitoring and/or passive/active recovery (selection to be determined during remedy design phase).	- Passive vent system (unless Phase 2 analysis demonstrates that an active collection and/or treatment system is required)	- Excavation of sediment hot spot areas, re-route brook to the south of the southern landfill lobe, and contain sediments in between lobes.	- Institutional Controls - Post landfill closure groundwater monitoring - Partial containment of groundwater with barrier - Groundwater remediation at downgradient end of containment barrier with in-situ or low volume extraction and ex-situ methods	- This alternative will effectively eliminate human and ecological exposure risks. Partial containment of the newly re-routed brook around the Southern Lobe with a barrier and groundwater treatment will also prevent any future re-contamination of the newly re-routed brook sediment or surface water from the Southern Lobe. - This alternative utilizes groundwater treatment processes to reduce the toxicity, mobility or volume of impacted groundwater. - With institutional controls, this is an effective alternative to prevent human exposure to and use of the impacted groundwater. - Provides long-term protection for exposure to the waste, brook and groundwater.	- Services and materials readily available to implement - Potential major disruption of the ecological habitat within the brook and wetlands. - Implementation will result in modification of hydrogeological flow patterns on-site; hyrogeo modeling will be required to ensure this alternative is feasible. - Extensive regulatory compliance conditions. - May not be enough land to recreate the 100-year flood plain that would be destroyed during the re-routing.	- High capital costs - Moderate to high O&M costs	This alternative was **retained as alternative LF-4** since it eliminates current and potential future risks to human and ecological receptors and reduces the toxicity, mobility and volume of impacted media.

TABLE 5-2a

DEVELOPMENT OF REMEDIAL ALTERNATIVES - Former Drum Disposal Area

Media of Concern	Retained General Response Action (see Table 4-2)	Retained Remedial Technology/ Process Option (see Table 4-2)	ALTERNATIVE								
			No Action	Limited Action	Containment of Soil and Groundwater with barriers	Containment of Soil (with cap) with in-situ remediation of Groundwater	Containment of Soil (with cap) and hydraulic containment of groundwater (through extraction and ex-situ treatment)	Excavation, treatment and/or disposal of soil with hydraulic containment of groundwater (through extraction and ex-situ treatment)	Excavation, treatment and/or disposal of soil with source area groundwater remediation (focused mass reduction) [1]	In-situ remediation of soil and groundwater	Excavation, treatment and/or disposal of soil with groundwater extraction and ex-situ treatment for area-wide contaminant reduction
Soil	No Action	Site Inspections	X								
	Limited Action	Access Restrictions		X							
		Institutional Controls		X	X	X	X				
	Containment	Low Permeability Cap			X	X	X				
	Excavation and Disposal	On-site disposal						X[d]	X[d]		X[d]
		Off-site disposal									
	Excavation and Ex-situ Treatment	Thermal desorption									
		Incineration						X[e]	X[e]		X[e]
		Chemical oxidation									
		Soil venting									
	In-situ Treatment or Remedial Action	Thermal desorption									
		Chemical Oxidation								X[e]	
		Monitored natural attenuation									
Groundwater	No Action	Site Inspections	X								
	Limited Action	Institutional Controls		X	X	X	X	X	X	X	X
		Long-term Monitoring		X	X	X	X	X	X	X	X
	Containment with Barrier	Slurry wall									
		Sheet pile wall			X[a]						
		Grout curtain wall									
	Containment with Groundwater Extraction	Vertical extraction wells					X[b]	X[b]	X[b]		
		Interceptor trench									
	Collection (source reduction)	Vertical extraction wells									
		Interceptor trench									X[b]
	Ex-situ Treatment - Physical/ Chemical	Filtration/microfiltration/ultrafiltration					X[c]	X[c]	X[c]		X[c]
		Reverse osmosis									
		Air stripping					X[c]	X[c]	X[c]		X[c]
		Aeration									
		Carbon adsorption									
		Clarification									
		Precipitation/ Flocculation									
		Advanced oxidation processes					X[c]	X[c]	X[c]		X[c]
		Ion exchange					X[c]	X[c]	X[c]		X[c]
	Discharge	Discharge to surface water									
		In-direct discharge (to POTW)									
		Injection wells					X[b]	X[b]	X[b]		X[b]
		Infiltration gallery/leach field									
		Infiltration wells (gravity drain)									
	In-situ Treatment or Remedial Action	Chemical Oxidation				X[f]			X[f]	X[f]	
		Enhanced Biodegradation				X[f]			X[f]	X[f]	
		Permeable Reactive barrier				X[f]			X[f]	X[f]	
		Monitored natural attenuation				X[f]			X[f]	X[f]	

Notes:

[1] - Selection of the groundwater remedial technology (extraction and ex-situ treatment or in-situ treatment) will be determined during the Detailed Analysis.

[a] - Type of vertical containment barrier to be determined in design stage.

[b] - Selection of the specific extraction and discharge method will be dependent on groundwater modeling performed for the detailed analysis.

[c] - Actual selection of treatment type will be dependent on detailed analysis.

[d] - Selection of disposal option to be determined in the detailed analysis and/or design phase.

[e] - The option to treat the excavated soil is retained for all alternatives utilizing excavation; the decision to dispose of the material with or without treatment will be dependent on the concentrations present in the impacted material and the cost effectiveness. It will be evaluated further in the detailed analysis.

[f] - Actual selection of in-situ treatment type or remedial action to be determined in the detailed analysis.

TABLE 5-2b
INITIAL SCREENING OF REMEDIAL ALTERNATIVES --
SOURCE AREA - FORMER DRUM DISPOSAL AREA

REMEDIAL ALTERNATIVE	APPROACH FOR MEDIA		EFFECTIVENESS	IMPLEMENTABILITY	RELATIVE COST	SCREENING COMMENTS
	SOIL	GROUNDWATER				
No Action	-No Action	-No Action	- Alternative does not eliminate the current or potential future risks to human and ecological receptors. - Will not achieve RAOs. - Does not minimize short-term impacts, nor provides long-term protection.	- Technically feasible to implement.	- No capital costs - Low O&M costs (site inspections)	The No Action remedial alternative is **retained as alternative FDDA-1** as a comparison to the remaining alternatives in accordance with the NCP.
Limited Action	-Access Restrictions -Institutional Controls	- Institutional Controls - Long-term Groundwater Monitoring	- Potentially lengthy timeframe to meet RAOs. - With institutional controls, this is an effective alternative to prevent human exposure to and use of the impacted soil and groundwater. - Provides long-term protection for human exposure, but does not prevent exposure to ecological receptors.	- Technically feasible to implement. - Services and materials readily available to implement.	- Low capital costs - Low O&M costs	Even though this alternative reduces current and potential future risks, it has been eliminated since it will not reach site RAOs in a reasonable timeframe.
Containment of soil and groundwater with barriers	-Institutional Controls -Low Permeability Cap	-Institutional Controls - Containment with Vertical Barrier - Long-term groundwater monitoring	- Alternative does not reduce the toxicity or volume of contaminants in soil or groundwater, but does eliminate the mobility of contaminants. - Lengthy timeframe to meet RAOs. - Effective alternative to prevent both human and ecological exposure to the impacted area. - Provides long-term protection for human and ecological exposure.	- Technically feasible to implement. - Services and materials readily available to implement.	- Moderate capital cost - Low O&M costs	Eliminated since other alternatives provide options to reduce the toxicity and/or volume of impacted material on-site through treatment.
Containment of soil (with cap) with in-situ remediation of groundwater	-Institutional Controls -Low Permeability Cap	- Institutional Controls - In-situ Remediation - Long-term groundwater monitoring	- Alternative does not reduce the toxicity or volume of contaminants in soil, nor does it prevent future leaching of contaminants to groundwater (i.e., water table fluctuations). This alternative does utilize natural attenuation processes and/or other in-situ methods to reduce the toxicity and volume of impacted groundwater. - Lengthy timeframe to meet RAOs. - Effective alternative to prevent both human and ecological exposure to the impacted area (with the cap) and use of the groundwater through institutional controls. - Provides long-term protection for human and ecological exposure.	- Technically feasible to implement. - Services and materials readily available to implement.	- Low to moderate capital cost - Moderate O&M costs	Eliminated since other alternatives provide options to reduce the toxicity and/or volume of both the soil and groundwater through treatment.
Containment of soil (with cap) and hydraulic containment of groundwater (through extraction and ex-situ treatment)	-Institutional Controls -Low Permeability Cap	- Institutional Controls - Hydraulic containment of groundwater through extraction, ex-situ treatment and discharge - Long-term groundwater monitoring	- Alternative does not reduce the toxicity or volume of contaminants in soil, but may reduce future migration of contaminants from soil to groundwater. This alternative does reduce the toxicity, volume and migration of the impacted groundwater through extraction and ex-situ treatment. - Reduced timeframe (over previous alternative) to meet RAOs. - Effective alternative to prevent both human and ecological exposure to the impacted area. - Provides long-term protection for human and ecological exposure.	- Technically feasible to implement. - Services and materials readily available to implement.	- High capital costs - Very high O&M costs	This alternative has been **retained as alternative FDDA-2** since it eliminates current and potential future risks to human and ecological receptors and reduces the toxicity, mobility and volume of impacted media through groundwater extraction and ex-situ treatment.

TABLE 5-2b
INITIAL SCREENING OF REMEDIAL ALTERNATIVES --
SOURCE AREA - FORMER DRUM DISPOSAL AREA

REMEDIAL ALTERNATIVE	APPROACH FOR MEDIA		EFFECTIVENESS	IMPLEMENTABILITY	RELATIVE COST	SCREENING COMMENTS
	SOIL	GROUNDWATER				
Excavation, treatment and/or disposal of soil with hydraulic containment of groundwater (through extraction and ex-situ treatment)	-Excavation with or without treatment, and disposal	- Institutional Controls - Hydraulic containment of groundwater through extraction, ex-situ treatment and discharge - Long-term Groundwater Monitoring	- Effective approach to eliminate human and ecological exposure to impacted soil (physical removal) and groundwater (containment and institutional controls). - Provides protection in the short and long term. - Alternative reduces the volume of contaminants in soil through physical removal and reduces the toxicity, mobility and volume of contaminants in groundwater through extraction and ex-situ treatment. - Provides the quickest timeframe to meet soil RAOs, with a potentially lengthier timeframe to meet groundwater RAOs.	- Technically feasible to implement. - Services and materials readily available to implement. - Extraction and treatment of an extensive volume of groundwater may be required to effectively contain the groundwater on-site.	- High capital costs - Moderate to high O&M costs	This alternative was **retained as alternative FDDA-3** since it eliminates current and potential future risks to human and ecological receptors and reduces the toxicity, mobility and volume of impacted media through groundwater extraction and ex-situ treatment.
Excavation, treatment and/or disposal of soil with source area groundwater remediation (focused mass reduction)	-Excavation with or without treatment, and disposal	- Institutional Controls - Contaminant mass reduction in source area groundwater through in-situ or extraction and ex-situ methods - Long-term Groundwater Monitoring	- Effective approach to eliminate human and ecological exposure to impacted soil (physical removal) and groundwater (institutional controls). - Provides protection in the short and long term. - Alternative reduces the volume of contaminants in soil through physical removal and reduces the toxicity, mobility and volume of contaminants in groundwater through in-situ methods (i.e. MNA, ISCO, etc.) or lower volume extraction and ex-situ treatment. - Provides the quickest timeframe to meet soil RAOs, with a potentially lengthier timeframe to meet groundwater RAOs.	- Technically feasible to implement. - Services and materials readily available to implement.	- High capital costs - High O&M costs	This alternative was **retained as alternative FDDA-4** since it eliminates current and potential future risks to human and ecological receptors and reduces the toxicity, mobility and volume of impacted groundwater through in-situ methods or extraction and ex-situ treatment.
In-situ remediation of soil and groundwater	-In-situ treatment	- Institutional Controls - In-situ Remediation - Long-term groundwater monitoring	- Alternative utilizes natural attenuation process and/or additional in-situ treatment methods to reduce the toxicity and volume of impacted media. - Effective approach to eliminate human and ecological exposure to impacted soil and groundwater. - Provides protection in the short and long term. - Potential lengthy timeframe to meet site RAOs. - Technologies may not be effective for all contaminants of concern.	- Technically feasible to implement. - Services and materials readily available to implement.	- Moderate capital costs - Moderate O&M costs	This alternative was eliminated because it may not be effective in reducing the toxicity, mobility or volume of all contaminants of concern in soil and groundwater.
Excavation, treatment and/or disposal of soil with groundwater extraction and ex-situ treatment for area-wide contaminant reduction.	-Excavation with or without treatment, and disposal	- Institutional Controls - Groundwater treatment through extraction and ex-situ treatment (groundwater restoration) - Long-term groundwater monitoring	- Effective approach to eliminate human and ecological exposure to impacted soil (physical removal) and groundwater (institutional controls). - Provides protection in the short and long term. - Alternative reduces the volume, and therefore migration, of contaminants in soil through physical removal; and effectively reduces the toxicity, mobility and volume of impacted groundwater through extraction and ex-situ treatment for area wide contaminant reduction/restoration. - Potentially provides the quickest timeframe to meet soil and groundwater RAOs.	- Technically feasible to implement. - Services and materials readily available to implement. - Extraction and treatment of an extensive volume of groundwater may be required to aggressively reduce contaminants in groundwater.	- High capital costs - High to very high O&M costs	This alternative was **retained as alternative FDDA-5** since it eliminates current and potential future risks to human and ecological receptors and reduces the toxicity, mobility and volume of impacted media in the most aggressive manner and potentially in the quickest timeframe.

TABLE 5-3a
DEVELOPMENT OF REMEDIAL ALTERNATIVES - Garage and Storage Area

Media of Concern	Retained General Response Action (see Table 4-3)	Retained Remedial Technology/ Process Option (see Table 4-3)	ALTERNATIVE			
			No Action	Limited Action	Containment of Soil	Excavation, Treatment and/or Disposal of Soil
SOIL	No Action	Site Inspections	X			
	Limited Action	Access Restrictions		X		
		Institutional Controls		X	X	
	Containment	Low Permeability Cap			X	
	Excavation and Disposal	On-site disposal Off-site disposal				X[a]
	Excavation and Ex-situ Treatment	Asphalt batching				X[b]
		Thermal desorption				X[b]
		Incineration				X[b]

Notes:

[a] - Selection of disposal option to be determined in the detailed analysis and/or design phase.

[b] - Evaluation of the use of ex-situ treatment, and subsequent selection of ex-situ treatment type, if necessary, will be determined in the detailed analysis.

TABLE 5-3b
INITIAL SCREENING OF REMEDIAL ALTERNATIVES --
SOURCE AREA - GARAGE AND STORAGE AREA

REMEDIAL ALTERNATIVE	APPROACH FOR MEDIA SOIL	EFFECTIVENESS	IMPLEMENTABILITY	RELATIVE COST	SCREENING COMMENTS
No Action	- No action	- Alternative does not eliminate the current or future risks to human or ecological receptors. - Will not achieve RAOs. - Does not minimize short-term impacts, nor provides long-term protection.	- Technically feasible to implement.	- No capital costs - Low O&M costs (site inspections)	The No Action remedial alternative is **retained as alternative GSA-1** as a comparison to the remaining alternatives in accordance with the NCP.
Limited Action	- Access Restrictions - Institutional Controls	- Potentially lengthy timeframe to meet RAOs. - Effective alternative to prevent human exposure to the impacted area, but does not eliminate exposure risks for ecological receptors. - Provides long-term protection for human exposure, but none for ecological receptors.	- Technically feasible to implement. - Services and materials readily available to implement. - A potential issue presented with this area is the continued use by others as a storage area with materials or vehicles routinely being stored on the property.	- Low capital costs - Low O&M costs	Eliminated as this alternative does not comply with the site RAOs and does not reduce potential current and future risks to receptors.
Containment of Soil	- Institutional Controls - Containment with low permeability cap	- Alternative does not reduce the toxicity or volume of contaminants in soil, but would prevent the mobility of surface soil. - Potentially lengthy timeframe to meet RAOs. - Effective alternative to prevent both human and ecological exposure to the impacted area. - Provides long-term protection for human and ecological exposure.	- Technically feasible to implement. - Services and materials readily available to implement. - A potential issue presented with this area is the continued use by others as a storage area with materials or vehicles routinely being stored on the property.	- Moderate capital cost - Low O&M costs	Eliminated as this alternative does not comply with the site RAOs and other alternatives provide options to reduce the toxicity, mobility and/or volume of impacted material on-site.
Excavation with Treatment and/or Disposal of Soil	- Excavation with or without ex-situ treatment, and disposal	- Highly effective approach to eliminate human and ecological exposure to impacted material. - Provides protection in the short and long term. - Alternative reduces the volume of contaminants through physical removal. - Provides the quickest timeframe to meet RAOs.	- Technically feasible to implement. - Services and materials readily available to implement. - A potential issue presented with this area is the continued use by others as a storage area with materials or vehicles routinely being stored on the property.	- Moderate (on-site disposal or off-site disposal/treatment) capital costs - No O&M costs	This alternative was **retained as alternative GSA-2** since it eliminates potential current and future risks as it eliminates the impacted material from the site.

TABLE 5-4a
DEVELOPMENT OF REMEDIAL ALTERNATIVES - Non-Source Area Downgradient Groundwater

Media of Concern	Retained General Response Action (see Table 4-4)	Retained Remedial Technology/ Process Option (see Table 4-4)	ALTERNATIVE				
			No Action	Limited Action	In-situ Remediation	Hydraulic Containment through Groundwater Extraction, Treatment and Discharge	Groundwater Extraction and Ex-situ Treatment for Area-wide Contaminant Reduction
Downgradient Groundwater	No Action	Site Inspections	X				
	Limited Action	Institutional Controls		X	X	X	X
		Long-term Monitoring		X		X	X
	Containment with Groundwater Extraction	Vertical extraction wells				X[a]	
		Interceptor trench					
	Collection (for contaminant reduction)	Vertical extraction wells					X[b]
		Interceptor trench					
	Ex-situ Treatment - Physical/ Chemical	Filtration/microfiltration/ultrafiltration				X[c]	X[c]
		Reverse osmosis				X[c]	X[c]
		Air stripping				X[c]	X[c]
		Aeration				X[c]	X[c]
		Carbon adsorption				X[c]	X[c]
		Clarification				X[c]	X[c]
		Precipitation/ Flocculation				X[c]	X[c]
		Advanced oxidation processes				X[c]	X[c]
		Ion exchange				X[c]	X[c]
	Discharge	Direct surface discharge				X[b]	X[b]
		Injection wells					
		Infiltration gallery/ leach field					
		Infiltration wells (gravity drain)					
		In-direct discharge (to POTW)					
	In-situ Treatment or Remedial Action	Enhanced Biodegradation			X		
		Engineered treatment wetland			X		
		Chemical oxidation			X		
		Monitored natural attenuation			X		

Notes:

[a] - Containment method to be determined in design stage.

[b] - Selection of the extraction and discharge method will be dependent on groundwater modeling performed for the detailed analysis.

[c] - Actual selection of treatment type will be dependent on detailed analysis.

[d] - Selection of the specific in-situ remediation option will be determined in the detailed analysis.

TABLE 5-4b
INITIAL SCREENING OF REMEDIAL ALTERNATIVES --
DOWNGRADIENT GROUNDWATER

REMEDIAL ALTERNATIVE	APPROACH FOR MEDIA - GROUNDWATER	EFFECTIVENESS	IMPLEMENTABILITY	RELATIVE COST	SCREENING COMMENTS
No Action	- No Action	- Alternative does not eliminate current or future risks. - Will not achieve RAOs. - Does not minimize short-term impacts, nor provides long-term protection.	- Technically feasible to implement.	- No capital costs - Low O&M costs (site inspections)	The No Action remedial alternative is **retained as alternative DGGW-1** as a comparison to the remaining alternatives in accordance with the NCP.
Limited Action	- Institutional Controls - Long-term groundwater monitoring	- Potentially lengthy timeframe to meet RAOs. - With institutional controls, this is an effective alternative to prevent human exposure to and use of the impacted groundwater. - Provides long-term protection for human exposure.	- Technically feasible to implement. - Services and materials readily available to implement.	- Low capital costs - Moderate O&M costs	Even though this alternative reduces current and potential future risks, it has been eliminated since other alternatives will reach site RAOs in a quicker timeframe.
In-situ Remediation	- Institutional Controls - In-situ Remediation	- Alternative utilizes natural attenuation processes, enhanced bioremediation techniques, or chemical addition to reduce the toxicity, mobility or volume of contaminants in groundwater; existing site data demonstrates that natural attenuation processes are reducing contaminant levels in-situ. - Potentially lengthy timeframe to meet RAOs. - Effective alternative to prevent human exposure to and use of the impacted groundwater - Provides long-term protection for human exposure.	- Technically feasible to implement. - Services and materials readily available to implement. - Phased implementation following source control alternatives is proposed to optimize the alternative's effectiveness.	- Low to moderate capital costs - Moderate to high O&M costs	This alternative has been **retained as alternative DGGW-2** since it eliminates current and potential future risks without adverse impacts to surrounding wetlands and reduces the toxicity, mobility and volume of contaminants in downgradient groundwater.
Hydraulic Containment through Groundwater Extraction, Treatment and Discharge	- Institutional Controls - Hydraulic containment through groundwater extraction and ex-situ treatment - Long-term groundwater monitoring	- Alternative effectively reduces the toxicity and volume of contaminants in groundwater through extraction and ex-situ treatment and reduces the mobility through pumping to contain the impacted material on-site. - Extraction and treatment of an extensive volume of groundwater may be required to effectively contain the groundwater on-site. - With institutional controls, this is an effective alternative to prevent human exposure to and use of the impacted groundwater. - Provides short-term and long-term protection for human exposure.	- Technically feasible to implement. - Services and materials readily available to implement. - Phased implementation following source control alternatives is proposed to optimize the alternative's effectiveness. - Extensive amount of groundwater may require extraction and treatment.	- High capital costs - Very high O&M costs	This alternative has been **retained as alternative DGGW-3** since it eliminates current and potential future risks and reduces the toxicity, mobility and volume of contaminants in downgradient groundwater.
Groundwater Extraction and Ex-situ Treatment for Area-wide Contaminant Reduction	- Institutional Controls - Contaminant mass reduction through groundwater extraction and ex-situ treatment - Long-term groundwater monitoring	- Alternative effectively reduces the toxicity, mobility and volume of contaminants in groundwater. - Extraction and treatment of an extensive volume of groundwater may be required to effectively treat the groundwater in an expedited timeframe. - With institutional controls, this is an effective alternative to prevent human exposure to and use of the impacted groundwater. - Provides short-term and long-term protection for human exposure. - Provides the quickest timeframe to meet RAOs.	- Technically feasible to implement; extraction and treatment of an extensive volume of groundwater may be required to effectively treat the groundwater in an expedited timeframe. - Alternative may have negative effect on wetlands due to excessive groundwater extraction. - Services and materials readily available to implement. - Phased implementation following source control alternatives is proposed to optimize the alternative's effectiveness.	- High capital costs - Very high O&M costs	This alternative has been **retained as alternative DGGW-4** since it eliminates current and potential future risks and strives to meet site RAOs in the quickest timeframe and most aggressive manner.

6. REMEDIAL ALTERNATIVES RETAINED FROM INITIAL SCREENING

The initial screening completed in Section 5 resulted in a series of retained remedial alternatives that represent viable options while preserving the range of containment and treatment alternatives initially developed. For the development and evaluation of remedial alternatives for the Site, the media of concern (soil, sediment, air, leachate, surface water and groundwater) have been organized based on their location (source area or non-source area [e.g. downgradient]). The following areas and associated media have been combined:

- "Source Areas":
  - Landfill lobes – waste, air, leachate, sediment, surface water, and groundwater
  - Former Drum Disposal Area – soil and groundwater
  - Garage and Storage Area – soil
- "Non-Source Areas" (Management of Migration) –groundwater in areas outside of the source areas

Refer to Figures 6-1 (source areas) and 6-2 (downgradient groundwater) for the locations of each of these on-site areas.

Based on the initial screening of alternatives, a total of eleven remedial alternatives, excluding the no action alternative for each area, were retained for further evaluation in the detailed analysis. A summary of the alternatives retained from the initial screening is provided in Table 6-1. A summary description of each of the retained alternatives for each area (Landfill Lobes, FDDA, Garage and Storage Area, "non-source" downgradient groundwater) is presented in the following sections.

Further definition of each retained alternative, including volumes or areas of impacted media to be addressed, the specific technologies to be used, and any performance requirements associated with those technologies is provided in the detailed analysis in Section 8.

6.1 NO ACTION ALTERNATIVE

The No Action alternative was retained for all on-site source areas (landfills, FDDA, garage and storage area) and non-source areas (management of migration). The No Action alternative was developed and screened for baseline comparison purposes in accordance with the NCP. The No Action alternative developed in the FS indicates that no remedial response actions will be performed at the Site. This alternative is proposed to identify concerns posed by the Site if no remedial actions are implemented. Existing control measures, such as the soil layer covering the landfill waste, would not be maintained or improved. Only annual site inspections and five-year reviews of site conditions are proposed as part of this alternative. No active remedial measures are proposed to limit human or ecological exposure to site contaminants associated with the landfill, FDDA soil, wetland sediment, and/or groundwater, or to reduce contaminant mass, toxicity, or mobility.

6.2 LANDFILL LOBES

As indicated on Table 5-1b, seven alternatives were developed and screened with three alternatives, aside from the No Action alternative, being retained for the detailed analysis. Each of the alternatives incorporates

capping the landfill with passive venting (with active system laterals designed and installed) and leachate monitoring and/or passive/active recovery. A discussion on the type of low permeability cap for each lobe is discussed in further detail in Section 8. The remaining components of the landfill alternatives address the management of impacted sediments in Sutton Brook as well as the options for impacted groundwater. The alternatives for the impacted sediments include either excavating and restoring the impacted areas or re-routing the brook (with hot spot excavation). For remedial alternatives that incorporate excavation with disposal, selection of the disposal option (on-site or off-site) will be influenced by the type, nature, and concentrations of contaminants present; further details are provided in Section 8.

The remedial options for landfill leachate were evaluated separately in the initial screening of general response actions, remedial technologies and process options. At the end of the initial evaluation, the leachate and groundwater options were combined given that the technologies to address them are similar and to prevent duplicity in the overall landfill area evaluation.

Impacted groundwater is addressed through containment and treatment technologies, either through containment of groundwater with a vertical barrier along a portion of the Southern lobe to eliminate future impacts to the brook (with groundwater remediation) or through hydraulic containment of groundwater with extraction and ex-situ treatment. The partial containment of groundwater option would utilize a vertical containment barrier that would be installed the length of the impacted portion of Sutton Brook along the Southern landfill lobe (south side of brook). By partial containment, this means prevention of groundwater flow and subsequent potential contamination of Sutton Brook from the Southern landfill lobe. This technology does not provide for 'full containment' around the entire Southern landfill lobe, as it still allows groundwater to flow to the downgradient wetlands and along the barrier. As a result, additional groundwater remediation measures (i.e. in-situ technologies, groundwater extraction and ex-situ treatment, etc.) and naturally occurring attenuation processes are included in conjunction with the 'partial containment' (i.e., impermeable vertical barrier) to meet the site RAOs. Further details on the groundwater components are provided in Section 8.6.

A summary of each of the landfill lobe alternatives is summarized below.

Alternative LF-2 - Containment of waste, vent landfill gas, restoration of wetlands and brook, partial containment of groundwater with a vertical barrier and groundwater remediation

This approach provides containment of the waste, restoration of the impacted sediment in brook, containment of the groundwater to prevent re-contaminating the brook, and either a phased approach to remediate impacted groundwater through naturally occurring attenuation processes with or without enhancements (LF-2a) or implementing an enhanced in-situ remedial technology in this area and/or extracting low volume of groundwater at the end of a containment barrier (LF-2b). In addition, through capping the landfill lobes, the generation and migration of landfill leachate and further impacts to groundwater will be reduced.

Alternative LF - 3 - Containment of waste, vent landfill gas, restoration of wetlands and brook, and contaminated groundwater collection and treatment

This approach provides containment of the waste and source reduction of the remaining media of concern. In addition, through capping the landfill lobes, the generation and migration of landfill leachate and further impacts to groundwater will be reduced. This alternative is the most aggressive alternative to meet regulatory requirements, focusing on reaching the groundwater remedial goals as quickly as practicable.

Alternative LF - 4 - Containment of waste, vent landfill gas, re-routing of the brook, excavation of impacted sediment hot spots, partial containment of groundwater (vertical barrier) with groundwater remediation.

This approach provides containment of the waste and elimination of the current and future risks associated with the brook and surface water. This alternative seeks to re-route the brook along the southern edge of the Southern lobe, preventing the further migration and impacts to the current brook from the landfill waste. In addition, through capping the landfill lobes, the generation and migration of landfill leachate and further impacts to groundwater will be reduced. Containment of the Southern lobe groundwater along the newly re-routed brook may be required to prevent any future impacts to the newly-routed brook and/or surface water. To address the impacted groundwater, implementing an enhanced in-situ remedial technology at the end of the barrier and/or extracting low volume of groundwater at the end of the containment barrier will be implemented.

This alternative will include major modification of the hydrologic and hydrogeological flow regime in the area and the associated effects on contaminant migration. Currently, the hydrogeological flow patterns combined with the natural attenuation processes are containing the impacted groundwater on-site. The permitting requirements for this alternative that must be substantially complied with are extensive and may present potential issues (i.e. recreating 100-year flood plain). Further discussion is provided in Section 8.

6.3 FORMER DRUM DISPOSAL AREA

As summarized on Table 5-2b, nine alternatives were developed and four alternatives, aside from the No Action alternative, were retained for the former drum disposal source area (FDDA). Each of these alternatives is summarized below.

Alternative FDDA - 2 - Containment of soil (with cap) and groundwater (through extraction and ex-situ treatment)

This approach provides full containment of impacted soil and groundwater through engineered barriers and groundwater extraction. Combined with institutional controls restricting use, this alternative controls the human health and ecological risks to acceptable levels. This alternative limits access to the impacted media and reduces the potential for future downgradient migration. Although this is an active approach, reducing contaminant mass though groundwater extraction and treatment, it does not provide an expedited timeframe to reach RAOs since the source material is left in place.

Alternative FDDA -3 – Excavation, treatment and/or disposal of soil with hydraulic containment of groundwater (through extraction and ex-situ treatment)

This approach provides source removal via soil excavation to eliminate exposure to this media by receptors. Removal of the remaining source material will eliminate future leaching into groundwater and expedite the timeframe to meet groundwater RAOs. Depending on the concentrations present in the excavated soil, the material may be treated prior to disposal.

Upon removal of the impacted soil, groundwater will be hydraulically contained to prevent the downgradient migration of the impacted plume through groundwater extraction and treatment, thereby eliminating the risk of human consumption and the potential for downgradient migration.

Alternative FDDA - 4 – Excavation, treatment and/or disposal of soil with groundwater remediation (focused mass reduction)

Similar to the previous approach, this alternative provides source removal via excavation to eliminate exposure to the impacted soil. Removal of the remaining source material will eliminate future leaching into groundwater and expedite the timeframe to meet groundwater RAOs. Depending on the concentrations present in the excavated soil, the material may be treated prior to disposal.

Upon removal of the impacted soil, groundwater will be remediated through a phased approach initiating with naturally occurring attenuation processes. Based on the monitoring results, in-situ methods (enhanced biodegradation, and/or chemical oxidation) or a focused extraction with ex-situ treatment may be implemented. Through institutional controls and these measures to remediate the impacted groundwater, the risk of human consumption and the potential for downgradient migration will be eliminated.

Alternative FDDA - 5 – Excavation, treatment and/or disposal of soil with groundwater extraction and ex-situ treatment for area-wide contaminant reduction

This approach provides source removal via excavation to eliminate exposure by receptors to the impacted media. Removal of the remaining source material will eliminate future leaching into groundwater and expedite the timeframe to meet groundwater RAOs. Depending on the concentrations present in the excavated soil, the material may be treated prior to disposal.

In addition to removing the source material, groundwater extraction and ex-situ treatment will be implemented for an aggressive approach to meet RAOs in an accelerated timeframe, targeting contaminant reduction across the FDDA.

6.4 GARAGE AND STORAGE AREA

In addition to the no action alternative, one additional alternative was retained to address the impacted soil at the garage and storage area. This additional alternative (GSA-2) provides source removal via soil excavation and disposal, thereby quickly and effectively eliminating the on-site risks.

6.5 DOWNGRADIENT GROUNDWATER

For the purposes of this FS, downgradient groundwater refers to the area of groundwater hydraulically downgradient of the landfill lobes and FDDA and in which concentrations of constituents have been detected in excess of PRGs. This area is depicted on 6-2.

As indicated on Table 5-4b, three alternatives, aside from the no action alternative, were retained to address impacted groundwater downgradient of the source areas. A phased approach towards the downgradient groundwater remedy initiating with naturally occurring attenuation processes has been incorporated to evaluate conditions after source control implementation (i.e., landfill closure, excavation of impacted soils from the FDDA, etc.) to determine the effects of the source control alternatives on the groundwater flow, distribution, and migration processes prior to the implementation of the groundwater components of the remedy. Further details on the phased groundwater approach are provided in Section 8.

Each of these alternatives is summarized below.

Alternative DGGW-2 - In-situ remediation

Site data has demonstrated that impacted downgradient groundwater is being reduced on-site through a variety of in-situ natural attenuation processes (see Section 7.2.1 for additional details). This alternative focuses on utilizing these existing natural attenuation processes to address downgradient groundwater. A phased approach to implementing enhanced treatment technologies based on monitoring results is also included in this alternative. In addition, through institutional controls and containment, the risk of human consumption of the impacted groundwater is eliminated.

Alternative DGGW-3 - Groundwater Containment and Treatment

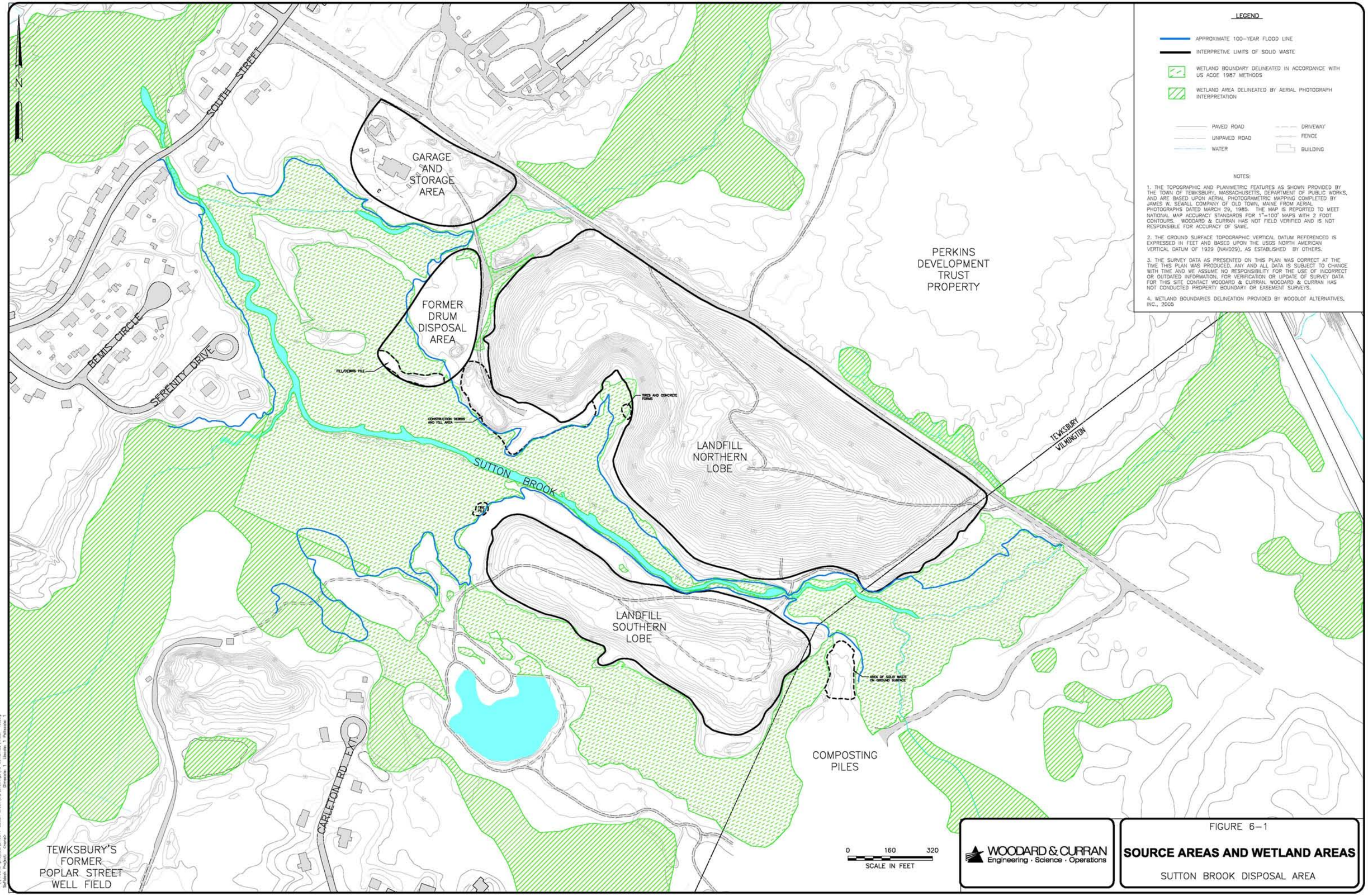
This alternative presents a containment approach that minimizes the potential of downgradient migration of impacted groundwater. Through institutional controls and containment, the risk of human consumption of the impacted groundwater is eliminated. Implementation of this alternative would immediately reduce these risks; however, a lengthier timeframe (than extraction of entire plume – DGGW-4) is anticipated to meet MCLs.

Alternative DGGW-4 - Groundwater extraction and ex-situ treatment for area-wide contaminant reduction

This alternative is an aggressive approach that seeks contaminant mass reduction through groundwater extraction and ex-situ treatment. Through institutional controls and groundwater extraction and treatment, the risk of human consumption and the potential for downgradient migration is minimized. Based on model estimates, this alternative may meet RAOs in a shorter timeframe than the other DGGW alternatives. However, extraction and treatment of an extensive volume of groundwater will be required to meet the site remedial goals.

TABLE 6-1
SUMMARY OF REMEDIAL ALTERNATIVE RETAINED FROM THE INITIAL SCREENING
Remedial Investigation and Feasibility Study
Sutton Brook Disposal Area Superfund Site - Tewksbury, MA

REMEDIAL ALTERNATIVE		APPROACH FOR MEDIA					
		WASTE	LEACHATE	AIR	SOIL	SEDIMENT AND SURFACE WATER	GROUNDWATER
LANDFILL LOBES							
LF-1	No Action	- No Action	- No Action	- No Action	--	- No Action	- No Action
LF-2	Containment of waste, vent landfill gas, restoration of wetlands and brook, partial containment of groundwater with a vertical barrier and groundwater remediation	- Institutional Controls - Containment of waste with low permeability cap	- Long term monitoring and/or passive/active recovery (selection to be determined during remedy design phase).	- Passive vent system (with active collection laterals designed and installed for potential future use)	--	- Excavation of impacted sediment and restoration of brook	- Institutional Controls - Post landfill closure groundwater monitoring - Partial containment of groundwater with barrier - Groundwater remediation at downgradient end of containment barrier through naturally occurring attenuation mechanisms, in-situ methods, or low volume extraction and ex-situ methods
LF-3	Containment of waste, vent landfill gas, restoration of wetlands and brook, and contaminated groundwater collection and treatment	- Institutional Controls - Containment of waste with low permeability cap	- Long term monitoring and/or passive/active recovery (selection to be determined during remedy design phase).	- Passive vent system (with active collection laterals designed and installed for potential future use)	--	- Excavation of impacted sediment and restoration of brook	- Institutional Controls - Post landfill closure groundwater monitoring - Contaminant mass reduction with extraction and ex-situ treatment
LF-4	Containment of waste, vent landfill gas, re-routing of the brook, excavation of impacted sediment hot spots, partial containment of groundwater (vertical barrier) with groundwater remediation	- Institutional Controls - Containment of waste with low permeability cap	- Long term monitoring and/or passive/active recovery (selection to be determined during remedy design phase).	- Passive vent system (with active collection laterals designed and installed for potential future use)	--	- Excavation of sediment hot spot areas, re-route brook to the south of the southern landfill lobe, and contain sediments in between lobes.	- Institutional Controls - Post landfill closure groundwater monitoring - Partial containment of groundwater with barrier - Groundwater remediation at downgradient end of containment barrier through naturally occurring attenuation mechanisms, in-situ methods, or low volume extraction and ex-situ methods
FORMER DRUM DISPOSAL AREA							
FDDA-1	No Action	--	--	--	- No Action	--	-No Action
FDDA-2	Containment of soil (with cap) and hydraulic containment of groundwater (through extraction and ex-situ treatment)	--	--	--	- Institutional Controls - Low Permeability Cap	--	- Institutional Controls - Hydraulic containment of groundwater through extraction, ex-situ treatment and discharge - Long-term groundwater monitoring
FDDA-3	Excavation, treatment and/or disposal of soil with hydraulic containment of groundwater (through extraction and ex-situ treatment)	--	--	--	- Excavation with or without treatment, and disposal	--	- Institutional Controls - Hydraulic containment of groundwater through extraction, ex-situ treatment and discharge - Long-term Groundwater Monitoring
FDDA-4	Excavation, treatment and/or disposal of soil with source area groundwater remediation (focused mass reduction)	--	--	--	- Excavation with or without treatment, and disposal	--	- Institutional Controls - Contaminant mass reduction in source area groundwater through in-situ or extraction and ex-situ methods - Long-term Groundwater Monitoring
FDDA-5	Excavation, treatment and/or disposal of soil with groundwater extraction and ex-situ treatment for area-wide contaminant reduction.	--	--	--	- Excavation with or without treatment, and disposal	--	- Institutional Controls - Groundwater treatment through extraction and ex-situ treatment (groundwater restoration) - Long-term groundwater monitoring
GARAGE AND STORAGE AREA							
GSA-1	No Action	--	--	--	- No action	--	--
GSA-2	Excavation with Treatment and/or Disposal of Soil	--	--	--	- Excavation with or without ex-situ treatment, and disposal	--	--
DOWNGRADIENT GROUNDWATER							
DGGW-1	No Action	--	--	--	--	--	- No Action
DGGW-2	In-situ Remediation	--	--	--	--	--	- Institutional Controls - In-situ Remediation through naturally occurring attenuation mechanisms and/or enhanced in situ methods
DGGW-3	Hydraulic Containment through Groundwater Extraction, Treatment and Discharge	--	--	--	--	--	- Institutional Controls - Hydraulic containment through groundwater extraction and ex-situ treatment - Long-term groundwater monitoring
DGGW-4	Groundwater Extraction and Ex-situ Treatment for Area-wide Contaminant Reduction	--	--	--	--	--	- Institutional Controls - Contaminant mass reduction through groundwater extraction and ex-situ treatment - Long-term groundwater monitoring


LEGEND
APPROXIMATE 100-YEAR FLOOD LINE
INTERPRETIVE LIMITS OF SOLID WASTE
WETLAND BOUNDARY DELINEATED IN ACCORDANCE WITH US ACOE 1987 METHODS
WETLAND AREA DELINEATED BY AERIAL PHOTOGRAPH INTERPRETATION
PAVED ROAD
UNPAVED ROAD
WATER
DRIVEWAY
FENCE
BUILDING
NOTES:
1. THE TOPOGRAPHIC AND PLANIMETRIC FEATURES AS SHOWN PROVIDED BY THE TOWN OF TEWKSBURY, MASSACHUSETTS, DEPARTMENT OF PUBLIC WORKS, AND ARE BASED UPON AERIAL PHOTOGRAMETRIC MAPPING COMPLETED BY JAMES W. SEWALL COMPANY OF OLD TOWN, MAINE FROM AERIAL PHOTOGRAPHS DATED MARCH 29, 1985. THE MAP IS REPORTED TO MEET NATIONAL MAP ACCURACY STANDARDS FOR 1"=100' MAPS WITH 2 FOOT CONTOURS. WOODARD & CURRAN HAS NOT FIELD VERIFIED AND IS NOT RESPONSIBLE FOR ACCURACY OF SAME.
2. THE GROUND SURFACE TOPOGRAPHIC VERTICAL DATUM REFERENCED IS EXPRESSED IN FEET AND BASED UPON THE USGS NORTH AMERICAN VERTICAL DATUM OF 1929 (NAVD29), AS ESTABLISHED BY OTHERS.
3. THE SURVEY DATA AS PRESENTED ON THIS PLAN WAS CORRECT AT THE TIME THIS PLAN WAS PRODUCED. ANY AND ALL DATA IS SUBJECT TO CHANGE WITH TIME AND WE ASSUME NO RESPONSIBILITY FOR THE USE OF INCORRECT OR OUTDATED INFORMATION. FOR VERIFICATION OR UPDATE OF SURVEY DATA FOR THIS SITE CONTACT WOODARD & CURRAN. WOODARD & CURRAN HAS NOT CONDUCTED PROPERTY BOUNDARY OR EASEMENT SURVEYS.
4. WETLAND BOUNDARIES DELINEATION PROVIDED BY WOODLOT ALTERNATIVES, INC., 2005
N
SOUTH STREET
GARAGE AND STORAGE AREA
FORMER DRUM DISPOSAL AREA
PERKINS DEVELOPMENT TRUST PROPERTY
BEMIS CIRCLE
SERENITY DRIVE
FILL/DEBRIS PILE
TIRES AND CONCRETE FORMS
CONSTRUCTION DEBRIS AND FILL AREA
LANDFILL NORTHERN LOBE
SUTTON BROOK
TEWKSBURY
WILMINGTON
LANDFILL SOUTHERN LOBE
AREA OF SOLID WASTE ON-GROUND SURFACE
COMPOSTING PILES
CARLETON RD. EXT.
TEWKSBURY'S FORMER POPLAR STREET WELL FIELD
0 160 320
SCALE IN FEET
WOODARD & CURRAN
Engineering · Science · Operations
FIGURE 6-1
SOURCE AREAS AND WETLAND AREAS
SUTTON BROOK DISPOSAL AREA

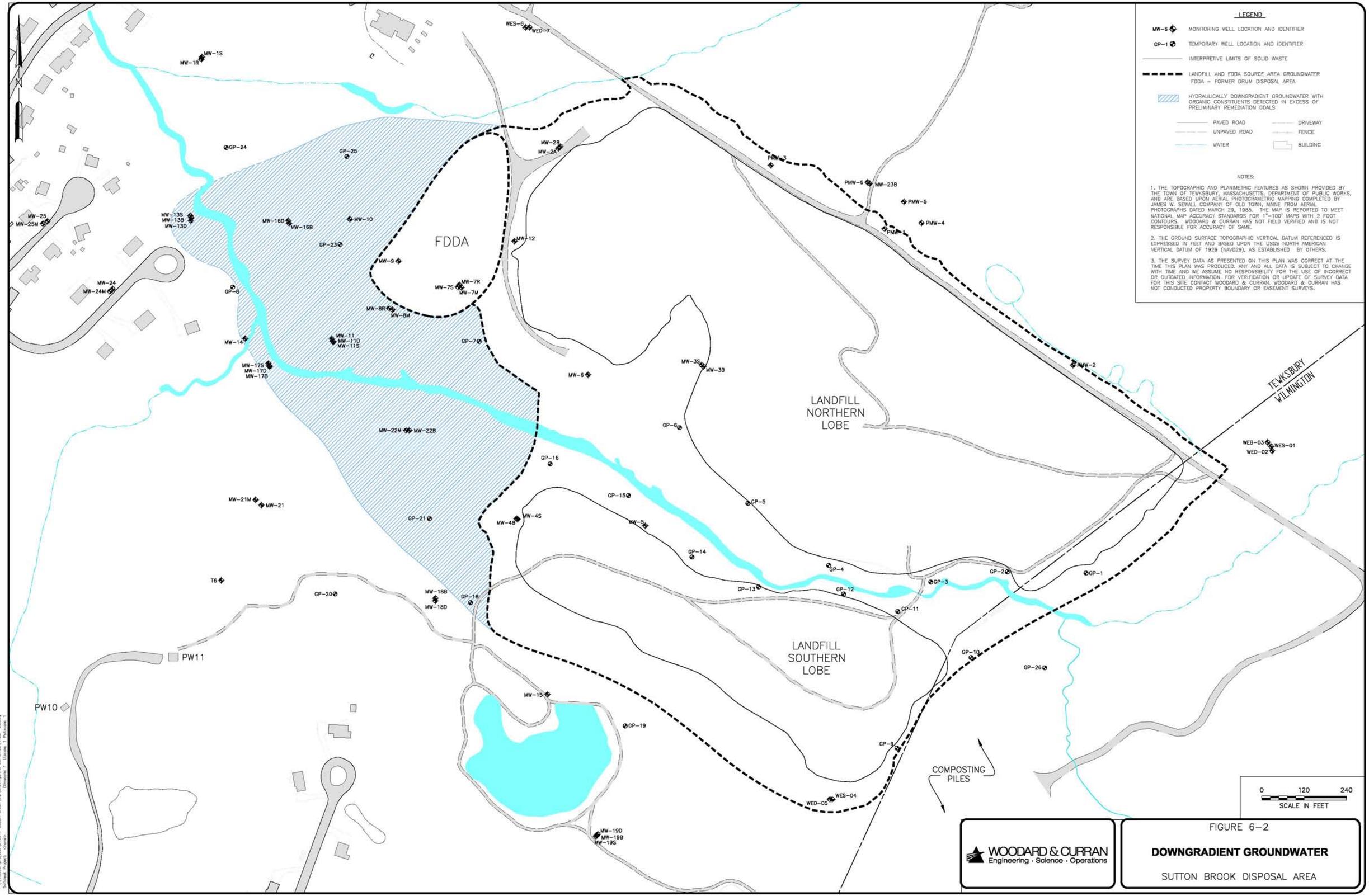


FIGURE 6-2

DOWNGRADIENT GROUNDWATER

SUTTON BROOK DISPOSAL AREA

7. SUPPLEMENTAL INVESTIGATION AND ASSESSMENT

The following sections summarize the supplemental investigation and assessment activities performed to aid in the detailed analysis of remedial alternatives for the Site. These investigations and assessment activities included collection and analysis of soil gas and groundwater. Further details are provided in the sections below.

7.1 SUPPLEMENTAL LANDFILL GAS EVALUATION

As part of the detailed analysis of the FS, further evaluation of landfill gas generation and migration was conducted to determine if passive venting or an active landfill gas collection system would be required in the selected remedial alternative. This evaluation included: 1.) evaluating if an active landfill gas collection and/or treatment is required with respect to landfill gas generation due to the volume and age of the waste; and 2.) screening the northern perimeter of the Northern lobe for landfill gases to evaluate migration potential at the property line. A discussion of these two evaluations is presented below.

7.1.1 Landfill Gas Generation

The criteria for installation of an active landfill gas collection and control system under the federal regulations (Clean Air Act) for landfill gas emissions, known as the New Source Performance Standards (NSPS) or Emission Guidelines (EG) for municipal solid waste landfills was reviewed to determine if active landfill gas collection and control should be incorporated into the alternatives evaluation. These regulations, described in 40 CFR Part 60, Subparts CC and WWW, were first promulgated on March 12, 1996.

The first criteria states that landfills with a maximum design capacity of less than 2.5 million megagrams (Mg), or 2.5 million cubic meters of solid waste are only required to submit a design capacity report to the implementing agency and are not subject to the NSPS requirements. The second criteria states that if the maximum design capacity is equal to or greater than 2.5 million Mg or 2.5 million cubic meters of solid waste, an evaluation of the yearly emission rate of the non-methane organic compounds (NMOC) is required. Active landfill gas collection and treatment systems are required at landfills with NMOC emission rates determined to be greater than 50 Mg/yr.

The limits of the solid waste areas, determined from the test pit excavations, soil borings, and site reconnaissance activities performed during the RI, are shown on Figure 2-3. To approximate a volume of waste in the two landfill lobes, the following assumptions were applied:

- The bottom of the waste is at or near the water table surface (prior to the landfill the ground surface in the area of the landfill was wetland/swamp deposits);
- The height (or length in the volume equation) of the waste was estimated as the ground surface elevation minus the top of the water table elevation; and
- The area of the landfill as determined by the test pit excavations as part of the RI was 30 acres for the Northern lobe and 10 acres for the Southern lobe.

Based on these assumptions, the gross volume of material (solid waste and cover soil) is estimated at 1.9 million cubic yards (870,000 Mg to 1,450,000 Mg) for the Northern lobe and 0.3 million cubic yards (140,000 Mg to 230,000 Mg) for the Southern lobe for a total of 2.2 million cubic yards (1 to 1.7 million Mg) of material present on-site.

Based on this estimate, the mass of solid waste in each lobe and the total on-site is less than the 2.5 million Mg threshold that would require an evaluation of the NMOC emission rate. Therefore, the NSPS do not apply and an active landfill gas control system is not required based on these regulations.

7.1.2 Landfill Gas Migration Potential

With the presence of wetland resource areas surrounding both landfill lobes along the majority of the waste perimeter and with the data collected in these wetland regions indicating that landfill gas is not migrating through them (e.g., groundwater monitored well headspace readings), the northern edge of the Northern landfill lobe (along the dirt access road to the composting facility and farm) was identified as the only property line perimeter requiring additional evaluation for potential migration pathways.

In accordance with the MassDEP landfill technical guidance, and given that the adjacent properties to the north of the Northern landfill lobe are currently undeveloped, soil gas points were installed approximately 650 linear feet away from one another along or near the property line to assess landfill gas generation and migration in this direction. Three temporary soil gas probes were installed along the northern edge of the Northern landfill lobe. The location of these probes was limited due to the location of the landfill waste in proximity to the edge of this property line; therefore, the soil gas probes were installed outside the edge of waste (less than 100 feet away from the waste). The three soil gas probes, SG-6, SG-7, and SG-8 were installed on December 11, 2006 to a depth of 7 feet, 5 feet, and 5 feet below ground surface (bgs), respectively. Refer to Figure 7-1 for the location of the soil gas points.

Each point was installed using a rotary hammer drill equipped with a hollow-stem auger. SG-6 (installed to 7 feet bgs) was constructed with ¾" PVC slotted screen extending from the bottom of the well to a depth of approximately 2 feet bgs with PVC riser extending approximately 3 feet above the ground surface. SG-7 and SG-8 (each installed to 5 feet bgs) were constructed with ¾" PVC slotted screen extending from the bottom of the well to approximately 1 foot bgs, and with PVC riser extending approximately 4 feet above the ground surface. Clean filter sand was placed within the annular space surrounding the screen section and a one foot bentonite seal was placed around the riser section between 0 to 2 feet bgs. The probes were finished with a PVC barbed-fitting and a cap to allow the standing air accumulated in the probes to be monitored and screened without losses to the atmosphere. A protective casing (1½" black steel pipe) was installed over the PVC to prevent damage to the probes.

The newly installed soil gas probes (SG-6, SG-7, and SG-8) and existing monitoring wells PMW-1, PMW-2, PMW-3, and/or PMW-6 were monitored for methane (%volume and %LEL), hydrogen sulfide, oxygen, and/or carbon dioxide. Refer to Figure 7-1 for the location of these monitoring points.

A CES-Landtec GEM2000 landfill gas monitor, calibrated to measure the parameters listed above, was used to perform the gas monitoring at the identified locations over selected time intervals. Prior to starting the monitoring, the temperature and barometric pressure were recorded. Monitoring of the landfill gas parameters commenced at the start of the well purging and was performed continuously, following the prescribed time intervals: readings were recorded after the first 15 and 30 seconds and then after each 30 seconds for a total of 5 minutes (300 seconds). In addition to the regularly-timed readings, all observed peaks (within the 30 second intervals) were also recorded. All measurements were recorded on a standard field log used for monitoring the selected parameters over time.

The landfill gas monitoring was performed on December 11, 2006 following the installation of the new soil gas probes, and again on January 22 and 23, 2007, when the ground was frozen and the barometric pressure was dropping (i.e. storm front approaching). This represents maximum potential for landfill gas migration with the landfill gas pressure being greater than atmospheric pressure.

The following table presents the summary of results of the landfill soil monitoring:

Sample Location	Date	Methane (% vol)	Methane (LEL%)	H_2S (ppm)	O_2 (%)	CO_2 (%)
SG-6	12/11/06	0.0	0	--	20.6	0.1
	1/22/07	41.4	>100	12	0.0	30.4
	1/23/07	50.6	>100	12	0.0	31.6
SG-7	12/11/06	0.1	1	--	20.5	0.1
	1/22/07	0.4	9	0	8.2	4.1
	1/23/07	1.0	20	0	8.6	4.9
SG-8	12/11/06	0.0	0	--	20.3	0.1
	1/22/07	0.1	1	0	22.7	0.1
	1/23/07*	0.4	9	0	21.5	0.2
PMW-1	11/23/04	0.0	--	0	19.0	0
	12/11/06	0.0	0	--	20.7	0.2
	1/23/07*	0.3	6	0	21.2	1.6
PMW-2	11/23/04	0	--	0	20.3	0
	12/11/06	0.1	1	--	20.4	0.1
	1/23/07	6.5	>100	0	14.2	5.4
PMW-3	11/23/04	0.0	--	0	19.6	0
	12/11/06	0.0	0	--	20.5	0.1
	1/23/07	0.7	13	0	21.4	0.9
PMW-6	11/23/04	0.1	--	0	19.0	0
	1/23/07*	0.2	5	0	21.7	0.2

Notes:

Values entered represent peak values (lowest %oxygen, highest for all other parameters)

There were no detections of explosive gases in soil gas along the property line exceeding 25% of the LEL during the December monitoring event. The soil gas measurements collected on December 11, 2006 showed stable readings for methane, oxygen, and carbon dioxide from each of the six monitoring points (SG-6 through SG-8 and PMW-1 through PMW-3). Though it was only detected intermittently, methane was detected at SG-7 and PMW-2 at 0.1% by volume and at 1% of the LEL. Oxygen and carbon dioxide levels ranged from 20.3 to 20.8% and 0.1 to 0.2%, respectively, comparable to ambient readings of 20.7 to 20.8%, and 0.1%, respectively. Hydrogen sulfide was not recorded during this monitoring event due to equipment malfunction.

Measurements collected on January 22, 2007 were recorded at SG-6, SG-7, and SG-8 under frozen ground and falling barometric pressure conditions. The recorded methane level at SG-6 exceeded 25% of the LEL during this monitoring event. Methane levels at the other two soil gas points were below 25% of the LEL with 9 and 1% of the LEL detected at SG-7 and SG-6, respectively. Levels of oxygen and carbon dioxide recorded in SG-8 were comparable to the measurements collected on December 11, 2006; however, increased carbon dioxide and decreased oxygen levels were recorded at SG-7 and SG-6. Hydrogen sulfide was detected at SG-6 at 12 ppm and non-detect at the other two points.

A second confirmation round of soil gas monitoring was conducted on January 23, 2007 at SG-6 through SG-8, PMW-1 through PMW-3, and PMW-6 under similar conditions as the day before (i.e., frozen ground and reduced barometric pressure). Methane levels at SG-6 and PMW-2 exceeded 25% of the LEL during this monitoring event; all other monitoring locations detected methane at concentrations less than 25% of the LEL, ranging from 0.2 to 1% methane by volume (5 to 20% of the LEL). Concentrations at

PMW-6, located approximately 125 feet to the north from the waste and the other points monitored detected little to no methane (comparable to ambient/background levels). Oxygen and carbon dioxide levels at the four PMW wells ranged from 14.2 to 21.7% oxygen and 0.2 to 1.6% carbon dioxide; hydrogen sulfide measurements were all non-detect. Oxygen, carbon dioxide, and hydrogen sulfide levels measured at SG-6 through SG-8 on January 23 were comparable to those measured the day before.

In summary, landfill gas has been detected along the edge of the Northern lobe waste; however the lateral extent of its migration away from the landfill (to the north) is limited (not present at PMW-6). The two different timeframes of measurements (December 2006 and January 2007) represent a range of conditions, with a higher potential for landfill gas migration demonstrated during the January monitoring events when the ground was frozen and the barometric pressure was dropping.

7.1.3 Landfill Gas Collection System Conclusion

Landfill gas control systems must consider factors such as the location of the Site relative to residences, odor concerns associated with the landfill, the depth to groundwater, the size of the fill, the age of the facility, hydrogeologic conditions, and the potential for gas migration from the site. The evaluation performed as part of the FS has assessed each of these factors in conjunction with the supplemental landfill gas monitoring. Due to the volume of waste in the Southern lobe below the NSPS threshold, combined with the fact that the entire lobe is surrounded by wetlands and/or surface water, subsurface landfill gas migration is not anticipated to be an issue for the Southern Lobe.

With the exception of the northern edge, the waste in the Northern lobe is surrounded by wetlands and/or surface water, preventing the subsurface migration of landfill gas off-site. In conjunction with being below the NSPS threshold in the volume of waste, active collection for the entire landfill is not anticipated to be warranted. However, due to the presence of landfill gas at concentrations exceeding 25% of the LEL at the closest property boundary (which corresponds to the edge of waste), additional monitoring and evaluation along the northern edge of the Northern lobe is anticipated to determine if active or passive venting along the northern portion of the landfill is warranted prior to design of the final cover system.

For the purposes of the FS, it is assumed that passive venting will be installed for both landfill lobes, with active system laterals (piping) designed and installed during the landfill final cover system construction, should active collection be required in the future.

7.2 NATURAL ATTENUATION EVALUATION

During the evaluation of data collected as part of the RI, analytical and geochemical data suggested that natural attenuation processes are degrading and reducing the mass of site contaminants in site groundwater. The natural in-situ attenuation processes that are likely occurring include biodegradation, dispersion, dilution, adsorption, volatilization, and chemical or biological stabilization, transformation, or destruction of contaminants. Supplemental monitoring and evaluation has been performed since the RI, and based on the field and laboratory measurements, it appears that the contaminant mass on-site continues to be reduced via a combination of these natural attenuation processes. Further discussion on the groundwater monitoring activities and the evaluation of natural attenuation processes is presented below.

Groundwater monitoring data has been collected on numerous occasions at the Site since 1995. This data has helped to identify the potential sources of contamination, migration pathways, specific contaminants

of concern (COC), and the nature and extent of those contaminants. In addition, during each monitoring event, data has been collected to aid in the understanding of the hydrologic, hydrogeologic, and geochemical conditions at the Site. Each of these events has contributed to the overall conceptual site model (CSM) presented in the RI.

As part of the RI, a select set of 15 groundwater monitoring wells were sampled for methane, sulfide, sulfite, dissolved organic carbon (DOC) and ferrous iron. The 15 monitoring wells (PMW-1, MW-4S/4B, MW-7S/7M/7R, MW-8M/8R, MW-11S/11, MW-17S/17D/17B, MW-22M, and MW-23B) were selected based on their location within, or hydraulically upgradient of or downgradient of the identified source areas on-site (FDDA and/or the Southern lobe). The analytical parameters were identified specifically to aid in the evaluation of natural attenuation processes that may potentially be occurring in these areas.

In June 2006 (during completion of the pre-ROD quarterly monitoring), supplemental data was collected from 25 groundwater monitoring wells to establish and evaluate trends and the chemical footprint of natural attenuation in these areas. The same monitoring wells that were sampled in November 2004 and March 2005 for the RI (see above), as well as ten additional monitoring wells (MW-5, MW-16D, MW-13S/13D/13B, MW-15, MW-19S/19D, PMW-6, and GP-24), were sampled for methane, ferrous iron, nitrate, sulfate, and total alkalinity. Table 7-1 presents the analytical testing summary, specific to evaluating natural attenuation processes, with the results presented in the RI report. These results have been used in the evaluation presented in the following sections.

Based on the groundwater data collected to date, the following lines of evidence were evaluated to determine if natural attenuation processes are occurring within and downgradient of the source areas:

- Stabilization in concentrations or extent of the contaminant plume;
- Decrease in concentrations or extent of the contaminant plume; and
- Chemical footprints (electron acceptors, metabolic byproducts, etc) demonstrating that intrinsic bioremediation is occurring.

The discussion is divided into VOCs/SVOCs and inorganics (arsenic).

7.2.1 Natural Attenuation Evaluation - VOCs and SVOCs

The discussion of the natural attenuation evaluation has been broken into the following sections, as presented in the following paragraphs:

- Contaminants, Source Areas, and Migration Pathways
- Historic Groundwater Contaminant Data and Trend Analyses
- Hydrogeologic and Geochemical Data
- VOC/ SVOC - Summary

Contaminants, Source Areas, and Migration Pathways

The lines of evidence for natural attenuation were examined based on the two main groundwater source areas on-site: the FDDA and the Southern Lobe. Focus was placed on the site COCs, generally categorized as purgeable aromatic hydrocarbons (including benzene, toluene, ethylbenzene, and xylene (BTEX) and trimethylbenzenes), chlorinated aliphatic hydrocarbons (including 1,1-DCA and TCE) and ketones (primarily, 4-methyl-2-pentanone and 2-butanone). Though occurring at different rates and under

different circumstances, each of these COCs under certain conditions has been reported to undergo attenuation via natural processes, as identified below.

In general, the above compounds are found dissolved in groundwater at the Site. Based on the potentiometric surveys conducted during the RI, the water table surface (i.e., top of the groundwater surface) mimics the natural land surface topography of the area and is influenced mainly by Sutton Brook and also by the streams and wetland areas surrounding Sutton Brook. Groundwater north of the site has been shown to flow southerly towards Sutton Brook or westerly towards the Shawsheen River; groundwater east of the Site, flows westerly or southerly towards Sutton Brook and an un-named tributary; groundwater south of the site flows northerly towards Sutton Brook or the Shawsheen River; and groundwater west of the site flows either northerly toward the Shawsheen River or easterly towards Sutton Brook.

The higher VOC concentrations are detected in the intermediate overburden groundwater. Hydraulic gradients in this zone of the aquifer are relatively flat (0.001 ft/ft range) and when combined with low conductivity, result in a reduced groundwater velocity and subsequently reduced contamination migration rates. Contaminant dissolution, flushing and dispersion processes are also expected to occur at lower rates due to reduced groundwater velocity.

To aid in estimating the rate of contaminant movement, a numerical groundwater model was used to simulate hydrogeologic conditions and the movement of groundwater in the vicinity of the site. The results of the model-simulated groundwater flow directions were generally consistent with groundwater flow directions configured from the groundwater level measurements. Based on the particle tracking analysis performed as part of the model calibration, the simulated discharge locations for particles placed in the source areas were consistent with mapped contaminant locations.

In summary, both the potentiometric surveys and the groundwater model confirm that dissolved VOCs and SVOCs (including purgeable aromatics, chlorinated compounds, and ketones, among others) migrate away from the two main source areas and toward Sutton Brook and the wetland areas surrounding Sutton Brook. In the area of the FDDA, the dissolved contaminants initially migrate in a southwesterly to westerly direction towards Sutton Brook and the associated wetlands. In the area of the Southern lobe, groundwater and the dissolved contaminants (based on concentrations detected in monitoring wells) initially migrate away from the source area in a predominantly northwesterly to northerly direction. Once at the brook and in the area of the wetlands surrounding the brook (downgradient from both source areas), regional groundwater controls the flow regime with groundwater following the brook, in a predominantly northerly flow direction.

Though the dissolved VOC plume predominantly migrates in the horizontal direction, hydraulic data collected at the Site shows that there is also a slight upward component of flow as groundwater approaches the brook/wetlands. Along with the low conductivity and reduced groundwater velocity estimated in the intermediate overburden, the upward component of flow may also have an impact on contaminant transport at the Site since the potential for off-site groundwater transport is further reduced due to groundwater discharge to the brooks/wetlands.

Historic Groundwater Contaminant Data and Trend Analyses

In 2004/2005, as part of the RI, additional monitoring wells were installed to determine the extent of the contaminated groundwater across the Site. Specifically, wells were installed to the west, north, and south of the landfill and source areas. As a result of samples collected from these wells, the limits of the

groundwater plume and the extent of the VOCs/SVOCs in groundwater were determined. Based on follow-up sampling conducted as part of the pre-ROD monitoring phase, the downgradient limits of the plume have remained the same.

As part of the investigation of the Site, groundwater samples have been collected from wells over a ten-year period from 1995-2006. Based on a comparison of these data, the Southern lobe and the FDDA have consistently been identified as the primary source areas for total VOCs. A comparison of the data over time demonstrates that once both plumes reach the general vicinity of the brook/wetlands, the plumes merge and are controlled by regional groundwater flow. This groundwater data suggests that advection, dispersion, and natural degradation/attenuation most likely are the primary characteristics controlling the migration of the dissolved VOC plumes away from the source areas. The dissolved VOC plumes are generally contained within the immediate boundaries of the site, and the concentrations within the plume appear either stable or decreasing (i.e., plume configurations are controlled by groundwater flow, discharge to the brook and associated wetlands, and degradation/attenuation mechanisms).

A statistical analysis of the groundwater data collected at the source areas, and at areas intermediate, and downgradient from those source areas was performed to further evaluate plume stability. Specific wells with numerous data points were selected from each respective area for the analyses. The Mann-Kendall Test was used to examine concentrations of total VOCs at: MW-7M and MW-9 (FDDA source wells); MW-8M and MW-11 (FDDA intermediate/downgradient wells); MW-4S, MW-4B, and MW-5 (Southern lobe source wells); MW-22M (Southern lobe intermediate/ downgradient well); and MW-13D and MW-17D (downgradient perimeter wells). The Mann-Kendall Test worksheets for the wells are provided in Appendix B.

The outcome of the Mann-Kendall analysis demonstrated no significant trends (upwards or downwards) in total VOC concentrations at each of the source area and downgradient wells. Analysis of the concentrations of total VOCs in intermediate/downgradient groundwater well MW-11 resulted in a significant downward trend, while no significant trend was measured in the monitoring wells MW-8M and MW-22M. The statistical analysis of total VOC trend data demonstrates that overall, within and downgradient of the source areas, concentrations are remaining stable and/or decreasing.

To further evaluate contaminant concentrations associated with the predominant categories of VOCs and SVOCs detected within the overall plumes, those compounds detected at the highest frequency and concentrations were evaluated based on available data collected from 1999-2001, 2004-2005, and 2006. This data evaluation was completed for the FDDA and the Southern lobe and presented as Figures 7-2 and 7-3, respectively. As stated on these figures, the wells utilized to create them included:

FDDA

Source – MW-7M and MW-9

Intermediate – MW-8M and MW-11

Downgradient – MW-13D, MW-14, MW-16D, MW-17D, and GP-24

Southern Lobe

Source – MW-4S and MW-5

Intermediate – MW-22M

Downgradient – MW-13D, MW-14, MW-16D, MW-17D, and GP-24

The grouping of compounds included:

1,4-Dioxane

Tetrahydrofuran (THF)

Ketones –

2-Butanone and 4,Methyl-2-pentanone

Purgeable Aromatics –

1,2,4-Trimethylbenzene, 1,3,5-Trimethylbenzene, Benzene, Ethylbenzene, Toluene, Xylenes, n-Butylbenzene, and n-Propylbenzene

CVOCs –

1,1,1-Trichloroethane, 1,1,2-Trichloroethane, 1,1-Dichloroethane, 1,1-Dichloroethene, 1,2-Dichloroethane, 1,2-Dichloroethene (Total), 1,2-Dichloropropane, Chloroethane, cis-1,2-Dichloroethene, Tetrachloroethene, Trichloroethene, and Vinyl chloride

SVOCs –

2,4-Dimethylphenol, 2-Methylphenol, 3-Methylphenol/4-Methylphenol, 4-Methylphenol, Bis(2-Ethylhexyl)phthalate, Diethyl phthalate, Dimethyl phthalate, Di-n-butylphthalate, Naphthalene, and Phenol

The process used to create these figures included the following steps:

1. For each well in the selected grouping (source, intermediate, downgradient) during the sampling event in the selected timeframe, the total concentration of each category of compounds was calculated (e.g. total of all detected SVOCs or CVOCs, etc.).
2. The maximum total concentration at each well during that time period (1999-2001, 2004-2005, 2006) was determined.
3. The maximum concentration from Step 2 for each grouping (source, intermediate and downgradient wells) was then averaged and presented on the chart.

Features that can be seen in this analysis include:

- The highest concentrations of VOCs are detected in the source areas, with ketones comprising the majority of the total VOC contaminant mass;

- Although there is some variability between compounds, overall each contaminant plume area (source, intermediate and downgradient) reveals an overall decrease over time. No general patterns of increasing concentrations of dissolved VOCs (or SVOCs) were observed over the approximate 10-year period in each area; however, concentrations of tetrahydrofuran and CVOCs within the Southern lobe source area wells (MW-4S and MW-5) have shown some fluctuation over time. Through statistical analysis (Mann-Kendall Test) of these compounds, it was determined that the detected increase in concentration does not represent a statistically significant upward trend and may instead be a result of seasonal variation, etc.

- Each contaminant plume demonstrates overall lower concentrations of VOCs as the plume migrates further from the source areas; however, the distribution of contaminant and concentration changes with distance from the source areas. The further downgradient locations detected higher concentrations of more soluble, mobile and harder to degrade contaminants (1,4 dioxane and/or chlorinated VOCs), whereas ketones and purgeable aromatics, which were the

predominant VOCs detected near the source areas are reduced to non-detect levels in the downgradient wells.

- In the FDDA, at each separate monitoring period (1999-2001, 2004-2005, and 2006) there is a significant reduction of purgeable aromatic hydrocarbons and ketones observed as the plume migrates into the downgradient intermediate area.

The results of the Mann-Kendall Tests, along with the contaminant specific observations identified in the respective source, intermediate, and downgradient areas, and the extent of the total VOC plume, support that the edge of the contaminant plume, as well as the overall configuration of the plume at the Site, appears to be stable, with minimal variation over time and that the concentrations within the plume appear to be stable or decreasing with time.

Hydrogeologic and Geochemical Data

In addition to the above-mentioned contaminant trends, which show a decrease in the contaminant plume and mass on the site, the site hydrogeologic and geochemical data support that the appropriate conditions exist for natural attenuation processes to take place within and downgradient of the source areas. The attenuation processes that are occurring in this area likely include dispersion, dilution, sorption, volatilization, biodegradation, and chemical or biological stabilization, transformation, or destruction. The occurrence of these processes is based on field and laboratory measurements specific to each process, as follows.

Dispersion and Dilution

Dissolved organic compounds can be spread by dispersion over a greater volume of the aquifer than what would be predicted solely from advection. This effect causes a decrease in the compound concentrations within the groundwater due to the mixing with “clean” groundwater (i.e., non-detectable levels of plume constituents); hence dispersion is a mechanism for dilution. Dispersion is also a key process in determining the fate of the dissolved VOCs at the site due primarily to regional groundwater flow patterns. Based on the potentiometric surveys conducted at the site, additional flow patterns from the western and eastern directions (off-site “clean” water) are migrating with the contaminant plumes from the source areas, contributing to overall dispersion and dilution.

Sorption

Evaluating the sorption (adsorption or absorption) of organic chemicals to soil is essential for determining the fate of organic chemicals, their potential adverse impacts on the environment, and for the assessment of remedial response alternatives for conducting site remediation. If an organic chemical is extensively sorbed by soil particles, it will generally not migrate with groundwater. If the chemical is weakly sorbed to the soil, it may have a greater tendency to migrate with groundwater than sorb to soil.

The degree of sorption not only affects the chemical's mobility but other transport mechanisms and transformation reactions (i.e., rates of volatilization, photolysis, hydrolysis, biodegradation, etc.). The extent to which an organic chemical is sorbed is determined by the chemical’s structure and the soil's physical and chemical characteristics. In determining the mobility of a chemical species in soil, a sorption coefficient is usually determined. For most organic compounds, the log octanol/water partition coefficient [log (K_{ow})] and log soil/sediment partition coefficient [log(K_{oc})] may be used as an indication of the mobility of a chemical species.

The log (K_{ow}) values of the predominant VOCs detected in groundwater range from -0.27 (1,4-dioxane) to 3.28 (m-xylene). As indicated, the low log (K_{ow}) values (generally less than 3) indicate that the predominant VOCs (with the exception of xylenes and ethylbenzene) will have a greater tendency to dissolve in water than to be sorbed to soils.

In addition to the (K_{ow}) and (K_{oc}) values, sorption to soil is also a function of the surface area of the soil particle, as well as the size, shape, and surface area of the sorbing molecule. For example, the finer the soils (i.e., greater percentage of silts and clays), the greater the surface area and thus the greater tendency for compounds to sorb to these soils. The higher concentrations of contaminants were detected in the intermediate overburden which is comprised of a higher percentage of these finer-grained materials than encountered at the water table.

In summary, the predominant VOCs detected in groundwater at the site have low log (K_{ow}) and log (K_{oc}) values and are expected to be highly to moderately soluble, mobile in water, and would have little tendency to sorb onto soil particles (except in areas of finer grained soils where the sorption rate may be controlled by surface area and grain size).

Volatilization

The extent to which an organic chemical can volatilize from the soil and water phases depends on its vapor pressure, aqueous solubility, and diffusion coefficient. For estimating releases from water to air, the Henry's Law constant, which is the partition coefficient that expresses the ratio of the chemical concentrations between air and water at equilibrium, is more appropriate than vapor pressure. Organic compounds with Henry's Law constants in the range of 10^{-3} atmospheres-cubic meter per mole (atm-m^3/mole) and larger can be expected to volatilize readily from water; those values ranging between 10^{-3} to 10^{-5} atm-m^3/mole are associated with significant, but lesser volatilization, while compounds with values less than 10^{-5} atm-m^3/mole volatilize from water only to a limited extent.

The Henry's Law Constant of the predominant VOCs detected in groundwater at the site range from 4.8×10^{-6} (1,4-dioxane) to 3.61×10^{-3} atm-m^3/mole (p-xylene). Based on their Henry's Law Constant values, several of the primary VOCs dissolved in groundwater have a Henry's Law Constant between 10^{-3} and 10^{-5} atm-m^3/mole and would be expected to volatilize to some extent from shallow groundwater. With the exception of 1,4-dioxane and THF, which have constants of greater than 10^{-5} and are expected to volatize only to a limited extent, volatilization has the potential to play a role in mass reduction on-site, especially considering the slight upward component of flow measured in the areas of the brook and the wetlands.

Biodegradation (and Chemical/Biological Stabilization, Transformation, or Destruction)

Biodegradation (also, chemical/biological stabilization, transformation, or destruction) of organic compounds is often one of the more important fate processes resulting in their removal from a subsurface environment. Microbes gain energy by promoting chemical oxidation, hydrolysis, or substitution reactions in the organic compound. The resulting product is generally more water soluble and often more readily degraded than the parent compound.

The primary environment for biological degradation is in groundwater, because it provides a transport media for the microbes and the chemicals, which act as their energy source, to come into contact. Microbial activity can be aerobic (requiring oxygen) or anaerobic (occurring in the absence of oxygen). Aerobic degradation in the subsurface is often limited by the availability of oxygen to the microbes.

Thus, compounds which otherwise might readily biodegrade can persist in the environment due to limits on oxygen transfer. However, in the absence of an oxygen-rich environment, other naturally occurring chemicals can be substituted as electron acceptors during biodegradation. Further discussion on the potential biodegradation processes occurring on-site and their reaction footprints are provided below.

Electron Acceptors - Oxygen, Nitrate and Sulfate

A review of the electron acceptors found in groundwater at the site, both within and downgradient of the FDDA and Southern lobe, was performed to assess the geochemical environment present in the area (and therefore the potential for biological degradation). The presence or absence of electron acceptors (oxygen, nitrate and sulfate) provides a potential footprint of microbial degradation. The disappearance of these acceptors in conjunction with a decrease in contaminants may indicate that each has been consumed through degradation processes.

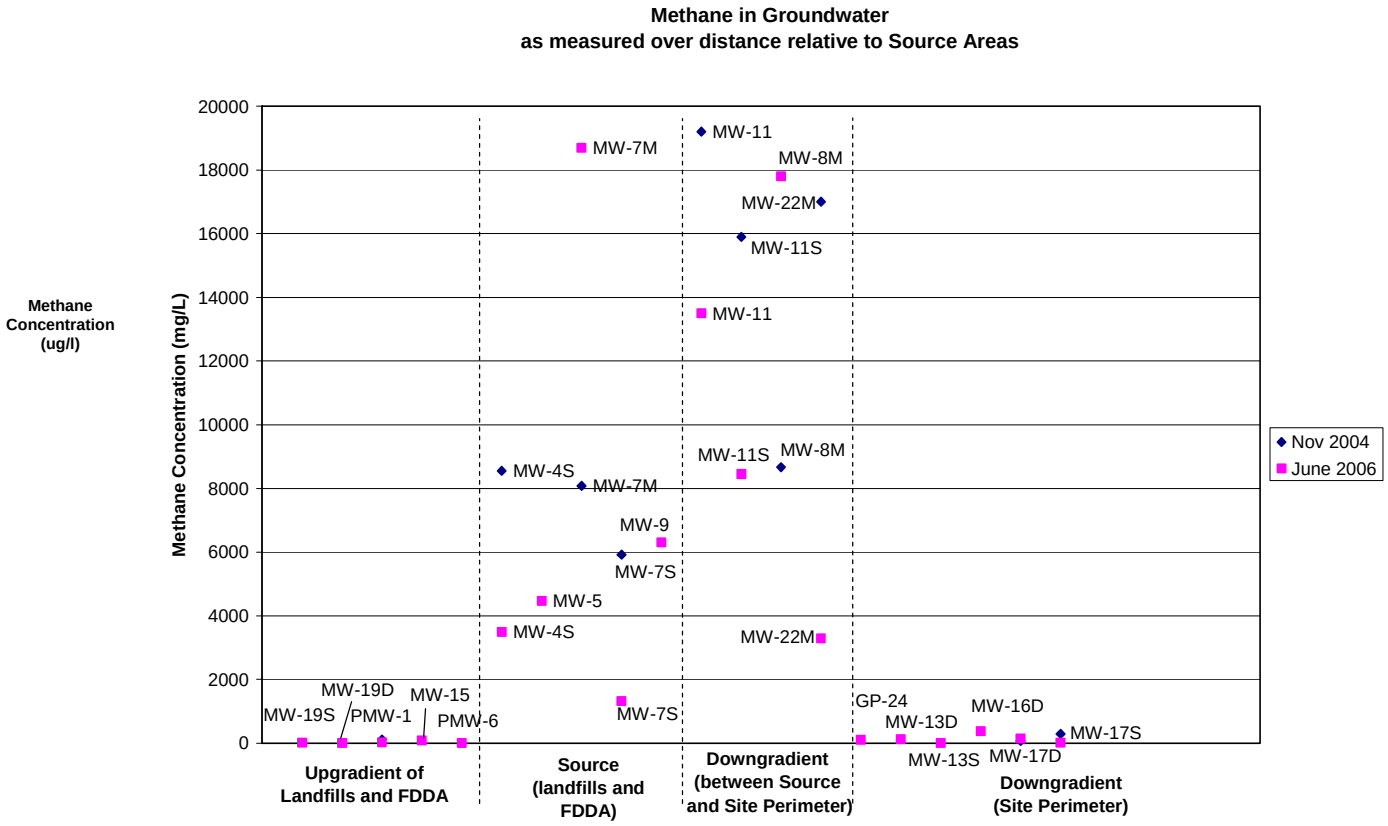
Consistently, reduced levels of dissolved oxygen (less than 1 mg/l) have been measured within and immediately downgradient of the two source areas. These measurements indicate that anaerobic conditions have prevailed in these areas and that aerobic degradation is likely not the primary driver for mass reduction on-site. In addition to the reduced oxygen levels in groundwater, ORP levels are predominantly negative in the source areas and immediately downgradient from the source areas (in the intermediate zone) demonstrating that reductive conditions exist in these areas.

Nitrate and sulfate levels were measured in select wells on-site in June 2006 to evaluate the potential for denitrification or sulfate reducing processes occurring on-site. The spatial analysis of the results across the site shows both nitrate and sulfate concentrations to be greater at upgradient and downgradient locations, as compared to those locations within the source areas or immediately downgradient of the source areas. The low levels of nitrate and sulfate in source area groundwater may demonstrate that denitrification or sulfate reduction processes are contributing to mass reduction on-site.

Metabolic Byproducts – Methane and Ferrous Iron

Two additional potential biodegradation processes include methanogenesis and iron reduction. Methanogenesis consists of the fermentation of contaminants into methane gas and carbon dioxide, providing methane as a footprint for this type of reaction. As methane gas is a common byproduct of landfill waste (and demonstrated to be present on-site as a result of the two landfill lobes) and due to the location of the dissolved VOC contaminant plume (immediately downgradient of the landfills), the specific source(s) of methane on site is difficult to isolate.

The figure below presents the methane levels detected in groundwater from wells located upgradient of the source areas (landfills and FDDA), within and immediately downgradient of the source areas, and from downgradient wells positioned near the site perimeter on two separate monitoring events (in 2004 and 2006). The plot illustrates the change in methane levels in site groundwater with little to no methane concentrations in upgradient wells or in downgradient wells near the site perimeter and increased concentrations near and immediately downgradient of the source areas.

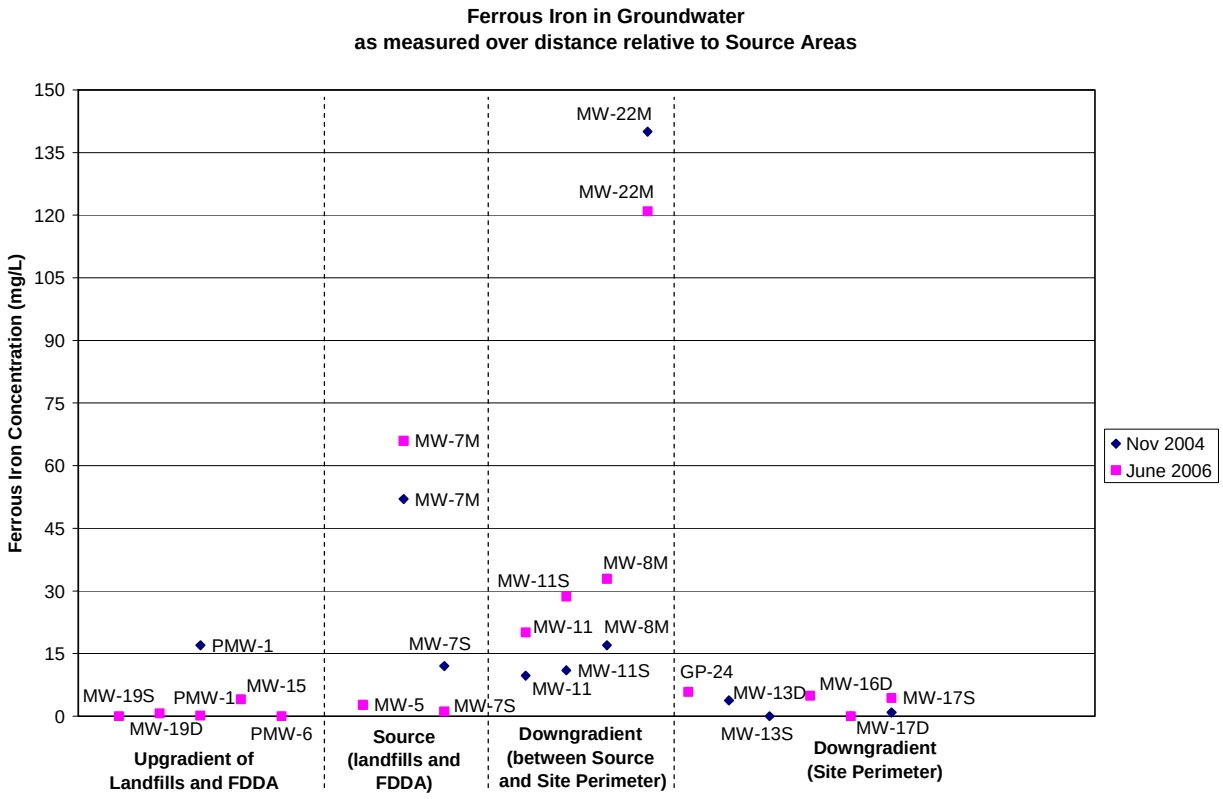


As shown in the plot above, although limited by two sampling rounds, the higher concentrations of dissolved methane were detected in wells downgradient from both source areas (landfills and FDDA) – MW-11, MW-8M, MW-22M - and in the wells located nearer to the landfills (MW-4 and MW-5, as well as MW-12 not shown on this graph). This data suggests that although there is contribution of methane to groundwater from the decomposition of buried waste in the landfills; as groundwater travels further away from the landfills, an increase in methane concentration is measured, providing the potential that additional breakdown (of contaminants in groundwater) via methanogenesis is occurring. It should also be noted that the highest levels of dissolved methane in groundwater have been detected within deeper regions (25 to 45 feet bgs). Therefore, the presence of methane in groundwater is believed to be a result of a combination of mechanisms - dissolution of landfill gas and a by-product of methanogenesis.

A similar evaluation was performed to examine the potential for iron reduction in site groundwater. During iron reduction processes, the reduction of ferric iron (Fe^{3+} - electron acceptor) produces dissolved ferrous iron (Fe^{2+} - metabolic byproduct). Therefore, ferrous iron can be utilized as a footprint for this type of reaction.

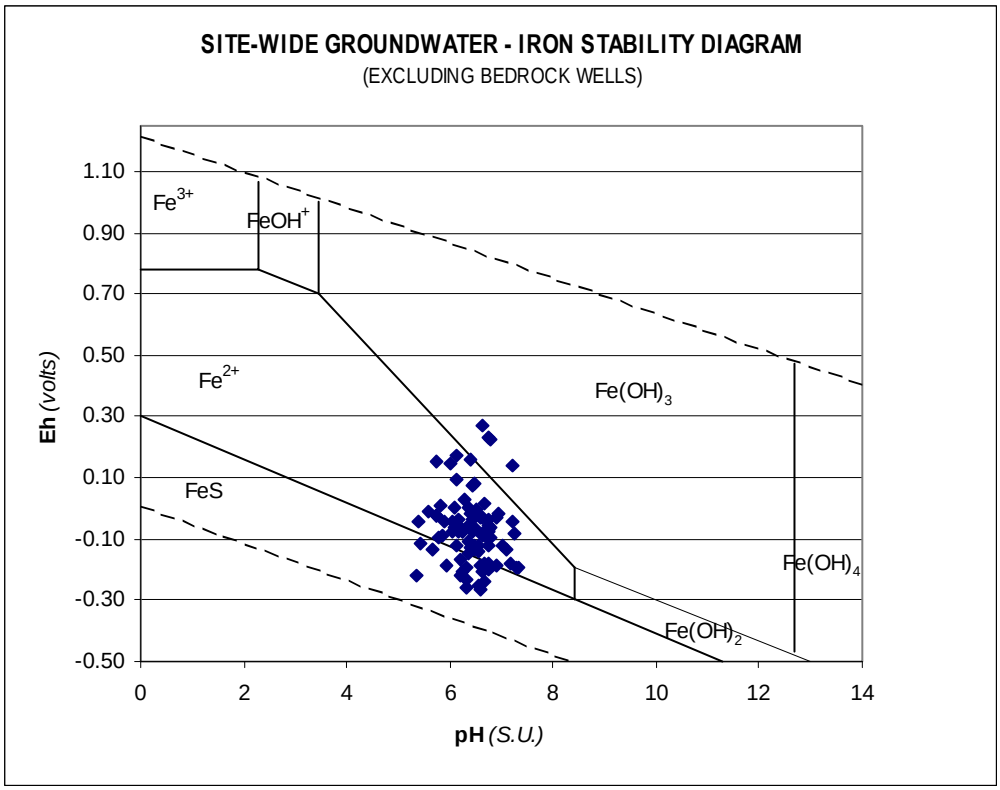
The figure below presents the ferrous iron levels detected in groundwater from wells located upgradient of the source areas (landfills and FDDA), within and immediately downgradient of the source areas, and from downgradient wells positioned near the site perimeter on two separate monitoring events (in 2004 and 2006). The plot illustrates the change in ferrous iron levels in site groundwater with little to no ferrous iron concentrations in upgradient wells or in downgradient wells near the site perimeter and increased concentrations in deeper screened wells located near and immediately downgradient of the

source areas. In addition, a slight increase in ferrous iron has been observed from 2004 to 2006 in each of those monitoring wells. This elevated presence of ferrous iron indicates that iron reduction degradation processes may be occurring within and downgradient of the source areas.



Note: Source wells MW-4S (avg. 578 mg/L) and MW-9 (294 mg/L) are not shown on this graph.

The elevated presence of ferrous iron demonstrates that iron reduction processes may be occurring in these regions with the interaction of site contaminants with ferric iron and the subsequent generation of ferrous iron. This is further illustrated through the following iron stability diagram. Site-wide groundwater chemistry (redox potential and pH) results (through 2004, excluding bedrock wells) are plotted below. Measured redox potential (Eh) and pH across the site demonstrate ferric iron reduction to dissolved ferrous iron (Fe^{2+}) for the majority of site groundwater.



♦ Site Groundwater

VOC/ SVOC - Summary

The VOC and SVOC groundwater data presented in the preceding paragraphs demonstrates that natural attenuation processes are occurring within and downgradient of the source areas through the lines of evidence evaluated. These natural attenuation processes, including biodegradation, dispersion, dilution, sorption, volatilization and chemical or biological stabilization, transformation, or destruction, have and continue to stabilize and/or decrease the size of the contaminant plume. In addition, chemical footprint indicators, including the absence of electron acceptors oxygen, nitrate and sulfate and the presence (and subsequent increase spatially on-site) of metabolic byproducts methane and ferrous iron have been measured within and immediately downgradient of source areas on-site, indicating that biodegradation processes are interacting with contaminants in groundwater.

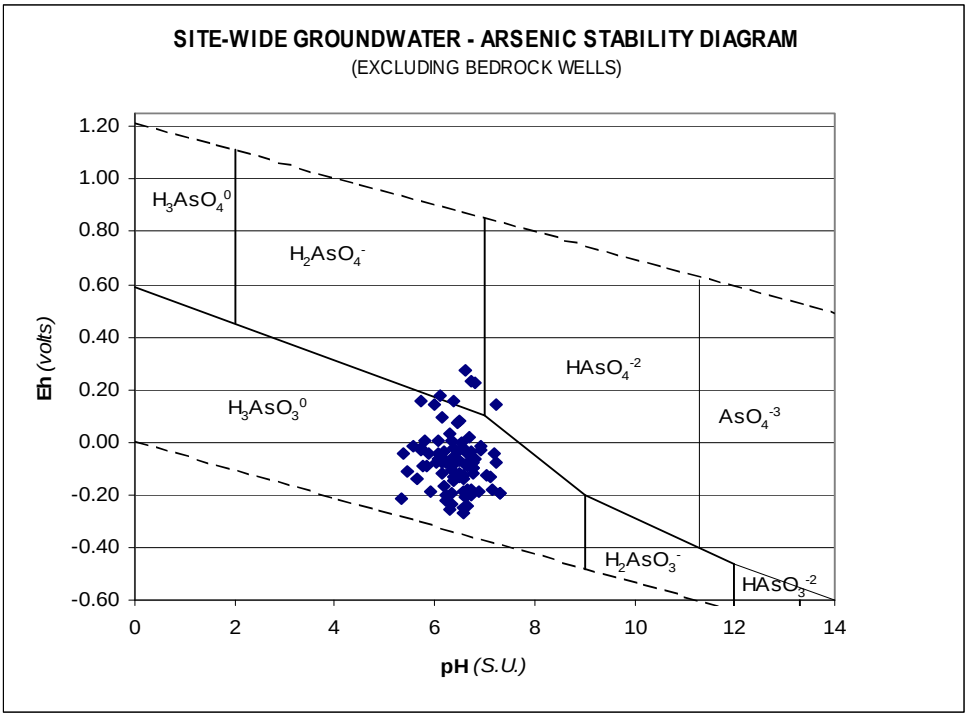
7.2.2 Natural Attenuation Evaluation – Arsenic

The most frequently detected inorganic constituents in groundwater across the Site were arsenic, nickel, aluminum, zinc, cobalt, vanadium, beryllium, chromium, cadmium, copper, lead, silver, cyanide, thallium, antimony and mercury (in descending order of frequency detected). For relative comparison purposes, metals concentrations were compared to maximum contaminant levels (MCLs) for the 1995 to 2005 groundwater data. This comparison indicated that concentrations of total arsenic were the most predominant metal detected in excess of the applicable MCL (a total of approximately 40 locations detected in excess of the MCL), followed by beryllium (22 locations), cadmium (21 locations), thallium (5 locations) and selenium (2 locations).

As discussed in Section 5.5 of the RI Report, beryllium and cadmium were detected at levels above MCLs at several locations during previous groundwater sampling events with the most exceedances observed in the June/July 1999 data set. Review of the beryllium and cadmium data indicated that all samples (with the exception of one location [MW-4S]) previously detected in excess of the MCL have been subsequently sampled at least once (and some over 3 additional rounds) and all results have exhibited concentrations below the MCLs (0.004 and 0.005 mg/l, respectively). Monitoring well MW-4S (located adjacent to the source area of the Southern Lobe) was most recently sampled in October 2006 and exhibited beryllium and cadmium concentrations of 0.005 and 0.0025 mg/l, respectively. All subsequent thallium and selenium concentrations have also been detected below their applicable MCL. In summary, arsenic is the only inorganic constituent consistently detected in excess of MCLs.

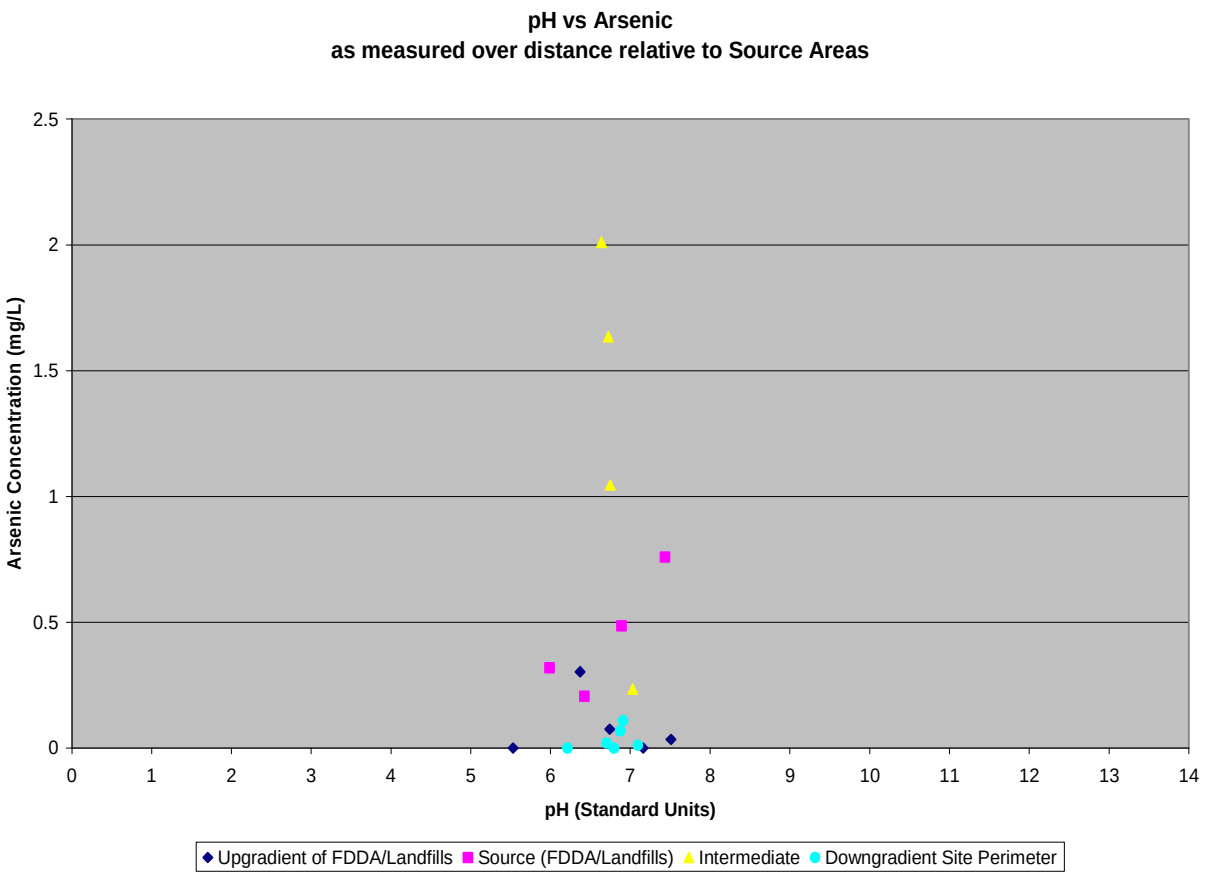
Due to the widespread distribution and extent of arsenic in groundwater and its concentrations in comparisons to MCLs, arsenic is the main inorganic evaluated in this section. Unlike the dissolved VOC and SVOC plumes, arsenic concentrations in groundwater in excess of MCLs are detected in site wells as well as upgradient wells, suggesting that arsenic concentrations may be naturally occurring at "elevated" levels. The highest concentrations of arsenic in groundwater have been detected adjacent to and immediately downgradient of the source areas (FDDA and the Southern lobe). The elevated levels adjacent to and immediately downgradient of source areas is believed to be a result of the reductive release of arsenic in select areas on-site.

The following arsenic stability diagram illustrates that reducing conditions are present on-site with the majority of groundwater within the anaerobic arsenite (H_3AsO_3) range. Research by others has shown that arsenic concentrations can increase as a result of microbial iron reduction under reducing conditions. The availability of organic carbon from the source areas, in conjunction with the reducing conditions present on-site, result in an environment susceptible to arsenic release into site groundwater via microbial iron reduction. Measured redox potential (Eh) and pH across the Site (illustrated in the iron stability diagram presented above) demonstrate that ferric iron reduction may be occurring across the site; therefore the increased levels and slight upward trend of arsenic in these same areas within the site may be attributable to the natural microbial processes occurring in-situ.



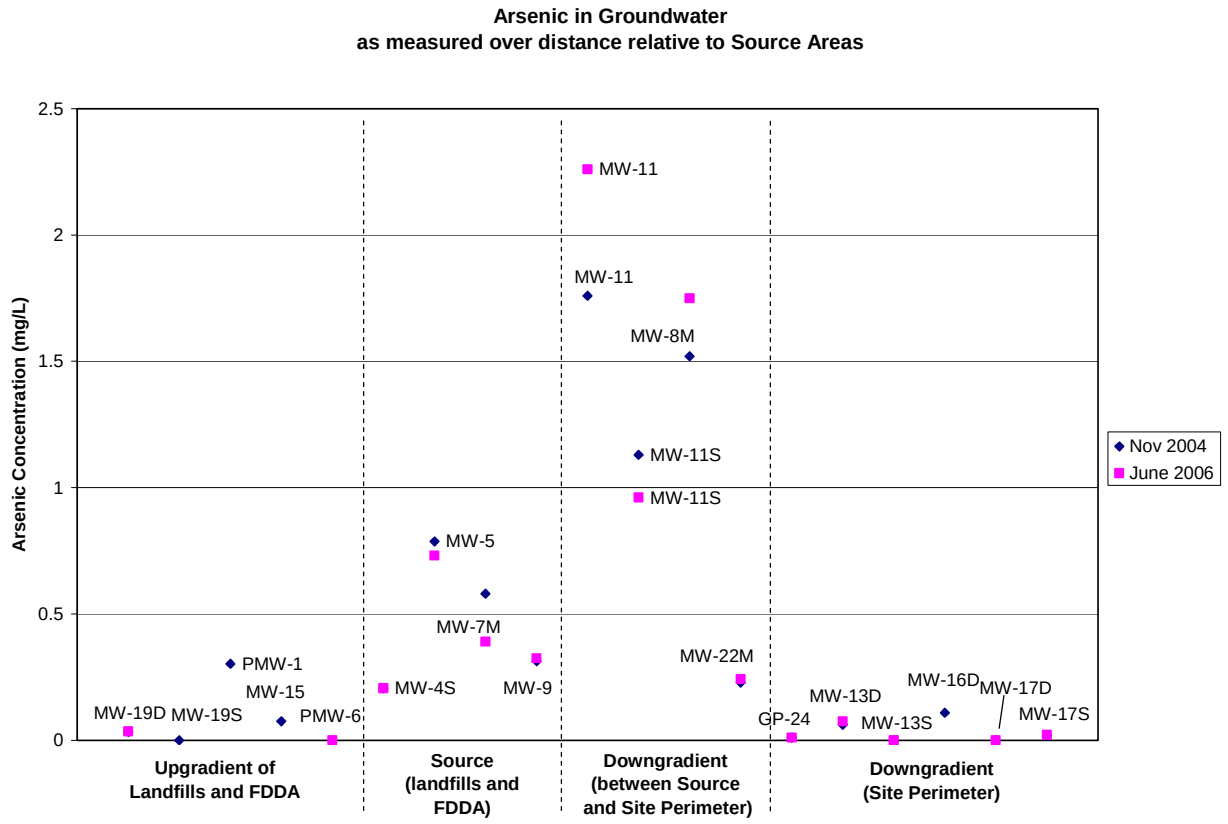
♦ Site Groundwater

Although groundwater upgradient of the landfill contains arsenic levels above the MCL, these concentrations are generally lower than those detected within and immediately downgradient of the FDDA and Southern lobe. Arsenic levels in groundwater upgradient of the source areas (landfills and FDDA), within and immediately downgradient of the source areas, and from downgradient wells positioned near the site perimeter on two separate monitoring events (in 2004 and 2006) were compared to pH levels, as shown on the plot below. pH levels were consistent; however, arsenic levels in the upgradient and downgradient wells were lower than groundwater in the source and immediately downgradient wells.



The highest arsenic concentrations in the area are located in the intermediate zone (immediately downgradient of source area). This illustrates that naturally occurring arsenic may be present at levels below 0.7 mg/l; as groundwater flows to the intermediate located wells, the arsenic concentrations increase to greater than 1 mg/l. This suggests that in-situ geochemical processes on-site are contributing to the release of naturally occurring arsenic in this area.

This is further illustrated by the second plot below which presents dissolved arsenic levels detected in groundwater from wells located upgradient of the source areas (landfills and FDDA), within and immediately downgradient of the source areas, and from downgradient wells positioned near the site perimeter on two separate monitoring events (in 2004 and 2006). The plot illustrates the change in dissolved arsenic levels in site groundwater with little to no dissolved arsenic concentrations in upgradient wells or in downgradient wells near the site perimeter and increased concentrations in wells located near and immediately downgradient of the source areas. This plot shows that arsenic concentrations in some source area wells are similar to upgradient concentrations and the higher arsenic concentrations are located in downgradient wells. As reducing conditions prevail (ORP is reduced) with the flow of groundwater through the source areas, the concentration of arsenic increases; as the ORP rises again and oxidizing conditions result in the area of the brook and wetlands, arsenic concentrations reduce as it binds, adsorbs, and/or reacts to fall out of solution.



7.2.3 Natural Attenuation Modeling

Two different types of natural attenuation modeling software were used as screening tools to aid in the evaluation of natural attenuation processes at the Site. A discussion of the results from this evaluation is presented in the following paragraphs.

Natural Attenuation Software

The Natural Attenuation Software (NAS) (Widdowson, version 2) was utilized as another screening tool to evaluate if natural attenuation processes are occurring on-site (and therefore aid in the analysis of utilizing MNA as a remedial technology for the site) and to evaluate what degree of source remediation may be required to meet site RAOs (in a quicker timeframe). The program, developed by the U.S. Geological Survey (USGS), Virginia Tech, and the Naval Facilities Engineering Command, consists of a basic model for application to hydrogeologic conditions consisting of porous, relatively homogeneous saturated media and assumes that flow is uniform and unidirectional. The program provides a variety of other features to address timing of remediation, etc.; however, due to the variety and complexity of hydrogeologic conditions at the site (upland sands into wetland regions), the model was used for its basic functions to aid in the MNA evaluation.

The program calculates a natural attenuation capacity (NAC), which is defined as the capacity of a system to absorb or transform contaminants through dispersion, advection, biodegradation, sorption, volatilization and/or plant uptake. The relative efficiency (based on calculated NAC) ranges from

inefficient (0.001 1/ft and less), to moderately efficient (0.01 range), to efficient (0.05 1/ft and greater). This is a general guidance and provides a relative evaluation of the different compounds on-site and their capacity to naturally attenuate given the site specific hydrogeological and geochemical conditions.

The program incorporates site specific hydrogeologic, contaminant and geochemical (redox) data to assess contaminant degradation rates and to determine if (and if so, which) redox zones are present on-site. If it is established that degradation is occurring on-site, the program can be utilized to determine if source reduction is required and if so, the level of source reduction, to meet site RAOs (and in what timeframe).

For the purposes of this FS, the model was used to evaluate the following questions:

1. Are natural attenuation processes occurring on-site, specifically in downgradient groundwater?
2. Are source area reduction measures required to achieve RAOs for downgradient groundwater?
3. Are reduction measures required to achieve RAOs for the source areas (FDDA and Southern lobe)? And if required, what level of source reduction would be required to achieve site RAOs?

NAC and Decay Rates

The model was run utilizing historical groundwater data, focusing on the main contaminants of concern in each of the source areas. Based on their prevalence in the source and/or intermediate areas, the following compounds were evaluated for both source areas: benzene, toluene, ethylbenzene, xylene, 1,4-dioxane, 2-Butanone (MEK), 4-methyl-2-pentanone (MIBK), and tetrahydrofuran (THF).

FDDA

The model was run for the FDDA utilizing both the November 2004 and June 2006 groundwater data. A summary of the hydrogeologic, contaminant and geochemical data utilized in the model for the FDDA is provided as Table B1 in Appendix B. The NAS model determined that the redox zones in the FDDA were sulfate reducing in 2004 and a combination of sulfate reducing and ferrogenic in 2006. This corresponds with the evaluation performed above in Section 7.2.1 as concentrations of sulfate were reduced in the FDDA source zone and concentrations of ferrous iron were elevated within and immediately downgradient of the source zone.

A summary of the NAC values (capacity of a system to absorb or transform contaminants through dispersion, advection, biodegradation, sorption, volatilization and/or plant uptake) calculated by the model for the FDDA is provided in the following table. The average NAC indicates that moderately efficient natural attenuation is occurring on-site, with the most efficient attenuation of the ketones (MIBK and MEK) and the least efficient of 1,4-dioxane.

FDDA - NATURAL ATTENUATION CAPACITY *(1/ft)*		
COC	**2004**	**2006**
Benzene	0.011	0.011
Toluene	0.033	0.015
Ethylbenzene	0.017	0.019

FDDA - NATURAL ATTENUATION CAPACITY *(1/ft)*		
COC	**2004**	**2006**
Xylene	0.014	0.015
MEK	NC	0.040
MIBK	0.056	0.041
1,4-dioxane	NC	0.009
THF	0.011	0.012
AVERAGE	0.024	0.020

NC – not calculated since concentration of downgradient data below detection limit

Southern Lobe

For the Southern lobe groundwater, the model was run utilizing the maximum concentrations detected in source area (including wells MW-4S, MW-5 and GP-11 through GP-16), intermediate (MW-22M) and downgradient (MW-17D) groundwater. This approach was utilized as the temporary GP wells along the northern edge of the Southern lobe (which generally detected the highest levels of the COCs) were sampled on different dates than the intermediate well (MW-22M). A summary of the hydrogeologic, contaminant and geochemical data utilized in the model for the Southern lobe is provided as Table B2 in Appendix B.

A summary of the NAC values calculated by the model is provided in the following table. The average NAC indicates that moderately efficient natural attenuation is occurring immediately downgradient of the Southern lobe, but at a slightly reduced decay rate than the FDDA. Similar to the FDDA, the most efficient attenuation noted is of the ketones (MIBK and MEK) and the least efficient of 1,4-dioxane.

SOUTHERN LOBE - NATURAL ATTENUATION CAPACITY (1/FT)	
COC	**NAC – MAX CONC**
Benzene	0.006
Toluene	0.021
Ethylbenzene	0.004
Xylene	0.004
MIBK	0.024
MEK	0.023
1,4-dioxane	0.002
THF	0.010
AVERAGE	0.013

Downgradient Groundwater and Source Reduction

Although natural attenuation processes have been shown on-site to be actively reducing contaminant concentrations, the model was utilized to confirm this condition and to evaluate if additional source zone measures will be required to meet site RAOs within the source areas (FDDA and Southern lobe) and downgradient groundwater.

FDDA

The model demonstrated that source zone measures were not required to meet RAOs in downgradient groundwater, as existing processes were reducing contaminant concentrations. This was true for all constituents except 1,4-dioxane. As anticipated, the reduced NAC for 1,4-dioxane demonstrated that additional source reduction measures in the FDDA may be warranted given the current 1,4-dioxane levels in source area groundwater.

For the FDDA source area, the model demonstrated that source reduction, specifically for benzene, toluene, MIBK, THF, and 1,4-dioxane will likely be required to meet PRGs at the downgradient edge of the FDDA (near MW-8M).

Southern Lobe

For the Southern lobe, the model demonstrated that source zone measures were not required to meet RAOs in downgradient groundwater (at MW-17D), as existing processes were reducing contaminant concentrations. This was true for all constituents except 1,4-dioxane, similar to the FDDA analysis.

The result of the source control measures implemented for the Southern lobe (e.g. low permeability final cover system, vertical barrier, and potentially enhanced groundwater treatment) will substantially affect the current groundwater conditions immediately downgradient of the Southern Lobe. It is anticipated that construction of the final cover system over the landfill will significantly reduce infiltration through the waste, reducing the potential for further contamination of the Southern lobe groundwater in the future. Regardless of which landfill source area alternative is selected (vertical barrier with natural attenuation, in situ groundwater treatment at the downgradient end of the barrier, or groundwater extraction and ex-situ treatment), the resulting groundwater flow patterns, contaminant levels and geochemistry will be significantly altered.

However, assuming a worst case situation of maximum levels detected in source area wells would be present at the downgradient edge of the landfill (e.g. at the edge of the vertical barrier), the model indicated that, a reduction in benzene, MIBK and 1,4-dioxane will likely be required to meet PRGs just beyond the downgradient edge of the Southern lobe should the groundwater concentrations flowing beneath the Southern lobe be at the maximum detected levels.

With the implementation of the source control measures (e.g. low permeability final cover system, etc.), it is anticipated that concentrations will be reduced and that this ‘worst case’ scenario would not be realistic. As a result, a phased approach for the groundwater has been incorporated into some of the remedial alternatives so that appropriate design and implementation of the selected groundwater remedy (i.e. perform monitoring [MNA] and/or pump tests after construction of the landfill final cover system (and vertical barrier [if selected]); further details on the phased approach are provided in Section 8.

NAS Summary

The evaluation utilizing the NAS model indicated that natural attenuation processes are occurring on-site, with varying levels of efficiency depending on the specific compound. For downgradient groundwater, no mass reduction is required to achieve RAOs, with the exception of 1,4-dioxane. For the both of the source areas, however, a reduction in source area groundwater will likely be required to achieve RAOs within each of the respective source areas. Monitoring following implementation will be required to determine if the source control measures will be sufficient to meet RAOs.

Bioscreen

The BIOSCREEN Natural Attenuation Decision Support System was initially utilized as a screening tool to determine if natural attenuation processes were reducing BTEX compounds on-site. As discussed above in the natural attenuation discussion, conditions are favorable to reduce BTEX concentrations on-site through natural attenuation processes and preliminary use of the model demonstrated this condition. However, given the results of the NAS modeling and that the higher concentrations of contaminants in the FDDA and Southern lobe are not the BTEX components, but rather the more prevalent (ketones) and more persistent compounds (1,4-dioxane), further use of the model to determine timeframes of remediation were not conducted. Refer to Section 8.4 for further details on timeframes to meet RAOs for each remedial alternative evaluated.

7.2.4 Natural Attenuation Summary

In summary, no significant increasing trends in concentrations of dissolved VOCs or significant changes in the shape of the dissolved VOC plumes have been detected at the site throughout the sampling events conducted from 1995-2006. Although a significant amount of new groundwater data has been recently collected, the extent and concentration distribution of the plume on the site appears to be generally consistent throughout the past ten years. Additionally, decreasing contaminant trends in VOCs are apparent with respect to time and distance from the source area, especially for the VOC and SVOC contaminant mass across the site.

Historical contaminant analytical data and the existing subsurface hydrogeology and geochemistry indicate that a combination of natural attenuation processes (biodegradation, dispersion, dilution, sorption, volatilization, and/or chemical or biological stabilization, transformation, or destruction of contaminants) are reducing contaminant concentrations on-site, reducing the overall mass and preventing the spread of dissolved contaminants off-site. Combining these processes with the ongoing sources of contaminants present in the source areas, it would be expected that similar or decreasing VOC and SVOC concentrations (as observed during the investigation) would persist in the subsurface and at downgradient locations, especially under scenarios that involve further source control methods.

Modeling of the hydrogeologic, contaminant and geochemical data indicates that source zone measures are likely required to meet RAOs within the source areas within the foreseeable timeframe; however, with the exception of 1,4-dioxane, the data indicates that existing natural attenuation processes in the downgradient groundwater will continue to reduce VOC levels in groundwater with or without source zone measures. Based on the data collected, monitored natural attenuation will be carried through the detailed analysis as a feasible stand alone remedial technology for downgradient groundwater and as a feasible remedial technology, in conjunction with source reduction measures, for the FDDA and Southern lobe.

TABLE 7-1

ANALYTICAL TESTING SUMMARY - NATURAL ATTENUATION EVALUATION

Remedial Investigation and Feasibility Study

Sutton Brook Disposal Area Superfund Site - Tewksbury, MA

Sample Location Identifier	Sample Date	VOC	1,4-Dioxane	SVOC	Metals		Methane	Ferrous Iron	Nitrate	Sulfate	Sulfite	Sulfide	Total Alkalinity	DOC
					Total	Dissolved								
MW-4B	11/15/04	X	X	X	X		X	X			X	X		X
	06/05/06	X	X	X	X		X	X	X	X			X	
MW-4S	11/15/04	X	X	X	X		X	X			X	X		X
	06/05/06	X	X	X	X		X	X	X	X			X	
MW-5	06/05/06	X	X	X	X		X	X	X	X			X	
MW-7M	11/17/04	X	X	X	X		X	X			X	X		X
	06/08/06	X	X	X	X		X	X	X	X			X	
MW-7R	11/17/04	X	X	X	X		X	X			X	X		X
	06/08/06	X	X				X	X	X	X			X	
MW-7S	11/17/04	X	X	X	X		X	X			X	X		X
	06/08/06	X	X				X	X	X	X			X	
	10/03/06						X							
MW-8M	11/18/04	X	X	X	X		X	X			X	X		X
	06/07/06	X	X	X	X		X	X	X	X			X	
MW-8R	11/18/04	X	X	X	X		X	X			X	X		X
	06/07/06	X	X				X	X	X	X			X	
MW-9	06/08/06	X	X	X	X		X	X	X	X			X	
MW-11	11/18/04	X	X	X	X	X	X	X			X	X		X
	06/07/06	X	X	X	X		X	X	X	X			X	
MW-11S	11/18/04	X	X		X	X	X	X			X	X		X
	06/07/06	X	X		X		X	X	X	X			X	
MW-12	10/05/06						X							
MW-13B	06/06/06	X	X		X		X	X	X	X			X	
MW-13D	06/06/06	X	X		X		X	X	X	X			X	
MW-13S	06/06/06	X	X		X		X	X	X	X			X	
MW-15	06/07/06	X	X				X	X	X	X			X	
MW-16D	06/08/06	X	X				X	X	X	X			X	
MW-17B	11/18/04	X	X	X	X		X	X			X	X		X
	06/06/06	X	X		X		X	X	X	X			X	
MW-17D	11/18/04	X	X	X	X		X	X			X	X		X
	06/06/06	X	X		X		X	X	X	X			X	
MW-17S	11/18/04	X	X	X	X		X	X			X	X		X
	06/06/06	X	X		X		X	X	X	X			X	
MW-19D	06/07/06	X	X		X		X	X	X	X			X	
MW-19S	06/06/06	X	X				X	X	X	X			X	

TABLE 7-1

ANALYTICAL TESTING SUMMARY - NATURAL ATTENUATION EVALUATION

Remedial Investigation and Feasibility Study

Sutton Brook Disposal Area Superfund Site - Tewksbury, MA

Sample Location Identifier	Sample Date	VOC	1,4-Dioxane	SVOC	Metals		Methane	Ferrous Iron	Nitrate	Sulfate	Sulfite	Sulfide	Total Alkalinity	DOC
					Total	Dissolved								
MW-22M	03/17/05	X	X	X	X		X	X				X		X
	06/05/06	X	X		X		X	X	X	X			X	
MW-23B	12/08/04	X	X	X	X		X	X			X	X		X
	06/07/06	X	X		X		X	X	X	X			X	
PMW-1	11/22/04	X	X	X	X		X	X			X	X		X
	06/07/06	X	X				X	X	X	X			X	
PMW-6	06/07/06	X	X		X		X	X	X	X			X	
GP-24	06/08/06	X	X		X	X	X	X	X	X			X	

NOTE:

X = The sample was submitted for the analysis indicated.

A blank space indicates the sample was not analyzed for this constituent.

VOC = Volatile organic compounds by EPA Method 8260 (1995), EPA Method 8260 (June 1999), EPA Method 8260B (2002, 2004-2006).

1,4-Dioxane by EPA Method 8260B-SIM (2004-2006).

SVOC = Semi-volatile organic compounds by EPA Method 8270B (1995), EPA Method 8270 (June 1999), EPA Method 8270C (2004-2006).

Total Metals = Total (unfiltered) metals by EPA 6000/7000 Series Methods (1995, 2002, 2004-2006), EPA Method 6010 and 245.1 (June 1999).

Dissolved Metals = Metal concentrations after the water sample was passed through a 0.45 micron filter by EPA 6000/7000 Series Methods (2004-2006).

Methane = Analysis of dissolved methane in groundwater by standard gas chromatographic technique (EPA-NE: Tech. Guid. For Natural Attenuation Indicators, July 2001).

Ferrous Iron by EPA Method 3500 (2004).

Nitrate by EPA Method 353.1 (1995).

Sulfate by EPA Method 375.4 (1995).

Sulfite by EPA Method 377.1 (2004).

Sulfide by EPA Method 376.2 (2004).

Alkalinity as $CaCO_3$ = Alkalinity as calcium carbonate by Standard Method 2320B (1995).

DOC = Dissolved organic carbon. Water was passed through a 0.45 micron filter by EPA Method 415.1.

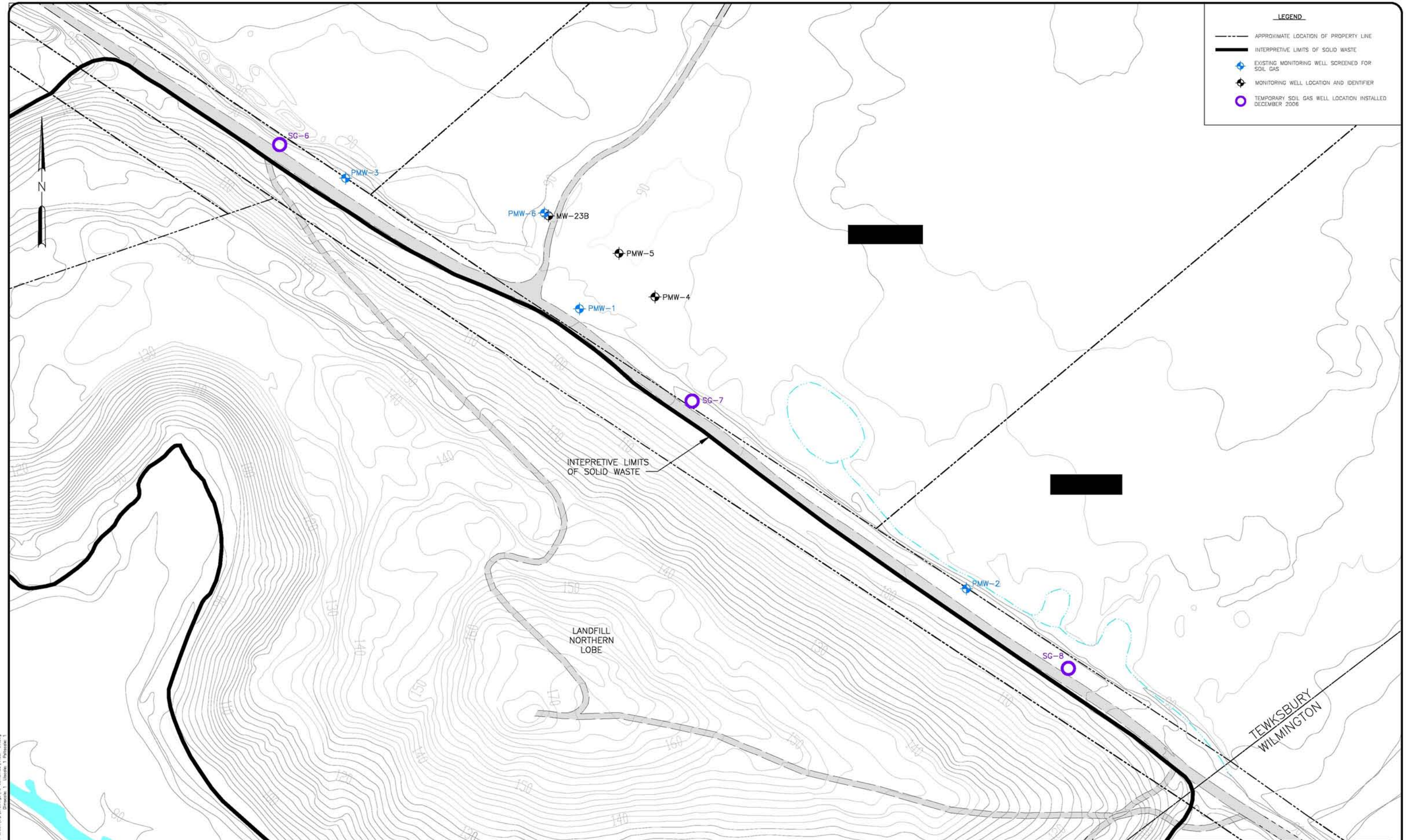


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FIGURE 7-1

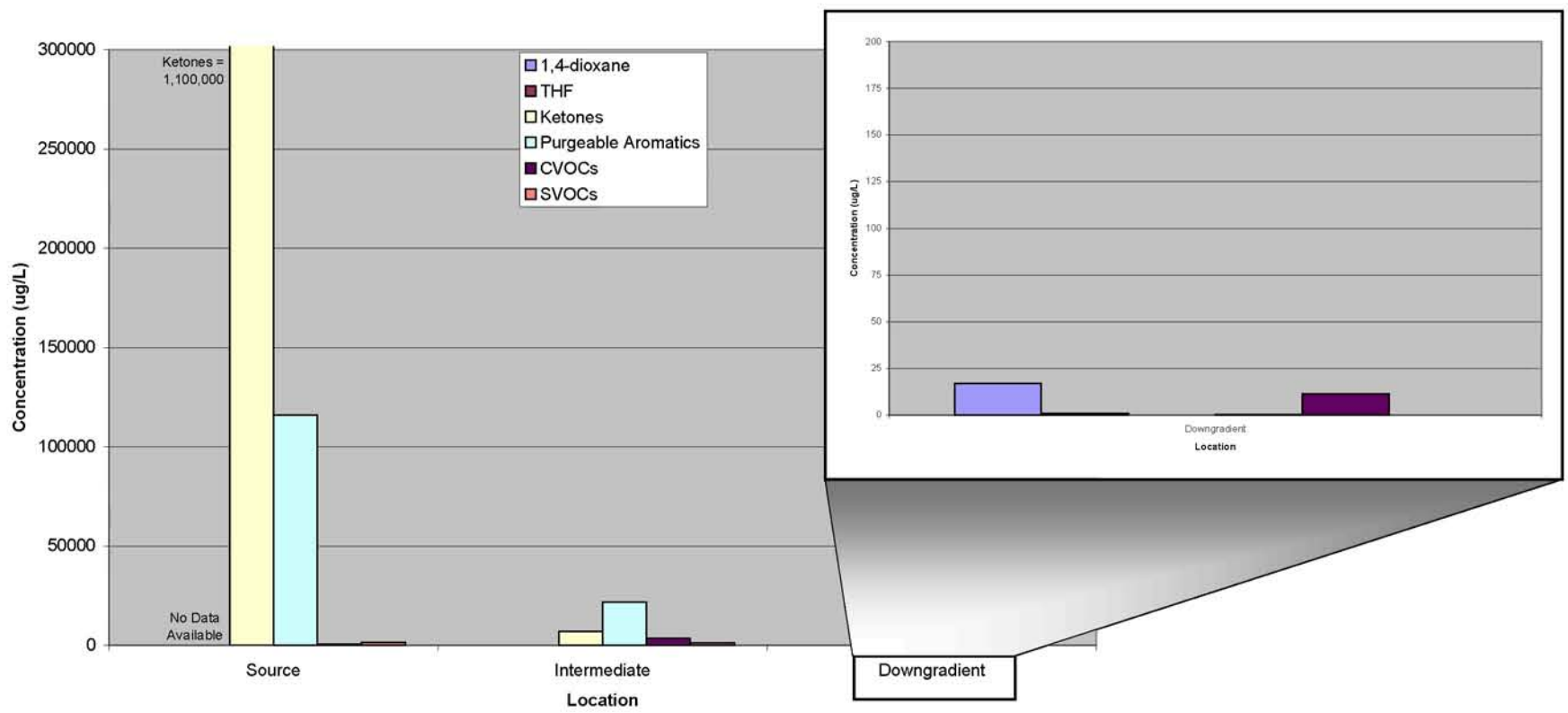
NORTHERN PROPERTY LINE SOIL GAS SAMPLING LOCATIONS

SUTTON BROOK DISPOSAL AREA

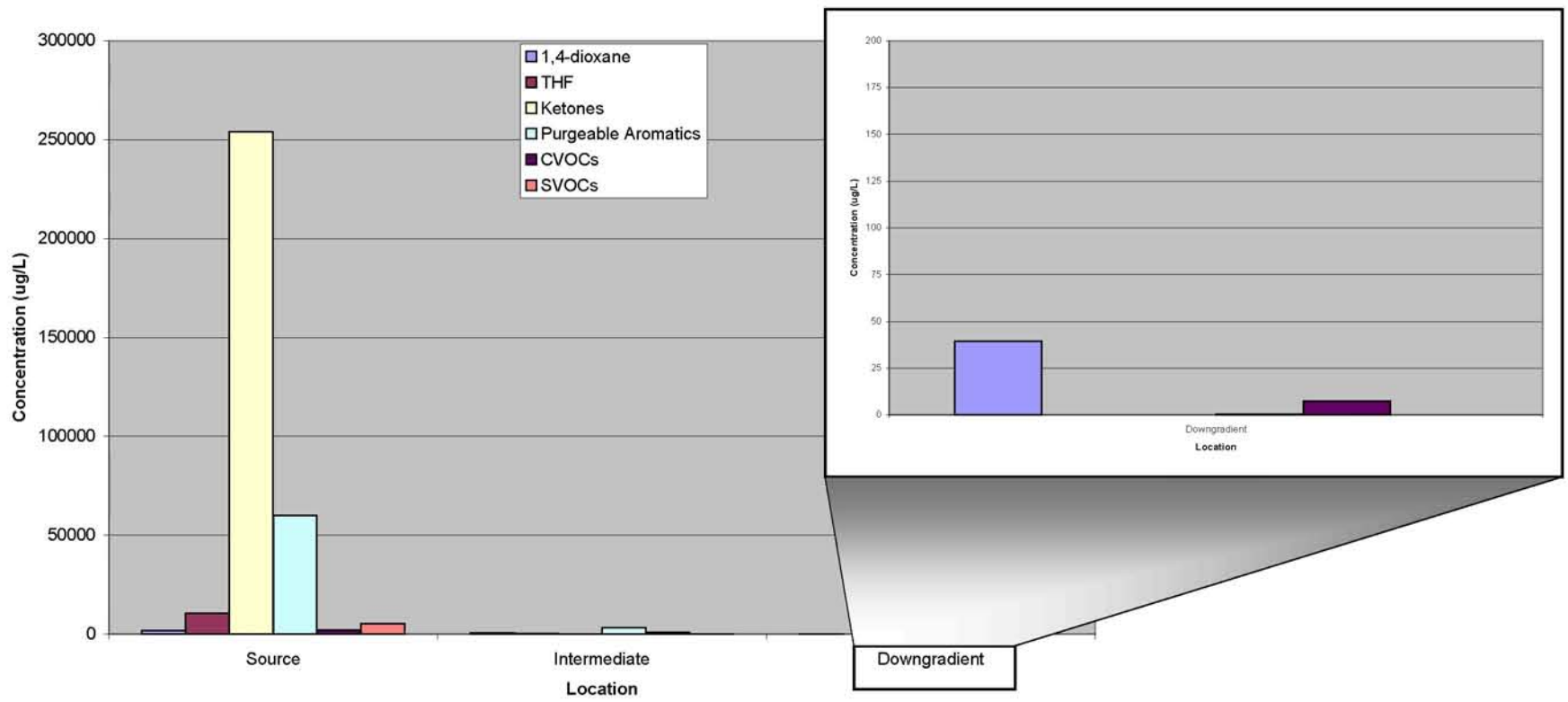
FIGURE 7-2

CONCENTRATIONS OF VOCs/SVOCs IN GROUNDWATER OVER TIME - FORMER DRUM DISPOSAL AREA
Remedial Investigation and Feasibility Study
Sutton Brook Disposal Area Superfund Site - Tewksbury, Massachusetts

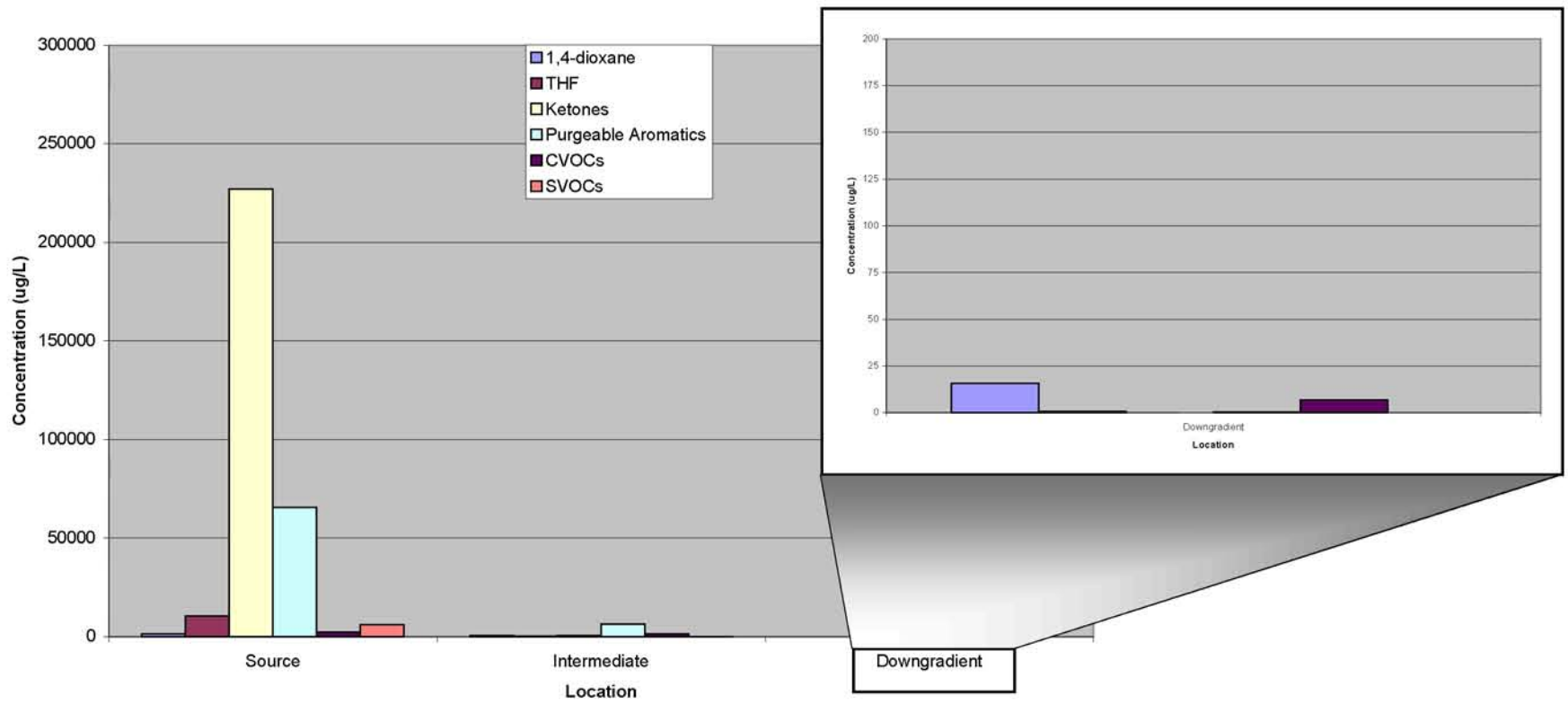
1999 - 2001



2004 - 2005



2006

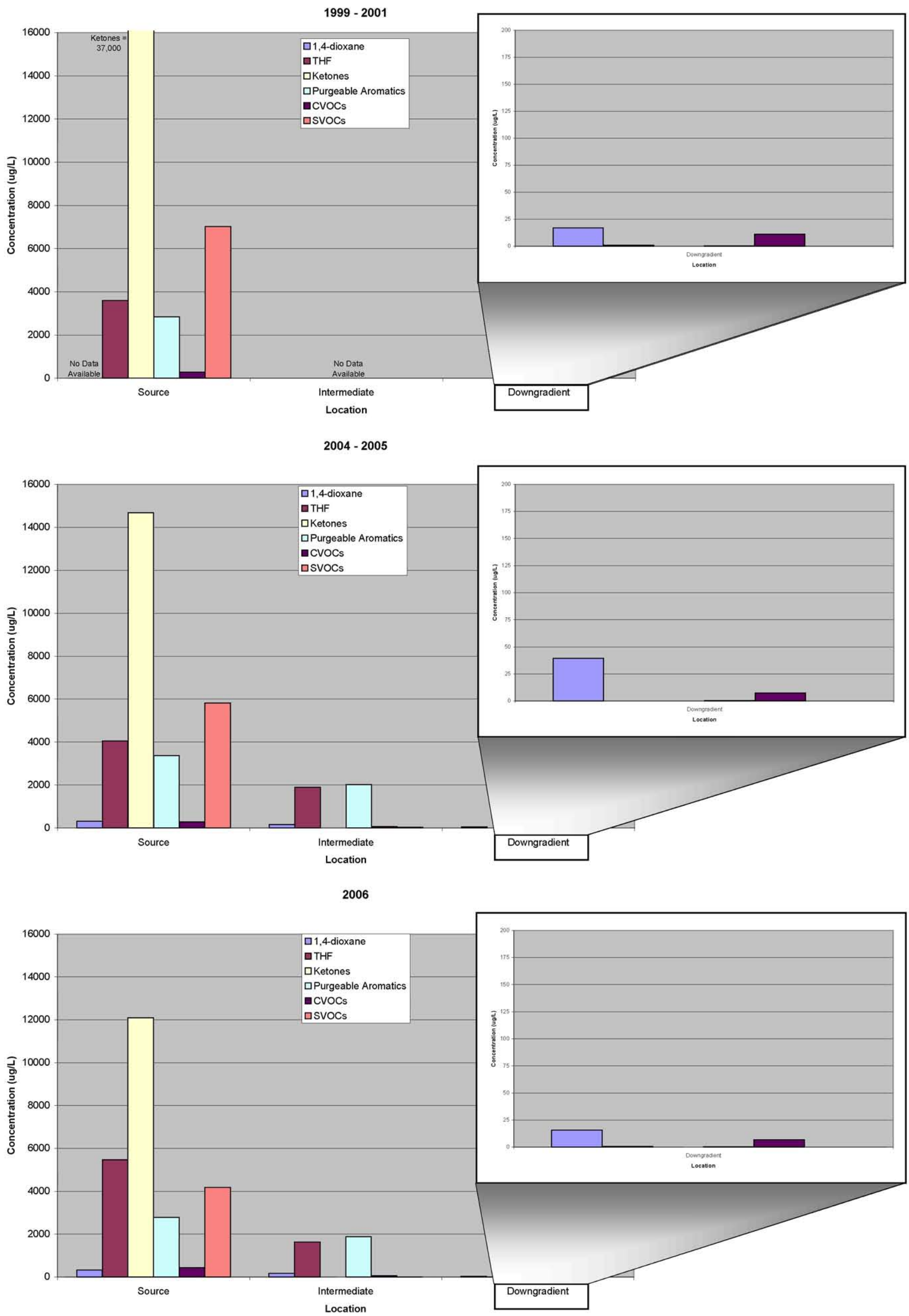


NOTES:

1. Wells utilized in the above analysis include: Source = MW-7M and MW-9; Intermediate = MW-8M and MW-11; and Downgradient = MW13D, MW-14, MW-16D, MW-17D, and GP-24.
2. Compounds utilized in the above analysis include:
   - 1,4-dioxane
   - Tetrahydrofuran (THF)
   - Ketones = 2-Butanone and 4-Methyl-2-Pentanone
   - Purgeable Aromatics = 1,2,4-Trimethylbenzene, 1,3,5-Trimethylbenzene, Benzene, Ethylbenzene, Toluene, Xylenes, n-Butylbenzene, and n-Propylbenzene
   - Chlorinated VOCs (CVOCs) = 1,1,1-Trichloroethane, 1,1,2-Trichloroethane, 1,1-Dichloroethane, 1,1-Dichloroethene, 1,2-Dichloroethane, 1,2-Dichloroethene (Total), 1,2-Dichloropropane, Chloroethane, cis-1,2-Dichloroethene, Tetrachloroethene, Trichloroethene, and Vinyl Chloride.
   - Semi-Volatiles (SVOCs) = 2,4-Dimethylphenol, 2-Methylphenol, 3-Methylphenol/4-Methylphenol, 4-Methylphenol, Bis(2-Ethylhexyl)phthalate, Diethyl phthalate, Dimethyl Phthalate, Di-n-butylphthalate, Naphthalene, and Phenol.

FIGURE 7-3

CONCENTRATIONS OF VOCs/SVOCs IN GROUNDWATER OVER TIME - SOUTHERN LOBE
Remedial Investigation and Feasibility Study
Sutton Brook Disposal Area Superfund Site - Tewksbury, Massachusetts



NOTES:

1. Wells utilized in the above analysis include: Source = MW-4S and MW-5; Intermediate = MW-22M; and Downgradient = MW-13D, MW-14, MW-16D, MW-17D, and GP-24.
2. Compounds utilized in the above analysis include:

1,4-dioxane
Tetrahydrofuran (THF)
Ketones = 2-Butanone and 4-Methyl-2-Pentanone
Purgeable Aromatics = 1,2,4-Trimethylbenzene, 1,3,5-Trimethylbenzene, Benzene, Ethylbenzene, Toluene, Xylenes, n-Butylbenzene, and n-Propylbenzene
Chlorinated VOCs (CVOCs) = 1,1,1-Trichloroethane, 1,1,2-Trichloroethane, 1,1-Dichloroethane, 1,1-Dichloroethene, 1,2-Dichloroethane, 1,2-Dichloroethene (Total), 1,2-Dichloropropane, Chloroethane, cis-1,2-Dichloroethene, Tetrachloroethene, Trichloroethene, and Vinyl Chloride.
Semi-Volatiles (SVOCs) = 2,4-Dimethylphenol, 2-Methylphenol, 3-Methylphenol/4-Methylphenol, 4-Methylphenol, Bis(2-Ethylhexyl)phthalate, Diethyl phthalate, Dimethyl Phthalate, Di-n-butylphthalate, Naphthalene, and Phenol.

8. DETAILED ANALYSIS OF REMEDIAL ALTERNATIVES

The detailed analysis of remedial alternatives provides sufficient information to compare the alternatives and facilitate selection of the preferred remedy for the site that best meets the following CERCLA requirements:

- is protective of public health and the environment;
- attains ARARs (or provides grounds for invoking a waiver);
- is cost-effective;
- is a permanent solution using alternative treatment technologies or resource recovery technologies to the maximum extent practicable; and
- provides preference for treatment that reduces toxicity, mobility, or volume.

The detailed analysis performed as part of the FS includes the following:

1. A description of each remedial alternative with the combination of remedial technologies proposed and the areas and volumes anticipated to be addressed by each alternative. These descriptions are used for conceptual design to aid in preparing feasibility level cost estimates. Costs presented in this analysis are based on existing data and knowledge of the site and will be reevaluated at the time of remedial design of the selected alternative; and
2. Detailed analyses of each alternative against seven of the nine evaluation criteria summarized in the table below. The detailed analysis of remedial alternatives provides the means by which data are assembled and evaluated to develop the rationale for selection of the preferred remedy in the ROD. The first two criteria listed are "threshold" criteria in that they relate directly to statutory findings that must be made in the ROD, and therefore must be satisfied in order for an alternative to be selected. The next five criteria represent the primary balancing criteria upon which the comparative analysis of alternatives is based. The final two evaluation criteria, state acceptance and community acceptance, represent modifying criteria which will be considered in the comparative analysis of alternatives and assessed following public comment on the FS report and the Proposed Plan.

Summary of Evaluation Criteria for the Detailed Analyses

Criteria	Description
Threshold Criteria	
Overall protection of human health and the environment	Describes how each alternative, as a whole, protects and maintains human health and the environment.
Compliance with ARARs	Describes how the alternative complies with ARARs or if a CERCLA waiver is required and how it is justified.

Summary of Evaluation Criteria for the Detailed Analyses

Criteria	Description
Primary Criteria	
Long-term effectiveness and permanence	Evaluates the long-term effectiveness of alternatives in protecting human health and the environment after response objectives have been met.
Reduction of mobility, toxicity, or volume through treatment.	Evaluates the anticipated performance of the specific treatment technologies.
Short-term effectiveness	Examines the short-term effectiveness of alternatives in protecting human health and the environment during the construction and implementation period until the response objectives are met.
Implementability	Assesses the technical and administrative feasibility of alternatives and the availability of required resources.
Cost	Evaluates the capital and operation and maintenance costs of each alternative.
Other Criteria – to be addressed in the ROD	
State Acceptance	Evaluates the technical and administrative issues and concerns the State may have.
Community Acceptance	Evaluates the issues and concerns the public may have.

Each of the alternatives retained in the initial screening (refer to Section 6) will be evaluated based on these nine criteria; with the first seven criteria presented herein and the last two criteria (state and community acceptance) presented in the ROD once comments on the final RI/FS report have been received and assessed by the EPA.

As discussed in Section 6, the site has been evaluated based on the main source areas (landfill lobes and FDDA) and the resulting downgradient groundwater area. In an effort to be able to effectively analyze and compare each alternative, the alternatives were kept separate for each area. The decision on the source area control measures (e.g. FDDA soil excavation, landfill final cover system) will directly impact both the source area and downgradient groundwater. Although this condition was included in the downgradient groundwater alternative analyses and the source area groundwater discussions, it is noted that specific combinations of source area and downgradient groundwater alternatives were not developed and evaluated as part of the detailed analyses.

Prior to the presentation of the detailed analyses for each alternative, a supplemental assessment and information/discussion is presented on the following site conditions in relation to the detailed evaluation:

- type(s) of landfill final cover system;
- potential disposal options (on-site versus off-site) for impacted soil and/or sediment;
- surface water;
- remedial timeframe estimates; and
- remedial alternative cost estimates.

Further details are provided below.

8.1 LANDFILL FINAL COVER SYSTEM

As indicated in the RI and risk assessments, both landfill lobes were presumed to be covered with a low permeability final cover system (i.e., cap) as part of the remedy to be selected for this site. The resultant sampling plans and evaluations of risk incorporated an engineered final cover system in the development and implementation of these components of the RI/FS. As such, each retained alternative associated with the landfill lobes incorporates a low permeability final cover system. The purpose of this final cover system is to prevent exposure to human and ecological receptors and reduce infiltration through the landfill contents and leaching of contaminants into groundwater.

As described in the RI report, the two landfill lobes (Northern and Southern) differ with regard to VOCs in landfill gas and impacts to adjacent groundwater. As such and as discussed in the initial screening, three different types of low permeability landfill final cover system designs were evaluated for potential use at the site. These final cover systems included a low permeability soil cover, a low permeability single geomembrane cover, and a low permeability two layer composite cover. The detailed evaluations of alternatives presented herein are not specific to a final design specification with the exception that it will include a low permeability final cover system. During the performance of the RI/FS, EPA has determined that 40 CFR 264.310 (RCRA Subtitle C) is an ARAR with regard to the landfill cover design for this site. The final landfill cover system will meet the performance specifications of the 40 CFR 264.310 regulations.

In addition to these cover systems, although not applicable as a stand alone technology, components of an evapotranspiration (ET) cover system was retained as a potential option to be used in conjunction with a low permeability final cover system. Components of an ET cover design may be incorporated into the final design scheme (i.e. design of the type and increased number of plantings/landscaping to reduce infiltration (and stormwater run-off) during select seasons of the year, etc.). Further evaluation of the effectiveness and use of components of an ET cap will be performed and determined in the design stage of the final cover system.

All of the three final cover systems initially screened provide comparable protection of risks to human health and the environment and will attain RAOs in a similar timeframe (upon completion of the final cover system). The long term effectiveness/permanence and implementability evaluation indicated that the low permeability composite cover and the low permeability single geomembrane cover systems will provide a higher level of reliability to prevent infiltration than the low permeability soil cover and a lower potential for landfill slope failure over time since both the low permeability composite cover and the low permeability single geomembrane cover systems incorporate a drainage layer.

The short term impacts to the surrounding community, however, may be slightly higher for the low permeability composite cover, followed by the low permeability single geomembrane cover system, and then the low permeability soil cover system, due to the potential increased amount of cover material required to be brought on-site, increasing the local truck/vehicular traffic through the area. None of the final cover systems reduce toxicity, mobility and volume through treatment; as the waste will remain in place. The collection and/or treatment of landfill gas will be the same for each of the final cover systems. The estimated cost to construct the low permeability composite cover system was the highest, with the low permeability single geomembrane cover and the low permeability soil cover systems significantly lower.

Additional discussion of other components of the landfill final cover system (i.e. extent of final cover system, storm water management, etc), is provided below. The detailed analysis of the final cover system and the landfill alternatives take into account each of these design components.

With the existing limits of landfill waste up to the dirt access roadway along the northern perimeter of the site and in proximity to wetland resource areas and Sutton Brook, the extent of the final cover system, if placed directly on the current limits of waste, would pose potential issues. Along the northern edge of the Northern landfill lobe, the waste extends up to the edge of the dirt roadway and the property line. If the final cover system was placed on the existing limits of waste, portions of the dirt access roadway would be covered, requiring relocation of the roadway and a possible property easement. Other options for this area include removing/relocating the waste so that the final cover system does not impede upon the dirt access roadway or construction of a gabion wall along the northern edge of waste. Due to the volume of waste that would require relocating, the subsequent re-grading that would be required (increasing the time and cost of implementation), and the potential opposition of extending the cap and access roadway into the adjacent properties, installation of a gabion wall (anticipated approximately 4 to 6 feet in height, depending on type of final cover system utilized) is carried through in the conceptual landfill design. Actual final cover system components (i.e. use of a gabion wall, road relocation, etc.) will be determined during the design phase.

The installation of the landfill cover would result in the unavoidable destruction of existing wetlands, although during remedial design the effects of remedial activities on the wetlands will be evaluated and minimized. Again, relocating the waste will be a potential design consideration; however, for conceptual design purposes, the final cover system is assumed to extend into the wetland resource areas. These areas are presented on the associated figures and in the detailed description tables, where appropriate. Compensatory wetlands mitigation would be performed as necessary to comply with ARARs. The actual extent of the final cover system in the resource areas will be determined during the design phase. Available practicable means will be used to reduce the risk of flood loss, to minimize the impact of floods and to restore and preserve floodplains. In areas where the landfill cover will result in the filling in of areas within the 100-year floodplain, there will be a replication of 100-year floodplain space equivalent to the amount loss by the final cover.

The third issue with the extent of the existing waste and subsequent final cover system is along the northern edge of the Southern lobe. A stretch of the existing landfill waste (between GP-12 and GP-13) is proximate to Sutton Brook. Construction of the final cover system over these existing limits would extend into the brook; therefore, relocation of waste in this area will be required (for alternatives LF-2 and LF-3).

During the landfill final cover system detailed analysis, storm water management components of the final cover system design were evaluated to determine if and where storm water could be directed following construction. Currently, the majority of storm water infiltrates through the landfill, with a smaller percentage flowing along the surface of the landfill. The main component, or advantage, of constructing a final cover system is to reduce and/or eliminate the infiltration through the landfill waste. Therefore, a larger volume of storm water will require management following construction. Preliminary estimates based on the size and location of the landfill lobes has indicated that stormwater detention basins will be required along the perimeter of both landfill lobes; however, due to the presence of wetland resource areas surrounding the majority of the landfill, limited area is available for storm water management.

Conceptually, as further evaluation will be required during the design stage of the final cover system, approximately 131,000 sq feet (2.5 feet in depth) and 68,700 sq ft (2 feet in depth) will be required for stormwater management basins for the Northern and Southern landfill lobes, respectively. A conceptual plan of areas that may be used for storm water management is provided on Figure 8-1. These areas include:

- for the Northern lobe: an area to the east (some wetlands impacts), the upland area to the northwest, and the FDDA, and
- for the Southern lobe: a portion of the deep marsh located to the west of the Southern lobe.

If any of these areas are identified resource areas, then they will require re-creation elsewhere on the site. Conceptual estimates of the area of wetlands that may be impacted as a result of the extent of the cap or from being used for storm water management are approximately 65,000 sq ft for the Northern Lobe and 80,000 sq ft for the Southern Lobe.

Use of the eastern side of the Northern landfill lobe may assist in providing/maintaining flow to the upgradient portion of the wetlands and Sutton Brook. In addition, due to the size of the Northern lobe, use of the FDDA as a storm water management area is likely going to be required; therefore, this potential re-use of the FDDA has been evaluated during the detailed analysis of each FDDA alternative. Use of a portion of the deep marsh as a storm water management area for the Southern lobe may be beneficial as it flows into the wetland area to the west of the Southern lobe and may assist in hydraulically controlling or preventing the spread of groundwater impacts in this area with the change in flow patterns resulting from the capped landfill. Again, hydrologic evaluations of the area as a result of the landfill final cover system will be required during the design stage so that resource areas are maintained and impacts are minimized. For the purposes of the FS, these areas are conceptually shown as *potential* storm water management areas to assist with the detailed analysis (i.e. re-use options on-site, cost estimates, remedial evaluation of the FDDA, etc.).

The leachate component of the final remedy will be incorporated into the landfill final cover system design for each of the landfill alternatives evaluated. The design and construction of the final cover system will reduce the potential for leachate generation and therefore related impacts to groundwater. Given that some of the landfill waste appears to extend to and potentially below the groundwater table and that the final cover system will prevent leachate outbreaks at the ground surface, a leachate collection system is not anticipated. However, an evaluation will be performed during the design stage of the final cover system to determine the applicability of such a collection system. Regardless, a routine leachate monitoring program will be incorporated into the full scale landfill final cover system O&M plan and has been included in the landfill lobe alternative description and analysis.

As discussed in Section 7.1, a passive vent system will be incorporated into each of the landfill lobe alternatives that include construction of a final cover system (LF-2 through LF-4). In addition, it is assumed that additional monitoring will be performed along the northern edge of the Northern lobe prior to design. For the purposes of the detailed analyses, piping to incorporate an active system either to control landfill gas migration and/or as part of an enhanced landfill gas extraction system (ELGE) for VOC mass removal will be designed and installed during the landfill final cover system construction. For the purpose of the FS, the final use of the landfill following cover installation has been assumed to be passive recreation.

8.2 DISPOSAL OPTIONS FOR SOURCE AREA SOILS/SEDIMENTS

With the design and construction of a final cover system for both the Southern and Northern landfill lobes, disposal or re-use (as shaping and grading material) beneath the final cover system is a feasible, practical and cost-effective option for the source area remediation. All material excavated from the site (soil, sediment and/or wetland soil) will be appropriately characterized prior to removal to determine if the material is characteristically hazardous or non-hazardous.

Given that each of the landfill lobe alternatives include removal of sediments from areas located in between the two lobes, dewatering activities will be required prior to the potential disposal or re-use (on-site or off-site) of these sediments. For the purposes of this FS, we have assumed the construction of a dewatering area that would be located within the boundaries of the site and be constructed following typical containment/dewatering designs. The specific details (location, type of containment, etc.) will be determined in the design stage upon selection and determination of the volumes of sediments that would require dewatering.

The waste characterization data from all non-hazardous material will be evaluated to determine the re-use options available (i.e. will it meet the MassDEP Comm 97-001 re-use requirements). If the data indicates that re-use is an available option, then utilization on-site beneath the final cover system is an applicable alternative. If the material is determined to be characteristically hazardous, a cost/benefit analysis will be conducted to determine if the material should be sent off-site for disposal at an approved hazardous waste disposal facility, or treated on-site (so it is no longer hazardous) and disposed of off-site or on-site.

The advantages and disadvantages of disposing of the material on-site or off-site, are summarized below.

Summary of Soil/Sediment Disposal Options

	On-site Disposal or Re-use	Off-site Disposal or Re-use
	• No direct exposure to the material; all human health and/or ecological risks are eliminated since the material is beneath the low permeability final cover system. • This option complies with applicable ARARs and achieves RAOs. • Significantly reduced truck traffic to/from the site. • Reduced costs (approximately $15 to $25 per cy).	• No direct exposure to the material; all human health and/or ecological risks are eliminated since the material is removed from the site. • This option complies with applicable ARARs and achieves RAOs. • No residual risks are present on-site.

Summary of Soil/Sediment Disposal Options

Disadvantages	On-site Disposal or Re-use	Off-site Disposal or Re-use
	• There is no reduction in toxicity, mobility or volume *through treatment.* • Residual risks may remain on-site	• There is no reduction in toxicity, mobility or volume *through treatment.* • Increased truck traffic to/from the site. • More expensive (approximately $30 to $60 per cy). • More risk of potential exposure to other receptors during transport off-site to the disposal facility.

Since both options provide a means to re-use the material (shaping/grading, etc.), comply with applicable ARARs, will achieve RAOs and are essentially very similar alternatives, with the exception of the location that the material would be disposed of or re-used, the additional benefits of reducing the truck traffic on local roads during construction activities and the reduction in overall costs, make on-site disposal or re-use a more practical, efficient and cost effective option. Therefore, throughout the remainder of the detailed analysis, the alternatives that utilize soil and/or sediment disposal will be evaluated for on-site disposal and/or re-use. If material is determined to be hazardous during waste characterization, a cost/benefit analysis will be conducted to determine if off-site disposal or on-site treatment and disposal should be implemented.

8.3 SURFACE WATER

As discussed in the RI Report and the initial screening, on-site surface water has been impacted by the existing and former source areas (i.e. landfill waste, FDDA, groundwater and/or sediment). By addressing these source areas, through the selected site-wide remedy, the impacts to surface water will be reduced and/or eliminated. Surface water remediation is directly tied to each of the source area remedial alternatives; implementation of a combination of remedial technologies (i.e. capping the landfills, excavation of sediments and/or soil, groundwater containment and/or treatment, etc.) will reduce and/or eliminate impacts to surface water. Therefore, an individual treatment technology for surface water is not included in any of the source area or downgradient alternatives; rather, surface water monitoring is incorporated into the operations and monitoring plan for the site (following the source area remedy implementation).

8.4 TIMEFRAME TO MEET RAOS

As part of the detailed analysis of alternatives, the estimated timeframe to meet RAOs (i.e., achieve PRGs) was qualitatively calculated for each groundwater alternative. However, the actual time to achieve groundwater PRGs cannot be accurately predicted as there are a wide number of subsurface mechanisms contributing to the natural attenuation of contaminants (e.g., biodegradation, dispersion, dilution, sorption, and volatilization), a degree of uncertainty associated with actual subsurface conditions, the physical and chemical mechanisms associated with remediation of groundwater, and the effectiveness of various treatment technologies. As a result, the timeframes are general estimates with their primary intent being a means of comparing remedial alternatives. As such, the estimates are provided as a range. A

description of the method used to estimate the timeframes to achieve groundwater PRGs, as well as input parameters and assumptions, is provided in Appendix C.

8.5 REMEDIAL ALTERNATIVE COST ESTIMATES

Utilizing the detailed descriptions of each remedial alternative (presented as Table 8-1 through 8-15), feasibility level cost estimates were developed. Costs presented in this analysis are based on existing data and knowledge of the site and will be re-evaluated at the time of remedial design of the selected alternative. Per the RI/FS guidance (USACE and USEPA, 2000), the costs are intended to be within the target accuracy range of -30 to +50 percent of actual cost. For comparison purposes, the costs for each alternative are estimated for 30 years, regardless of the anticipated time frames beyond 30 years to meet RAOs. The relative change in present value O&M costs is minimal past the 30 year timeframe. Costs are presented in the detailed analysis tables for each remedial alternative and backup is provided in Appendix D.

8.6 DETAILED ANALYSIS – SOURCE AREA – LANDFILL LOBES

Further details on each alternative description for the landfill source area, including treatment types, volumes, areas or flowrates, estimated time to reach RAOs and anticipated re-use options, are provided in Tables 8-1a through 8-4a. The detailed analysis for the four alternatives for the landfill lobe source area are provided on Tables 8-1b through 8-4b. A discussion of the analysis is included for each alternative below. Refer to Appendix E (Table E-1) for an evaluation of each remedial alternative's compliance with ARARs.

8.6.1 Alternative LF-1

No Further Action

The No Action alternative was developed and screened for baseline comparison purposes in accordance with the NCP. The No Action alternative, LF-1, indicates that no remedial response actions will be performed in the landfill lobe source area. This alternative is evaluated to identify the concerns posed by the site if no remedial actions are implemented. Existing control measures, such as the soil layer covering the landfill waste, would not be maintained or improved. Only annual site inspections and five-year reviews of site conditions are proposed as part of this alternative. No active remedial measures are proposed to limit human or ecological exposure to site contaminants associated with the landfill waste, brook sediment, and/or groundwater, or to reduce contaminant mass, toxicity, or mobility.

A summary of the alternative description, including remedy components, operation, maintenance and monitoring requirements, area/volume of media addressed, the estimated timing for construction and attainment of RAOs is provided in Table 8-1a. The detailed analysis for this alternative, evaluating this remedy based on the seven criteria discussed above, is provided as Table 8-1b.

8.6.2 Alternative LF-2

Containment of waste, vent landfill gas, restoration of wetlands and brook, partial containment of groundwater with a vertical barrier and groundwater remediation

Alternative LF-2 incorporates a series of source control measures to eliminate current and potential future human and ecological risks. The main source control components include (refer to Figure 8-2 for a conceptual layout of this alternative):

- Construction of a low permeability cover system over both landfill lobes, including:
  - Engineered cap over both lobes: Northern lobe - 30 acres and Southern lobe – 10 acres;
  - Landfill waste relocation, as needed (estimated 3,200 sq ft for the Northern lobe and 7,000 sq ft for the Southern lobe);
  - Consolidation and relocation of miscellaneous debris piles across the site beneath the landfill cover system;
  - Installation of landfill gas system, including the potential for an ELGE system for VOC removal; and
  - Stormwater management (construction of detention ponds located to the east & west of the Northern lobe and west of the Southern lobe)
- Excavation of approximately 900 cubic yards of impacted sediment in Sutton Brook (between the two landfill lobes) with on-site disposal (assuming not a characteristic hazardous waste) and restoration of the brook;
- Containment of groundwater with a vertical barrier along a portion of the Southern lobe to eliminate future impacts to the brook via groundwater discharge (est. 1,700 linear feet to a depth of approximately 30 feet below current grade); and
- Remediation of groundwater at the downgradient end of the containment barrier.

In addition to these source control measures, the following other components of this alternative will also be implemented:

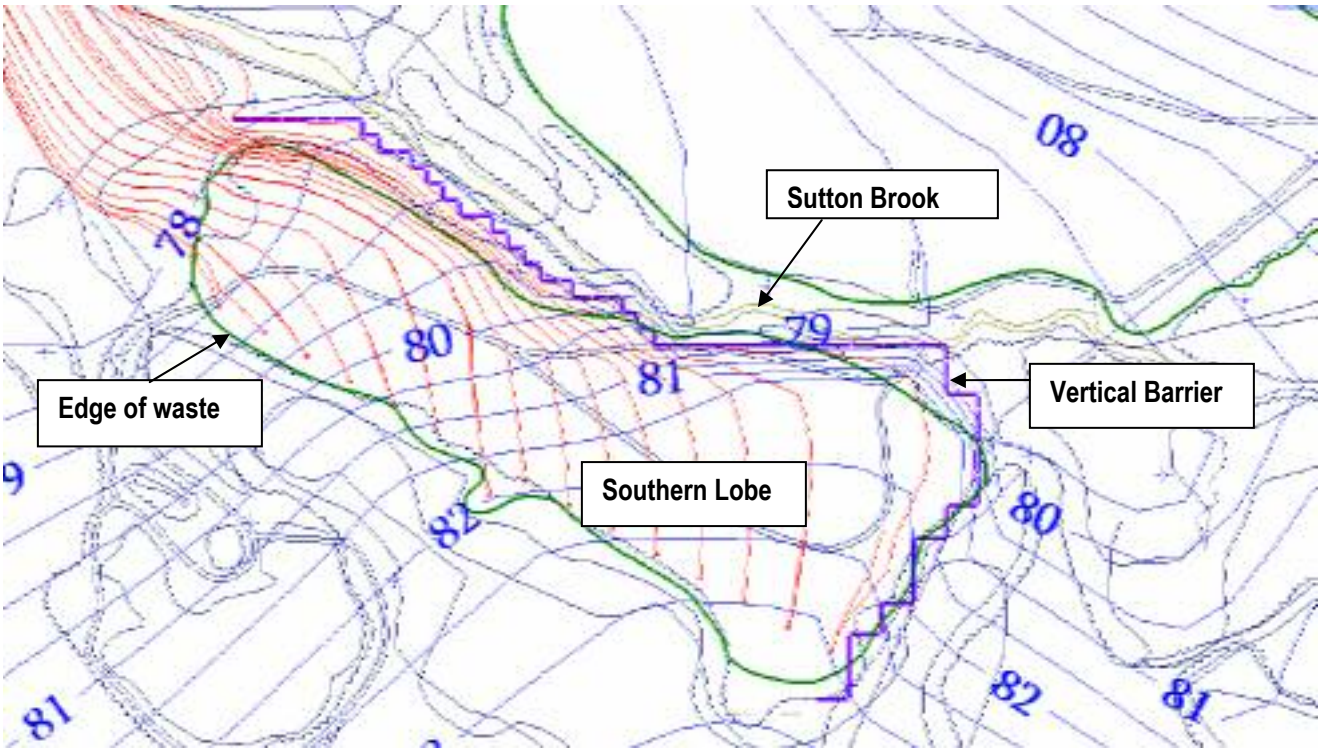
- Institutional controls to limit future use of the landfill lobes and groundwater (specifically, restrict the future use/access to the landfill and restrict the future use of groundwater until remedial goals are met);
- Long term monitoring of groundwater, landfill gas, leachate, and surface water; and
- Operation and maintenance of each component of the remedy (i.e. cap repairs, mowing, etc.).

In Alternative LF-2, groundwater is addressed through a combination of containment and remedial actions. The remedial approach for groundwater immediately downgradient of the Southern Lobe incorporates a vertical barrier that would be installed the length of the impacted portion of Sutton Brook between the Southern lobe and Sutton Brook to eliminate future impacts to the brook via contaminated groundwater discharge. The type of impermeable vertical barrier (i.e. sheet pile, slurry wall, etc.) will be determined during the design phase given the site specific details (i.e. hydrogeology, access, etc.) should it be selected as the remedial alternative. The design of the impermeable barrier would be required to meet the site RAOs and ensure that groundwater from the Southern lobe would not impact Sutton Brook in the future.

The remedial approach for groundwater immediately downgradient of the Northern lobe is monitored natural attenuation. This approach is applicable for Northern lobe groundwater based on the following

conditions: 1) low concentrations of contaminants have been detected in groundwater immediately adjacent to the Northern lobe (no or limited exceedances of MCLs); and 2) concentrations in groundwater are expected to further decrease upon implementation of the source control remedial actions.

With the implementation of the source control remedial measures for this alternative (i.e. landfill cover, excavation of impacted sediment in the brook, installation of the vertical containment barrier, and construction of storm water detention basins), groundwater and surface water hydrology and contaminant migration and distribution are anticipated to change from current configurations. Using MODFLOW, groundwater simulations were run with the landfill capped (eliminating infiltration through the waste) and with a vertical containment barrier between the brook and northern and eastern boundaries of the Southern landfill lobe, as shown on the figure below. The base of the vertical barrier was simulated to be 30 feet below grade (approximate depth to the bedrock surface; if not bedrock, then within the lower permeability till layer).



Based on this modeling, the vertical barrier would significantly reduce if not prevent groundwater migration and discharge into the brook and re-direct groundwater from beneath the Southern lobe towards the western/northwestern end of the landfill. In order to achieve this condition under model simulations, the vertical barrier was extended along the southeastern edge of the landfill lobe. The contours on the above figure result from the interpolation and grid spacing used to display the simulated heads. The steepness of the contours adjacent to the wall indicates that it effectively separates flow within the Southern lobe from that occurring north of the wall. As would be expected, groundwater flowing beneath the landfill may create a slight mound behind the barrier. Under current model simulations, the rise in water table varies over the Southern Lobe from approximately 0.1 feet in some areas to an approximate maximum of 2.6 feet with an average of around 1 foot. Although there is some predicted mounding,

given the higher hydraulic conductivities of the upper overburden materials, the predominant groundwater flow direction is anticipated to remain in the horizontal direction (as depicted in the above figure).

This technology does not provide for 'full containment' around the Southern landfill lobe; as it allows groundwater to flow through the landfill to the downgradient wetlands and along the barrier. As a result, additional groundwater remedial actions (i.e. MNA, groundwater extraction and ex-situ treatment, etc.) will be required in conjunction with the 'partial containment' (i.e. impermeable vertical barrier) to meet the site RAOs. Further evaluation on the type of groundwater remediation technology to be utilized in conjunction with the vertical containment feature is provided below.

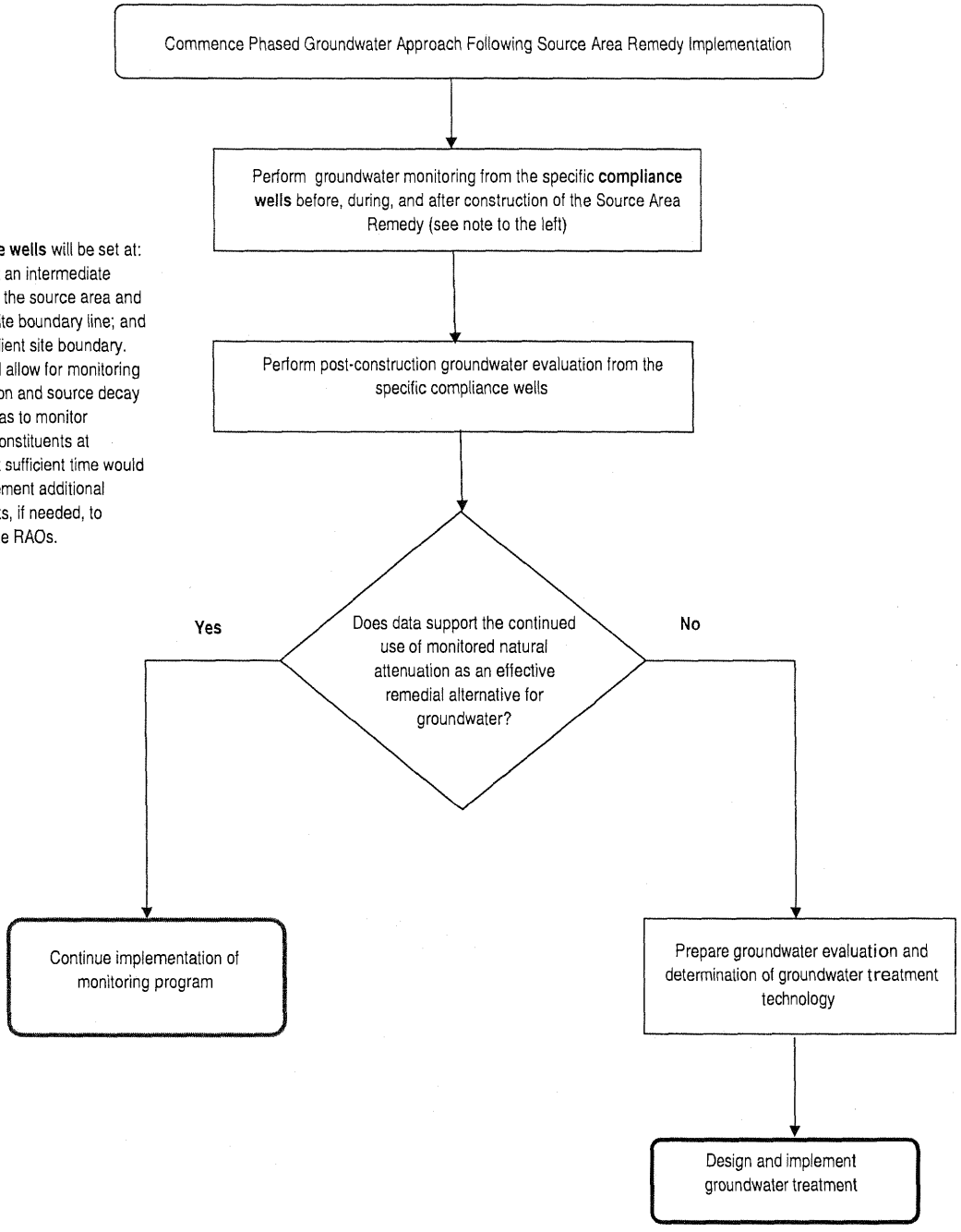
The technologies for groundwater remediation retained from the initial screening included: 1) in-situ treatment methods (including chemical oxidation, permeable reactive barrier, phytoremediation utilizing a phytobed, enhanced bioremediation, and engineered treatment wetland); 2) naturally occurring attenuation mechanisms (monitored natural attenuation); and 3) collection and ex-situ treatment of groundwater. The selection of a groundwater remedial technology or combination of technologies is dependent and may substantially be influenced by groundwater flow patterns and contaminant concentrations resulting from construction of the final cover system and installation of the vertical containment barrier.

The main contaminants in groundwater that emanate from the Southern lobe include VOCs (chlorinated VOCs, BTEX, 1,4-dioxane, and THF), SVOCs, and metals. Due to the wide range in contaminants, more than one technology will likely be required to adequately address the impacted groundwater. Screening of the groundwater technologies indicated that current conditions (without source area remediation) hydraulically downgradient of the Southern lobe are reducing contaminant concentrations in groundwater as they migrate away from the source area (Southern lobe). As discussed in Section 7.2.1 and illustrated on Figure 7-3:, concentrations as a result of natural attenuation processes have decreased over time and space from the source area (e.g. MW-4S) to downgradient intermediate areas (MW-22M).

Given the groundwater conditions, the LF-2 alternative has been divided into two separate alternatives with respect to groundwater. Alternative LF-2a consists of a phased approach to the implementation of the groundwater component following the landfill cover and vertical barrier construction and Alternative LF-2b consists of the implementation of an active groundwater remedial action at the end of the containment barrier following the landfill cover and vertical barrier construction. The other source control actions described above would be the same under both scenarios.

Alternative LF-2a would incorporate a period of time between the completion of source area remedial measures where groundwater flow, geochemistry, contaminant distribution, and migration would be monitored. Based on the results of the natural attenuation processes (as presented in Section 7.2), a MNA approach would be initiated immediately upon construction of the landfill final cover system and the groundwater vertical containment barrier. Monitoring would be performed to determine the resulting flow regime, contaminant levels, and effectiveness of the existing conditions to treat contaminants through natural attenuation. Site specific criteria will be established to compare the results from this monitoring to determine the applicability of MNA or if additional measures (e.g., in situ chemical oxidation, groundwater extraction and treatment) need to be implemented. A conceptual plan for the phased groundwater approach is provided in the flow chart on the following page.

CONCEPTUAL
PHASED GROUNDWATER APPROACH FLOW CHART



NOTE: **Compliance wells** will be set at: the source area; at an intermediate location in between the source area and the downgradient site boundary line; and near the downgradient site boundary. These locations will allow for monitoring of natural attenuation and source decay processes, as well as to monitor concentrations of constituents at locations, such that sufficient time would be allowed to implement additional remedy components, if needed, to continue to meet the RAOs.

Under alternative LF-2b, following construction of the landfill cover and vertical barrier, an area immediately downgradient of the Southern Lobe and barrier would be targeted for active and focused groundwater treatment (refer to Figure 8-2). Given the anticipated change to subsurface conditions, pilot testing of potential treatment methods will be conducted as an initial phase of this component. These tests would be developed for either in situ treatment methods (i.e., chemical oxidation, enhanced bioremediation, etc.) or groundwater extraction and treatment methods (i.e., pumping tests, etc.).

For cost comparisons within this FS, the groundwater flow model was used to simulate capture zones under pumping conditions within this area of the site. The model indicated that a groundwater extraction and treatment system consisting of one to two extraction wells placed downgradient of the vertical barrier wall pumping at a combined rate of 15 gallons per minute (gpm) would meet the alternative's objectives. Actual pumping conditions would be determined during pre-design pumping tests. Optimizing well positions and pumping rates will be performed to meet the alternative's objectives while mitigating potential impacts to the brook/wetlands due to extraction effects.

Table 8-2a presents a more detailed summary of the alternative description, including remedy components, operation, maintenance and monitoring requirements, area/volume of media addressed, and the estimated timing for construction and attainment of RAOs. The detailed analysis for Alternative LF-2a and LF-2b based on the seven evaluation criteria discussed in the beginning of this section is provided as Table 8-2b(i) and Table 8-2b(ii), respectively.

8.6.3 Alternative LF-3

Containment of waste, vent landfill gas, restoration wetlands and brook, and contaminated groundwater collection and treatment

Alternative LF-3 incorporates a series of source control measures to eliminate/control current and potential future human and ecological risks. With regard to the landfill closure and brook restoration in between the two landfill lobes, this alternative is the same as Alternative LF-2. The main difference between the two alternatives is the approach to groundwater. As such, refer to the discussion presented above under Alternative LF-2 for the landfill and brook remediation, including the additional components (e.g., institutional controls).

With regard to groundwater, alternative LF-3 incorporates a groundwater extraction and ex-situ treatment approach in place of the containment (through vertical barrier) and a focused groundwater remedial action for the Southern lobe and monitored natural attenuation for the Northern lobe. This alternative would not have a phased component to groundwater since there is no other containment portion of the groundwater remedy to protect the remediated brook. The goal of this approach would be to contain groundwater from discharging into Sutton Brook in between the two lobes and reduce contaminant mass in groundwater by aggressively extracting groundwater from wells positioned along the downgradient sides of the two landfill lobes. This alternative is the most aggressive alternative with respect to groundwater, focusing on meeting regulatory goals as quickly as practicable.

The MODFLOW model indicated that a groundwater extraction and treatment system consisting of 10 wells along the downgradient edge of the Northern lobe pumping at a combined rate of 150 gpm and 7 wells along the downgradient edge of the Southern lobe pumping at a combined rate of 95 gpm for a total of 17 wells pumping at a combined rate of 245 gpm would be required to meet the alternative's objectives. Drawings depicting the capture zones via particle tracking are provided in Appendix F.

Actual pumping conditions would be determined during pre-design pumping tests. Although the model utilized methods which maintain water levels in Sutton Brook at calibrated elevations, impacts to the brook (i.e., lower water levels) due to groundwater extraction are not expected to be significant based on a review of brook and predicted extraction flow rates. Optimizing well positions and pumping rates will be performed to meet the alternative's objectives while mitigating potential impacts to the brook/wetlands due to extraction effects.

The remedial technologies for ex-situ groundwater treatment retained from the initial screening included reverse osmosis, air stripping, aeration, carbon adsorption, advanced oxidation processes and ion exchange, as well as additional pre-treatment steps including filtration, precipitation, and clarification. The selection of an ex-situ groundwater treatment technology or combination of technologies for this alternative will be determined during the design stage. Due to the wide range in contaminants, more than one treatment technology will be required to adequately address the impacted groundwater. Based on a preliminary screening of these technologies, it is anticipated that metals treatment and advanced oxidation (e.g. UV oxidation), as well as one or more pre-treatment steps (filtration, etc.) will be required to meet discharge limits.

Figure 8-3 presents a conceptual layout of this alternative and Table 8-3a provides a more detailed summary of the alternative description, including remedy components, operation, maintenance and monitoring requirements, area/volume of media addressed, the estimated timing for construction and attainment of RAOs. Incorporating the ex-situ groundwater treatment technologies discussed above, alternative LF-3 was screened based on the seven evaluation criteria discussed in the beginning of this section. The detailed analysis for this alternative is provided as Table 8-3b.

8.6.4 Alternative LF-4

Containment of waste, vent landfill gas, re-routing of the brook, excavation of impacted sediment hot spots, partial containment of groundwater (vertical barrier) with groundwater remediation.

Alternative LF-4 incorporates a set of source control measures to eliminate/control current and potential future human and ecological risks. The approach to the landfill closure is similar to the other two alternatives; however, the approach to the brook and groundwater differs in Alternative LF-4 compared to the two other alternatives.

The main source control components that this alternative incorporates include (refer to Figure 8-4 for a conceptual layout of this alternative):

- Construction of a low permeability cover system over both landfill lobes, including:
  - Engineered cap over both lobes: Northern lobe - 30 acres and Southern lobe – 10 acres;
  - Landfill waste relocation, as needed (estimated 3,200 sq ft for the Northern lobe and to 7,000 sq ft for the Southern lobe);
  - Consolidation and relocation of miscellaneous debris piles across the site beneath the landfill cover system;
  - Installation of a landfill gas system;
  - Stormwater management (construction of detention ponds located to the east of the Northern lobe and south of the Southern lobe); and

- As described below, this alternative includes permanently re-routing the portion of Sutton Brook that passes between the two landfill lobes. If selected, this alternative includes the potential for imported materials from off-site locations (soil, fill, construction debris etc.) to be properly disposed in the area in between the two landfill lobes.

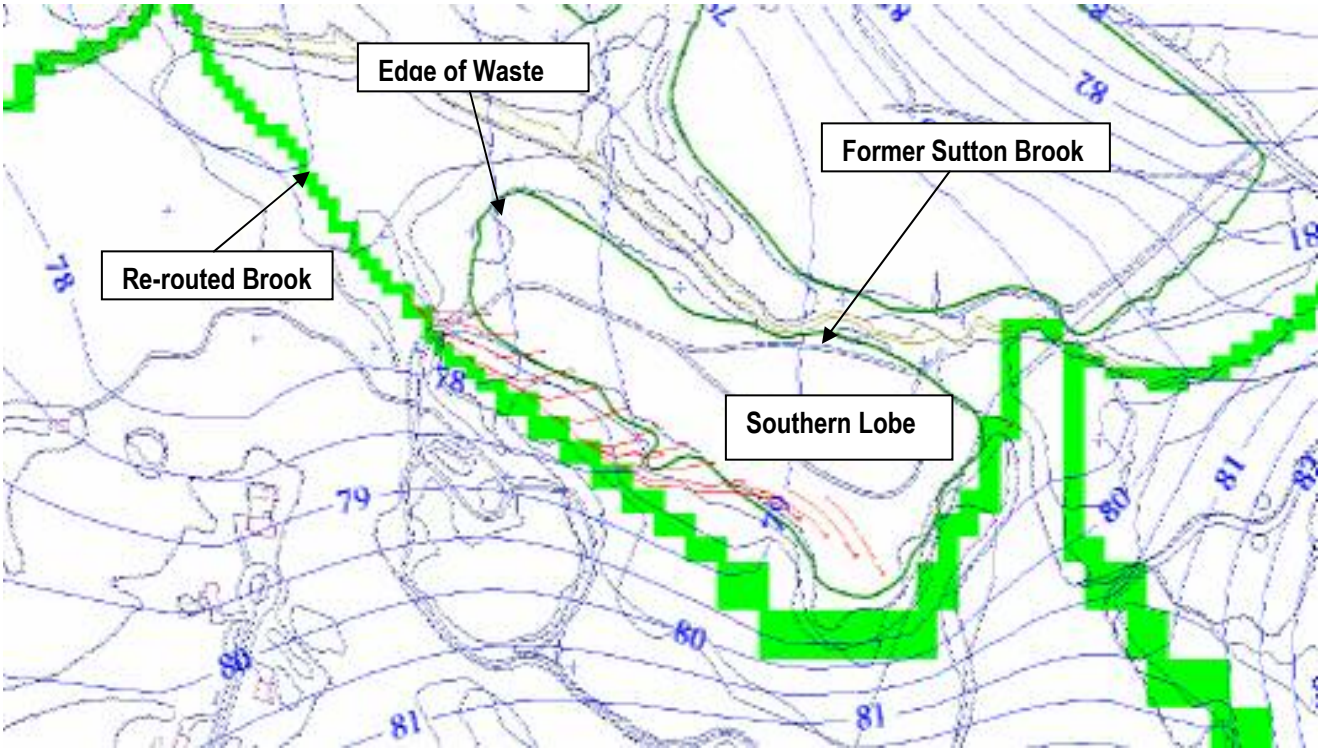
- Excavation of hot spot areas (approximately 200 cubic yards) of impacted sediment in Sutton Brook (between the two landfill lobes) with on-site disposal (assuming not a characteristic hazardous waste);
- Re-routing of the brook around the southern boundary of the Southern lobe;
- Containment of groundwater with a vertical barrier along a portion of the Southern lobe between the lobe and the newly routed brook to minimize future impacts to the brook via groundwater discharge (est. 1,500 linear feet to a depth of approximately 30 feet below current grade) – see discussion below; and
- Remediation of groundwater at the downgradient end of the containment barrier.

In addition to these source control measures, the following other components of this alternative will also be implemented:

- Institutional controls to limit future use of the landfill lobes groundwater (specifically, restrict the future use/access to the landfill and restrict the future use of groundwater until remedial goals are met)
- Long term monitoring of groundwater, surface water, landfill gas and leachate
- Operation and maintenance of each component of the remedy (i.e. cap repairs, mowing, etc.).

Re-routing of the brook presents two significant issues: 1) major modification of the hydrologic and hydrogeological flow regime in the area and the associated effects on contaminant migration; and 2) wetland regulation issues that will require substantial compliance with during implementation.

With regard to the changing hydrogeological flow regime, the following figure depicts simulated groundwater conditions incorporating capped landfills and the re-routed brook. As indicated below, flow is simulated to show significant alterations due to the new location of the brook with groundwater from beneath the Southern lobe discharging into the newly routed brook to the south as opposed to its current discharge to the north.



Based on these conditions, Alternative LF-4 incorporates the installation of a vertical barrier along the southern side of the Southern lobe between the landfill and the re-routed brook (similar to Alternative LF-2 along the northern and eastern sides of the landfill). Refer to Figure 8-4 for its proposed location.

Similar to alternative LF-2b, following construction of the landfill covers, vertical barrier, and re-routing of the brook, an area immediately downgradient of the landfill and barrier would be targeted for active and focused groundwater treatment (refer to Figure 8-4). Given the anticipated change to subsurface conditions, pilot testing of potential treatment methods will be conducted as an initial phase of this component. These tests would be developed for either in situ treatment methods (i.e., chemical oxidation, enhanced bioremediation, etc.) or more traditional extraction and treatment methods (i.e., pumping tests, etc.).

For cost comparisons within this FS, the groundwater flow model was used to simulate capture zones under pumping conditions within this area of the site. The model indicated that a groundwater extraction and treatment system consisting of one to two extraction wells placed downgradient of the vertical barrier wall pumping at a combined rate of 15 gallons per minute (gpm) would meet the alternative's objectives. Actual pumping conditions would be determined during pre-design pumping tests. Optimizing well positions and pumping rates will be performed to meet the alternative's objectives while mitigating potential impacts to the brook/wetlands due to extraction effects.

The second significant issue associated with the brook re-routing is the wetland regulation issues that will require substantial compliance during implementation. The resource areas that will require alteration to implement this option include land under water bodies and waterways, inland bank, bordering vegetated wetlands, bordering land subject to flooding and riverfront area. Re-creation of this potential loss in resource areas, specifically the wetlands and bordering vegetated wetland, as well as flood storage

capacity, presents many challenges given the site conditions. An estimated 168,000 to 178,000 sq ft of non-resource area is present within the site for use in replication (depending on which FDDA alternative is selected). Due to the lengthier path that the brook would be required to take around the Southern lobe than its current path, an additional 37,000 sq ft of area would be required for the newly re-routed brook. As the majority of the newly re-routed brook passes through wetland resource areas, re-creation of this additional area will be required elsewhere. Due to the limited non-resource areas available on-site, if this alternative is selected in conjunction with other alternatives that require wetland replication (e.g. DGGW-4), meeting the replication requirements may prove to be difficult. An estimate of the amount of resource area that would require replication is in the order of approximately 150,000 sq ft.

Should the necessary area for wetland replication be available on-site, this alternative will also need to demonstrate that no other practical alternative exists with less, in terms of magnitude, resource area impacts. Under the Massachusetts Wetlands Protection Act, the project must demonstrate that there is no practicable alternative to the response action being proposed that would be less damaging to the resource areas. Both alternatives, LF-2 and LF-3, present viable options that are less damaging to the on-site resource areas.

Table 8-4a presents a more detailed summary of the alternative description, including remedy components, operation, maintenance and monitoring requirements, area/volume of media addressed, the estimated timing for construction and attainment of RAOs. The detailed analysis for Alternative LF-4 based on the seven evaluation criteria discussed in the beginning of this section is provided as Table 8-4b.

8.7 DETAILED ANALYSIS - SOURCE AREA – FORMER DRUM DISPOSAL AREA

Further details on each alternative description for the Former Drum Disposal Area (FDDA) source area, including treatment types, volumes, areas or flow rates, estimated time to reach RAOs and anticipated re-use options, are provided in Tables 8-5a through 8-9a. The detailed analysis for the five alternatives for the FDDA source area are provided on Tables 8-5b through 8-9b. A discussion of the analysis is included for each alternative below. Refer to Appendix E (Table E-2) for an evaluation of each remedial alternative's compliance with ARARs.

As discussed in the landfill cover system detailed analysis section above, use of, or a portion of, the FDDA as a storm water management area will likely be incorporated into the landfill closure design. Due to the limited amount of non-resource area surrounding the landfill lobes, the relatively large non-wetland resource area that the FDDA represents makes it a viable location to utilize as a storm water management area (i.e. detention basin) for the Northern lobe. Therefore, future re-use of the FDDA as part of the stormwater management system for the landfill cover system has been assumed during the detailed evaluation of FDDA alternatives.

8.7.1 Alternative FDDA-1

No Further Action

The No Action alternative was developed and screened for baseline comparison purposes in accordance with the NCP. The No Action alternative, FDDA-1, indicates that no remedial response actions will be performed in the former drum disposal area. This alternative is evaluated to identify the concerns posed by the site if no remedial actions are implemented. Only annual site inspections and five-year reviews of site conditions are proposed as part of this alternative. No active remedial measures are proposed to limit

human or ecological exposure to site contaminants associated with the impacted soil and/or groundwater, or to reduce contaminant mass, toxicity, or mobility.

A summary of the alternative description, including remedy components, operation, maintenance and monitoring requirements, area/volume of media addressed, the estimated timing for construction and attainment of RAOs is provided in Table 8-5a. The detailed analysis for this alternative, evaluating this remedy based on the seven criteria discussed above, is provided as Table 8-5b.

8.7.2 Alternative FDDA-2

Containment of soil (with cap) and groundwater (through extraction and ex-situ treatment)

Alternative FDDA-2 incorporates a combination of remedial measures to eliminate current and potential future human and ecological risks. These containment measures include:

- Construction of an engineered barrier over the impacted soil (low permeability cover over a 45,000 sq ft area) to prevent infiltration and eliminate direct exposures;

- Installation and operation of a groundwater collection and ex-situ treatment system to prevent downgradient migration of contaminants from the source area and reduce the mass of contaminants in the subsurface.

In addition to these remedial measures, institutional controls will be implemented to limit future use of the soil and groundwater, long term monitoring of groundwater will be conducted, and operation and maintenance of each component of the remedy (e.g. cap repairs, groundwater pump replacement, etc.) will be carried out.

Based on the MODFLOW model, to achieve this alternative's objective, four wells would be installed along the downgradient edge of the FDDA (in between MW-9/MW-7 triplet and MW-8 triplet) pumping at a combined rate of 20 gpm, as shown on Figure 8-5. Drawings depicting the capture zones via particle tracking are provided in Appendix F. Actual pumping conditions would be determined during pre-design pumping tests. Optimizing well positions and pumping rates will be performed to meet the alternative's objectives while mitigating potential impacts to the brook/wetlands due to extraction effects.

The remedial technologies for ex-situ groundwater treatment retained from the initial screening included reverse osmosis, air stripping, carbon adsorption, advanced oxidation processes and ion exchange, as well as additional pre-treatment steps (e.g. filtration). The selection of an ex-situ groundwater treatment technology or combination of technologies for this alternative would be determined during the design stage; however, preliminary screening reveals that metals treatment and advanced oxidation (potentially in conjunction with air stripping) will be required as well as one or more pre-treatment steps (e.g. filtration, etc.) to meet discharge limits.

Refer to Figure 8-5 for a conceptual layout of this alternative and Table 8-6a for a more detailed summary of the alternative description, including remedy components, operation, maintenance and monitoring requirements, area/volume of media addressed, the estimated timing for construction and attainment of RAOs. Alternative FDDA-2 was screened based on the seven evaluation criteria discussed in the beginning of this section. The detailed analysis for this alternative is provided as Table 8-6b.

8.7.3 Alternative FDDA-3

Excavation, treatment and/or disposal of soil with hydraulic containment of groundwater (through extraction and ex-situ treatment)

Alternative FDDA-3 incorporates a combination of source control and containment measures to eliminate current and potential future human and ecological risks. This alternative differs from FDDA-2 in that the approach directly addresses soil impacts through removal; while the groundwater approach is the same as FDDA-2.

Refer to the discussion above with regard to the groundwater component of the alternative as well as the additional measures (institutional controls, O&M, etc.). The only difference is a slight increase in groundwater flow rate to a combined flow of 24 gpm (from the 4 extraction wells) due to increased infiltration given that the low permeability cover under FDDA-2 would not be installed. Drawings depicting the capture zones via particle tracking are provided in Appendix F. Actual pumping conditions would be determined during pre-design pumping tests. Optimizing well positions and pumping rates will be performed to meet the alternative's objectives while mitigating potential impacts to the brook/wetlands due to extraction effects.

In place of a containment component for the soils, this alternative incorporates the excavation of contaminated soil to eliminate future exposure to receptors and leaching of residual source material to groundwater. Based on the following conditions, a soil volume of 8,900 cubic yards over a 38,300 square foot area is estimated for removal as part of this alternative:

- a comparison of the PRGs to existing site data;
- the area of soil removal from the previous soil/drum removal phase performed in this area; and
- the saturated soil/groundwater data.

The depth of soil removal varies depending on impacts to saturated soils/groundwater and/or shallow soil PRG exceedances (see Figure 8-6); however, the average depth is estimated to be 5 to 7 feet below ground surface. The excavated soil is anticipated to be disposed of on-site under the landfill cover. Based on the waste characterization testing results, some soils may require treatment prior to onsite disposal.

By removing the residual contaminants in soils near or at the water table surface, the timeframes to meet the groundwater RAOs are expected to be expedited.

Refer to Figure 8-6 for a conceptual layout of this alternative (with the groundwater extraction wells) and Table 8-7a for a more detailed summary of the alternative description, including remedy components, operation, maintenance and monitoring requirements, area/volume of media addressed, the estimated timing for construction and attainment of RAOs. The detailed analysis for this alternative based on the seven evaluation criteria discussed in the beginning of this section is provided as Table 8-7b.

8.7.4 Alternative FDDA-4

Excavation, treatment and/or disposal of soil with groundwater remediation (focused mass reduction)

Alternative FDDA-4 incorporates a combination of source control measures to eliminate current and potential future human and ecological risks to meet site RAOs.

Similar to the FDDA-3, this alternative provides source removal via soil excavation to eliminate exposure to this media by receptors. Removal of the remaining source material in soils will also reduce future leaching into groundwater and expedite the timeframe to meet groundwater RAOs. The volume of soil estimated under FDDA-3 would be the same under this alternative (8,900 cubic yards). The excavated soil is anticipated to be disposed of on-site under the landfill cover (with or without treatment depending on the concentrations detected in the excavated soil).

In place of a downgradient containment/reduction extraction approach (as in FDDA-3), upon removal of the impacted soil, a focused groundwater remediation program will be implemented. The technologies for groundwater remediation retained from the initial screening included: in-situ treatment methods, (including chemical oxidation, permeable reactive barrier, phytoremediation utilizing a phytobed, enhanced bioremediation, and engineered treatment wetland); naturally occurring attenuation mechanisms (monitored natural attenuation); and collection and ex-situ treatment of groundwater. The selection of a groundwater remediation technology or combination of technologies is dependent on the groundwater flow patterns and contaminant concentrations following the source/soil removal component of the remedial alternative and the installation of the stormwater management detention basin in this area.

The main contaminants in groundwater in the FDDA include VOCs (ketones, BTEX, 1,4-dioxane, and THF), SVOCs, and metals. Due to the wide range in contaminants, more than one technology will likely be required to adequately address the impacted groundwater. Screening of the groundwater technologies indicated that current conditions (without source area remediation) hydraulically downgradient of the FDDA are reducing contaminant concentrations in groundwater as they migrate away from the source area. As discussed in Section 7.2.1 and illustrated on Figure 7-2, concentrations as a result of natural attenuation processes have decreased over time and space from the source area (e.g. MW-9) to further downgradient wells (e.g., MW-11).

Alternative FDDA-4 would incorporate a period of time between the completion of source area remedial measures where groundwater flow, geochemistry, contaminant distribution, and migration would be monitored. Based on the results of the natural attenuation processes (as presented in Section 7.2), a MNA approach would be initiated immediately upon soil removal. Monitoring would be performed to determine the resulting flow regime, contaminant levels, and effectiveness of the existing conditions to treat contaminants through natural attenuation. Site specific criteria will be established to compare the results from this monitoring to determine the applicability of MNA or if additional measures (e.g., in situ chemical oxidation, groundwater extraction and treatment) need to be implemented. Refer to the previously provided flow chart in Section 8.6.2, which depicts a conceptual plan for the phased groundwater approach.

Refer to Figure 8-7 for a conceptual layout of this alternative and Table 8-8a for a more detailed summary of the alternative description, including remedy components, operation, maintenance and monitoring requirements, area/volume of media addressed, the estimated timing for construction and attainment of

RAOs. Alternative FDDA-4 was screened based on the seven evaluation criteria discussed in the beginning of this section. The detailed analysis for this alternative is provided as Table 8-8b.

8.7.5 Alternative FDDA-5

Excavation, treatment and/or disposal of soil with groundwater extraction and ex-situ treatment for area-wide contaminant reduction

Alternative FDDA-5 involves a combination of source control measures to eliminate current and potential future human and ecological risks. Similar to the FDDA-3 and FDDA-4, this alternative provides source removal via soil excavation to eliminate direct exposure to this media by receptors. Removal of the remaining source material in soils will also eliminate leaching to groundwater and expedite the timeframe to meet groundwater RAOs. The volume of soil estimated under FDDA-3 and FDDA-4 would be the same under this alternative (8,900 cubic yards). The excavated soil is anticipated to be disposed of on-site under the landfill cover (with or without treatment depending on the concentrations detected in the excavated soil).

In place of a downgradient containment/reduction extraction approach (as in FDDA-3) or a phased and focused groundwater remedial approach (as in FDDA-4), upon removal of the impacted soil under this alternative, groundwater in areas within and immediately downgradient of the source area will be extracted and treated ex-situ. Through institutional controls and treatment of the impacted groundwater, the risk of human consumption and the potential for downgradient migration will be eliminated.

The goal of this approach would be to contain groundwater from migrating downgradient from the source area and reduce contaminant mass in groundwater by aggressively extracting groundwater from wells positioned within and immediately downgradient of the source area. This alternative is the most aggressive alternative with respect to groundwater, focusing on meeting regulatory goals as quickly as practicable.

Based on the MODFLOW model, to achieve this alternative's objective, 5 extraction wells would be installed within the impacted area at a combined flow rate of 50 gpm, as shown on Figure 8-8. The groundwater treatment technologies would be the same as those described under Alternative FDDA-2 (refer to the preceding sections). Drawings depicting the capture zones via particle tracking are provided in Appendix F. Actual pumping conditions would be determined during pre-design pumping tests. Optimizing well positions and pumping rates will be performed to meet the alternative's objectives while mitigating potential impacts to the brook/wetlands due to extraction effects.

Refer to Figure 8-8 for a conceptual layout of this alternative and Table 8-9a for a more detailed summary of the alternative description, including remedy components, operation, maintenance and monitoring requirements, area/volume of media addressed, the estimated timing for construction and attainment of RAOs. Alternative FDDA-5 was screened based on the seven evaluation criteria discussed in the beginning of this section. The detailed analysis for this alternative is provided as Table 8-9b.

8.8 DETAILED ANALYSIS - SOURCE AREA – GARAGE AND STORAGE AREA

Further details on each alternative description for the garage and storage area, including volumes and estimated time to reach RAOs and anticipated re-use options, are provided in Tables 8-10a and 8-11a.

The detailed analysis for the two alternatives for the garage and storage area is provided on Tables 8-10b and 8-11b. A brief summary of the analysis is included for each alternative below. Refer to Appendix E (Table E-3) for an evaluation of each remedial alternative's compliance with ARARs.

8.8.1 Alternative GSA-1

No Action

The No Action alternative was developed and screened for baseline comparison purposes in accordance with the NCP. The No Action alternative, GSA-1, indicates that no remedial response actions will be performed in the garage and storage area. This alternative is evaluated to identify the concerns posed by the site if no remedial actions are implemented. Only annual site inspections and five-year reviews of site conditions are proposed as part of this alternative. No active remedial measures are proposed to limit human or ecological exposure to site contaminants associated with the impacted surface soil, or to reduce contaminant mass, toxicity, or mobility.

A summary of the alternative description, including remedy components, operation, maintenance and monitoring requirements, area/volume of media addressed, the estimated timing for construction and attainment of RAOs is provided in Table 8-10a. The detailed analysis for this alternative, evaluating this remedy based on the seven criteria discussed above, is provided as Table 8-10b.

8.8.2 Alternative GSA-2

Excavation, Treatment and/or Disposal of Impacted Soil

Alternative GSA-2 involves the excavation of impacted soil to eliminate current and potential future human and ecological risks. Based on the results of the RI and risk assessments, no additional controls or measures are anticipated for this alternative.

Comparing soil data to the PRGs and reviewing the risk assessment results, approximately 530 cubic yards of soil over an 8,150 square foot area has been incorporated into this alternative. Depths of soil removal range from 1 to 2.5 feet below grade. In addition to the removal of soils based on PRGs, removal of surficial soils and miscellaneous surface debris piles and stored equipment/vehicles is also anticipated to occur during this alternative's implementation. The excavated soil is anticipated to be disposed of on-site under the landfill cover.

Refer to Figure 8-9 for a conceptual layout of this alternative and Table 8-11a for a more detailed summary of the alternative description, including remedy components, operation, maintenance and monitoring requirements, area/volume of media addressed, the estimated timing for construction and attainment of RAOs. The detailed analysis for this alternative based on the seven criteria discussed above is provided as Table 8-11b.

8.9 DETAILED ANALYSIS - DOWNGRADIENT GROUNDWATER

For the purposes of this FS, downgradient groundwater refers to the area of groundwater hydraulically downgradient of the landfill lobes and FDDA in which concentrations of constituents have been detected in excess of PRGs (refer to Figure 6-2). As discussed in Section 7.2, existing data indicates that natural

attenuation processes in this area have stabilized the plume on-site and are continuing to degrade contaminants in-situ.

With the implementation of source control measures (e.g. landfill closure, FDDA containment or removal/treatment, etc.), the downgradient groundwater will be directly impacted as the source material will be removed or contained, minimizing further leaching and reducing the potential for infiltration. The four remedial alternatives retained for this area include no action, in-situ remediation of groundwater, hydraulic containment of groundwater on-site, and area-wide contaminant reduction.

Further details on each alternative description for downgradient groundwater, including volumes and estimated time to reach RAOs and anticipated re-use options, are provided in Tables 8-12a through 8-15a. The detailed analysis for the four alternatives are provided on Tables 8-12b through 8-15b. Refer to Appendix E (Table E-4) for an evaluation of each remedial alternative's compliance with ARARs. A description of each of the alternatives is provided in the following sections.

8.9.1 Alternative DGGW-1

No Action

The No Action alternative was developed and screened for baseline comparison purposes in accordance with the NCP. The No Action alternative, DGGW-1, indicates that no remedial response actions will be performed to address residual impacts to downgradient groundwater. This alternative is evaluated to identify the concerns posed by the site if no remedial actions are implemented. Only annual site inspections and five-year reviews of site conditions are proposed as part of this alternative. No active remedial measures are proposed to limit human or ecological exposure to site contaminants associated with the impacted sediment and wetland soil, or to reduce contaminant mass, toxicity, or mobility.

A summary of the alternative description, including remedy components, operation, maintenance and monitoring requirements, area/volume of media addressed, the estimated timing for construction and attainment of RAOs is provided in Table 8-12a. The detailed analysis for this alternative based on the seven criteria discussed above is provided as Table 8-12b.

8.9.2 Alternative DGGW-2

In-situ remediation

Alternative DGGW-2 involves implementation of an in-situ approach to address residual groundwater impacts in the downgradient portion of the site. In addition to the in-situ approach, institutional controls will be implemented to limit future use of groundwater (until RAOs are met), long term monitoring of groundwater will be conducted, and operation and maintenance of the in-situ approach (e.g. well development/maintenance, etc.) will be carried out.

The remedial technologies for in-situ groundwater remediation retained from the initial screening included enhanced bioremediation, engineered treatment wetland, chemical oxidation, permeable reactive barrier wall, and monitored natural attenuation. Based on the evaluation presented in Section 7.2, including modeling using NAS, natural attenuation processes are occurring on-site, with varying levels of efficiency depending on the specific compound. Based on the technology screening of the other in-situ technologies for the remediation of downgradient groundwater (e.g., implementation/access issues,

injection into wetlands and competing organic matter, etc.), monitored natural attenuation was retained for the initiation of Alternative DGGW-2.

However, final design of an in-situ groundwater remediation approach is dependent on the groundwater flow patterns resulting from the implementation of upgradient source control measures (e.g. construction of landfill final cover system, excavation or containment of FDDA soil, etc.). For this alternative, a phased approach towards the remedy will be incorporated to evaluate conditions after source control implementation (i.e., landfill closure, FDDA containment or excavation, etc.) to determine the post-construction effects on the groundwater flow, distribution, and migration processes.

Alternative DGGW-2 would incorporate a period of time between the completion of source area remedial measures where groundwater flow, geochemistry, contaminant distribution, and migration would be monitored. Monitoring of the downgradient groundwater would be performed to determine the resulting flow regime, contaminant levels, and effectiveness of the existing conditions to treat contaminants through natural attenuation. Site specific criteria will be established to compare the results from this monitoring to determine the applicability of MNA or if additional measures (e.g., in situ chemical oxidation, etc.) need to be implemented. Refer to the previously provided flow chart in Section 8.6.2, which depicts a conceptual plan for the phased groundwater approach.

Refer to Table 8-13a for a more detailed summary of the alternative description, including remedy components, operation, maintenance and monitoring requirements, area/volume of media addressed, the estimated timing for construction and attainment of RAOs. Utilizing the phased groundwater approach and addressing downgradient groundwater through MNA, alternative DGGW-2 was screened based on the seven evaluation criteria discussed in the beginning of this section. The detailed analysis for this alternative is provided as Table 8-13b.

8.9.3 Alternative DGGW-3

Groundwater Containment and Treatment

Alternative DGGW-3 involves installation and operation of a groundwater collection and ex-situ treatment system for hydraulic containment of impacted groundwater on-site and the reduction of contaminant mass through groundwater extraction and treatment. In addition, institutional controls will be implemented to limit future use of groundwater (until RAOs are met), long term monitoring of groundwater will be conducted, and operation and maintenance of the groundwater extraction and treatment system (e.g. groundwater pump replacement, etc.) will be carried out.

Based on the MODFLOW model, to achieve this alternative's objective, three wells would be installed within the downgradient groundwater area positioned proximate to Sutton Brook. Each well would extract groundwater at approximately 25 gpm for a combined flow rate of 75 gpm. Drawings depicting the capture zones via particle tracking are provided in Appendix F. Actual pumping conditions would be determined during pre-design pumping tests. Although the model utilized methods which maintain water levels in Sutton Brook at calibrated elevations, impacts to the brook (i.e., lower water levels) due to groundwater extraction are not expected to be significant based on a review of brook and predicted extraction flow rates. Optimizing well positions and pumping rates will be performed to meet the alternative's objectives while mitigating potential impacts to the brook/wetlands due to extraction effects.

The remedial technologies for ex-situ groundwater treatment retained from the initial screening included reverse osmosis, air stripping, carbon adsorption, advanced oxidation processes and ion exchange, as well as additional pre-treatment steps (e.g. filtration). The selection of an ex-situ groundwater treatment technology or combination of technologies for this alternative would be determined during the design stage; however, preliminary screening indicates that metals treatment and advanced oxidation (potentially in conjunction with air stripping) will be required as well as one or more pre-treatment steps (e.g. filtration, etc.) to meet discharge limits.

Refer to Figure 8-10 for a conceptual layout of this alternative and Table 8-14a for a more detailed summary of the alternative description, including remedy components, operation, maintenance and monitoring requirements, area/volume of media addressed, the estimated timing for construction and attainment of RAOs. The detailed analysis for Alternative DGGW-4 based on the seven evaluation criteria discussed in the beginning of this section is provided as Table 8-14b.

8.9.4 Alternative DGGW-4

Groundwater extraction and ex-situ treatment for area-wide contaminant reduction

Alternative DGGW-4 involves installation and operation of a groundwater collection and ex-situ treatment system for area-wide contaminant reduction. Although similar in nature to DGGW-3, this alternative not only contains the plume on-site but also provides an aggressive approach to restore groundwater in the downgradient area to levels that meet the RAOs.

In addition to an extraction and ex-situ treatment system, institutional controls will be implemented to limit future use of groundwater (until RAOs are met), long term monitoring of groundwater will be conducted, and operation and maintenance of the groundwater extraction and treatment system (e.g. groundwater pump replacement, etc.) will be carried out.

Based on the MODFLOW model, to achieve this alternative's objective, 14 wells would be installed at locations throughout the downgradient groundwater area. Each well would extract groundwater at approximately 10 gpm for a combined flow rate of 140 gpm. Drawings depicting the capture zones via particle tracking are provided in Appendix F. Actual pumping conditions would be determined during pre-design pumping tests. Although the model utilized methods which maintain water levels in Sutton Brook at calibrated elevations, impacts to the brook (i.e., lower water levels) due to groundwater extraction are not expected to be significant based on a review of brook and predicted extraction flow rates. Optimizing well positions and pumping rates will be performed to meet the alternative's objectives while mitigating potential impacts to the brook/wetlands due to extraction effects.

The remedial technologies for ex-situ groundwater treatment would be similar to those described above for Alternative DGGW-3.

Refer to Figure 8-11 for a conceptual layout of this alternative and Table 8-15a for a more detailed summary of the alternative description, including remedy components, operation, maintenance and monitoring requirements, area/volume of media addressed, the estimated timing for construction and attainment of RAOs. The detailed analysis for alternative DGGW-4 based on the seven evaluation criteria discussed in the beginning of this section is provided as Table 8-15b.

TABLE 8-1a
SUMMARY OF REMEDIAL ALTERNATIVE
Remedial Investigation and Feasibility Study
Sutton Brook Disposal Area Superfund Site - Tewksbury, MA

LF-1: No Action

Media Addressed	None
Remedy Components	
Containment	None included
Treatment/ Source Removal	None included
Institutional Controls	None included
Monitoring Requirements	Annual site inspections
Operation and Maintenance Requirements	Review of site conditions and risks at five year intervals
Area/ Volume of Media Addressed by Alternative	None
Estimated Timing	
Design and Construction	None required
Attainment of RAOs	This alternative will not achieve site RAO's.
Anticipated Reuse Outcomes	None

TABLE 8-1b
DETAILED ANALYSIS OF REMEDIAL ALTERNATIVE
Remedial Investigation and Feasibility Study
Sutton Brook Disposal Area Superfund Site - Tewksbury, MA
LF-1: No Action

EVALUATION CRITERIA	DETAILED ANALYSIS
OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT	
Human Health Protection	The HHRA presumed that the Northern and Southern landfill lobes will be capped; thereby eliminating access to soils located in these areas. The results of the HHRA concluded if groundwater is used as a source of potable water, groundwater may also pose a risk to future site residents or workers. Under this alternative, no remedial actions will be conducted to contain the landfill waste or to reduce concentrations in groundwater to cleanup goals, therefore the potential human health risks will remain and RAOs will not be achieved.
Ecological Protection	The results of the ecological risk assessment indicated that VOCs and/or metals in sediment and surface water within Sutton Brook between the two landfill lobes may pose potential risk to ecological receptors. Under this alternative, no remedial actions will be conducted to reduce concentrations in sediment to cleanup goals, therefore the potential future risk to ecological receptors will remain and RAOs will not be achieved.
COMPLIANCE WITH ARARs	
Chemical Specific	Under existing conditions, concentrations of select compounds in waste and groundwater exceed chemical specific ARARs. Contaminant concentrations in waste, sediments, surface water, and groundwater are not anticipated to reduce significantly in the foreseeable future; therefore, chemical specific ARARs will not be met for this alternative in a timely manner.
Location Specific	Location specific ARARs do not apply for this alternative since there are no remedial activities associated with this alternative that will cause adverse impacts to natural resources.
Action Specific	Action specific ARARs do not apply for this alternative since there are no remedial activities associated with this alternative.
LONG-TERM EFFECTIVENESS AND PERMANENCE	
Magnitude of Residual Risk	Since there are no remedial actions or institutional controls associated with this alternative, potential future exposure to human and ecological receptors to contaminants in landfill waste, sediment, surface water, and groundwater will continue to pose an elevated level of residual risk (compared to other LF alternatives evaluated).
Adequacy and Reliability of Controls	No controls are proposed for this alternative.
REDUCTION OF TOXICITY, MOBILITY AND VOLUME THROUGH TREATMENT	
Treatment Process Used and Materials Treated	No active treatment is proposed for this alternative.
Amount Destroyed or Treated	None
Degree of Expected Reductions in Toxicity, Mobility or Volume through Treatment	No active treatment is proposed for this alternative, therefore, no reduction in toxicity, mobility, or volume through treatment will be achieved with this alternative.
Degree to which Treatment is Irreversible	No treatment is proposed.

TABLE 8-1b
DETAILED ANALYSIS OF REMEDIAL ALTERNATIVE
Remedial Investigation and Feasibility Study
Sutton Brook Disposal Area Superfund Site - Tewksbury, MA
LF-1: No Action

EVALUATION CRITERIA	DETAILED ANALYSIS
Type and Quantity of Residuals Remaining after Treatment	Existing conditions will remain since no treatment is proposed.
Degree to Which Treatment Reduces Principal Threats	No treatment is proposed.
SHORT-TERM EFFECTIVENESS	
Protection of Community During Remedial Action	Not applicable since no remedial actions are included in this alternative.
Protection of Workers During Remedial Action	Not applicable since no remedial actions are included in this alternative.
Environmental Impacts	Not applicable since no remedial actions are included in this alternative.
Time Until Remedial Action Objectives are Achieved	No active remedial actions will be implemented to contain the landfill waste or to reduce concentrations in sediment, surface water or groundwater to cleanup goals. Therefore, RAO's will not be achieved through this alternative in the foreseeable future.
.	
Ability to Construct and Operate the Technology	Not applicable since no remedial actions are included in this alternative.
Reliability of the Technology	Not applicable since no remedial actions are included in this alternative.
Ease of Undertaking Additional Remedial Actions, if necessary	This alternative will not limit or interfere with the ability to implement or perform future remedial actions.
Ability to Monitor Effectiveness of Remedy	Not applicable since no remedial actions or monitoring are included in this alternative.
Ability to Obtain Approvals and Coordinate with Other Agencies	Not applicable since no remedial actions are included in this alternative; therefore, no approvals or coordination required.
Availability of off-site Treatment, Storage and Disposal Services and Capacity	Not applicable for this alternative.
Availability of Necessary Equipment and Specialists	No equipment or specialists required for this alternative.
Availability of Technology	Not applicable since no remedial technologies will be used.
COSTS - *net present value (7%) - 30 years*	
Capital Costs	$0
Annual Operation, Maintenance and Monitoring	$68,000
Periodic Costs	$43,000
TOTAL	$111,000

TABLE 8-2a
SUMMARY OF REMEDIAL ALTERNATIVE
Remedial Investigation and Feasibility Study
Sutton Brook Disposal Area Superfund Site - Tewksbury, MA

LF-2a and LF-2b: Containment of waste, vent landfill gas, restoration of wetlands and brook, partial containment of groundwater with a vertical barrier and groundwater remediation

Media Addressed	Waste/ landfill gas/ leachate Brook sediment Groundwater
Remedy Components	
Containment	
Waste/Landfill gas/Leachate	Construction of a low permeability final cover system
Brook sediment	--
Groundwater	Partial containment of groundwater with a vertical barrier along the northern and eastern perimeter of the Southern lobe (estimated length of 1,700 ft and depth of 30 ft)
Treatment/ Source Removal/ Other	
Waste/soil	No treatment included.
Landfill gas	Installation of a landfill gas system (including piping laterals)
Leachate	None anticipated; monitoring only
Brook sediment	Excavation of impacted sediment in the brook (between the two landfill lobes) with on-site disposal beneath landfill final cover system
Groundwater	LF-2a - phased groundwater approach with MNA. Monitoring to be conducted to determine if additional measures are needed. LF-2b - active and focused groundwater treatment following source control construction. Pre-design studies of in situ remedial measures or groundwater extraction and treatment to be conducted. If groundwater extraction is implemented, the estimated extraction rate is 15 gpm and ex-situ treatment components may include air stripping, advanced oxidation, metals treatment, etc.
Institutional Controls	
Waste/ Landfill gas/ Leachate	Deed restriction to restrict future use/access of the landfill waste
Brook sediment	None required
Groundwater	Deed restriction to restrict future use of groundwater until RAOs are met
Monitoring Requirements	Post excavation confirmatory sediment sampling in the brook Routine monitoring of groundwater treatment system influent and effluent (if groundwater extraction and ex-situ treatment implemented) Routine monitoring of landfill gas, leachate, surface water and groundwater Annual Site Inspections

TABLE 8-2a
SUMMARY OF REMEDIAL ALTERNATIVE
Remedial Investigation and Feasibility Study
Sutton Brook Disposal Area Superfund Site - Tewksbury, MA

LF-2a and LF-2b: Containment of waste, vent landfill gas, restoration of wetlands and brook, partial containment of groundwater with a vertical barrier and groundwater remediation

Operation and Maintenance Requirements	Review of site conditions and risks at five year intervals Maintenance of the final cover system (i.e. cap repairs, landscaping (mowing), etc.) O&M of the landfill gas system, groundwater monitoring well system, and groundwater remedial system (as applicable)
Area/ Volume of Media Addressed by Alternative	
Waste	Northern Lobe - 30 acres or 1.9 million cy Southern Lobe - 10 acres or 0.3 million cy
Brook sediment	24,000 sq ft or 890 cy
Groundwater	At downgradient end of containment barrier
Estimated Timing	
Design and Construction	
Waste/ leachate & landfill gas	2 to 3 years
Brook sediment	2 to 2.5 years
Groundwater	Following landfill cover and barrier construction
Attainment of RAOs	
Waste/ leachate & landfill gas	Upon construction of final cover system (3 years)
Brook sediment	Upon removal of impacted sediment (2 to 2.5 years)
Groundwater	65 to 210 years (variation due to different compounds)
Anticipated Reuse Outcomes	Passive recreation

Refer to Figure 8-2 for conceptual layout

TABLE 8-2b(i)
DETAILED ANALYSIS OF REMEDIAL ALTERNATIVE
Remedial Investigation and Feasibility Study
Sutton Brook Disposal Area Superfund Site - Tewksbury, MA

LF-2a: Containment of waste, vent landfill gas, restoration of wetlands and brook, containment of groundwater with a vertical barrier and groundwater remediation

EVALUATION CRITERIA	DETAILED ANALYSIS
OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT	
Human Health Protection	The HHRA presumed that the Northern and Southern landfill lobes will be capped; thereby eliminating direct exposure to soils located in these areas. The results of the HHRA concluded if groundwater is used as a source of potable water, groundwater may also pose a risk to hypothetical future site residents or workers. Under this alternative, the landfill waste will be capped and impacted groundwater immediately downgradient of the Southern lobe will be prevented from discharging into the brook (preventing migration and potential re-contamination of the brook), sediments within the brook will be excavated, and in-situ natural attenuation mechanisms will be monitored to address groundwater impacts. In conjunction with institutional controls, future risk of groundwater ingestion by site users will be controlled, therefore the site RAOs will be achieved.
Ecological Protection	The results of the ecological risk assessment indicated that VOCs and/or metals in sediment and surface water within Sutton Brook between the two landfill lobes may pose a potential risk to ecological receptors. Due to these potential risks, PRGs were established for the specific constituents determined to be "risk drivers" in sediment and surface water. Under this alternative, the landfill waste will be capped, the Southern lobe impacted groundwater will be controlled, minimizing discharge to the brook (preventing potential re-contamination of the brook sediment/surface water) and excavation of the impacted sediment will be conducted to reduce concentrations to meet RAOs.
COMPLIANCE WITH ARARs	
Chemical Specific	Potential chemical specific ARARs for this alternative are presented in Table E-1 in Appendix E; this alternative will be designed and implemented to comply with applicable chemical-specific ARARs.
Location Specific	Potential location specific ARARs for this alternative are presented in Table E-1 in Appendix E; this alternative will be designed and implemented to comply with applicable location-specific ARARs.
Action Specific	Action specific ARARs for this alternative are presented in Table E-1 in Appendix E; this alternative will be designed and implemented to comply with applicable action-specific ARARs.
LONG-TERM EFFECTIVENESS AND PERMANENCE	
Magnitude of Residual Risk	With the construction of a final cover system over the landfill lobes and the excavation of impacted sediment from the brook, the residual risks for direct exposure of landfill waste and impacted sediment are eliminated. However, given the potential for some wastes to have been placed near or at the water table surface, the potential will remain for some leaching of contaminants from the waste into groundwater. Prevention of further impacts to the brook through groundwater containment and natural attenuation mechanisms will minimize future residual risk to re-contaminating the brook sediment and/or surface water. In conjunction with institutional controls, future risk of groundwater ingestion by site users will be controlled. Therefore, residual risk is low for this alternative.

TABLE 8-2b(i)
DETAILED ANALYSIS OF REMEDIAL ALTERNATIVE
Remedial Investigation and Feasibility Study
Sutton Brook Disposal Area Superfund Site - Tewksbury, MA

LF-2a: Containment of waste, vent landfill gas, restoration of wetlands and brook, containment of groundwater with a vertical barrier and groundwater remediation

EVALUATION CRITERIA	DETAILED ANALYSIS
Adequacy and Reliability of Controls	Capping of the landfill waste is an effective and reliable technology to prevent exposure to the waste and to reduce infiltration through the waste and leaching to groundwater. The combination of groundwater containment (via a vertical barrier), natural attenuation mechanisms, and institutional controls will effectively and reliably limit human exposure to impacted groundwater until groundwater RAOs are met. Monitoring of the containment system and natural attenuation mechanisms will be required to demonstrate reliability.
REDUCTION OF TOXICITY, MOBILITY AND VOLUME THROUGH TREATMENT	
Treatment Process Used and Materials Treated	This alternative does not treat the landfill waste. Treatment of the excavated sediment is not anticipated prior to on-site disposal beneath the landfill final cover system; however, if deemed necessary based on the pre-design waste characterization results of the material being excavated, ex-situ treatment of soil may be implemented prior to on-site disposal. This alternative does not actively treat groundwater. Monitored natural attenuation processes will address COCs in situ. Following the phased approach, this alternative may also include an active groundwater treatment component.
Amount Destroyed or Treated	The landfill waste and excavated sediment are not anticipated to be treated. Groundwater will be addressed with natural attenuation processes. Current dissolved concentrations indicate an estimated 2,700 to 4,500 lbs of VOCs in Northern and Southern lobe groundwater.
Degree of Expected Reductions in Toxicity, Mobility or Volume through Treatment	Compared to the other alternatives evaluated for the landfill lobes, this alternative provides a low level of reduction in toxicity, mobility and volume of contaminants through treatment.
Degree to which Treatment is Irreversible	This alternative does not include active treatment technologies.
Type and Quantity of Residuals Remaining after Treatment	This alternative does not treat the landfill waste. Through excavation of the impacted sediment, no residuals presenting exposure risks will remain. This alternative does not actively treat groundwater. Monitored natural attenuation processes will address COCs in situ.
Degree to Which Treatment Reduces Principal Threats	Principal threats of direct exposure and potential leaching from waste to groundwater are addressed via landfill containment (cap). The principal threats/ exposure risks of groundwater migration and ingestion will be controlled/reduced through groundwater containment (via vertical barrier), natural attenuation, and institutional controls.

TABLE 8-2b(i)
DETAILED ANALYSIS OF REMEDIAL ALTERNATIVE
Remedial Investigation and Feasibility Study
Sutton Brook Disposal Area Superfund Site - Tewksbury, MA

LF-2a: Containment of waste, vent landfill gas, restoration of wetlands and brook, containment of groundwater with a vertical barrier and groundwater remediation

EVALUATION CRITERIA	DETAILED ANALYSIS
SHORT-TERM EFFECTIVENESS	
Protection of Community During Remedial Action	This alternative will have moderate short-term effects on the local community during the construction of the landfill final cover system due to an increase in local truck/ vehicular traffic (bringing in soil cover material). Limited short term effects are anticipated as a result of the sediment excavation or groundwater MNA portions of this alternative.
Protection of Workers During Remedial Action	Work will be performed in accordance with applicable OSHA standards. Site-specific health and safety plan(s) will be developed to protect site workers.
Environmental Impacts	Impacts to the wetland resource areas are anticipated to be low to moderate during construction activities due to the location of the wetland resource areas surrounding the landfill lobes (erosion controls and stormwater management will be required to reduce impacts) and during the brook excavation, temporary re-directing/routing of the brook may be required to effectively remove the impacted sediment, potentially causing disruption to the existing ecological habitat. Once the landfill capping and brook excavation are complete and the area restored, operation and monitoring activities are anticipated to have minimal impacts. Available practical means such as erosion and stormwater control measures will also be implemented to minimize harm to wetland areas during construction.
Time Until Remedial Action Objectives are Achieved	Landfill waste RAOs will be achieved upon construction of the final cover system (design/approvals 1 year, construction 2 to 3 years) and the sediment RAOs will be achieved upon removal of the impacted sediment (confirmatory sediment sampling will be performed to document the achievement of RAOs) - (design/approvals - 1 year, construction/restoration 1 to 1.5 years). The estimated time to achieve groundwater RAOs is approximately 65 to 210 years
IMPLEMENTABILITY	
Ability to Construct and Operate the Technology	Construction of the landfill final cover system is a common technique that is straight forward to implement; the presence of wetland resource areas and the adjacent 100-year flood plain may present potential design challenges (stormwater management, etc.). Preliminary evaluation of stormwater/ drainage features at the site indicate that upon capping the landfill, use of the FDDA and Deep Marsh may be required for stormwater detention ponds. Excavation of impacted sediment from existing waterways is a fairly common construction activity; site specific engineering and erosion controls will be required to minimize environmental impacts. The installation of a vertical containment barrier involves common construction techniques. This alternative requires a lower level of operation, maintenance, and monitoring than other alternatives evaluated (e.g. LF-3).
Reliability of the Technology	Excavation of impacted sediment is an effective and reliable method since the material will be removed. Capping of the landfill waste is an effective and reliable technology to prevent direct exposure to the waste and to reduce infiltration through the waste into groundwater. The combination of groundwater containment (via a vertical barrier), natural attenuation, and institutional controls should effectively and reliably limit human exposure to impacted groundwater until groundwater RAOs are met.

TABLE 8-2b(i)
DETAILED ANALYSIS OF REMEDIAL ALTERNATIVE
Remedial Investigation and Feasibility Study
Sutton Brook Disposal Area Superfund Site - Tewksbury, MA

LF-2a: Containment of waste, vent landfill gas, restoration of wetlands and brook, containment of groundwater with a vertical barrier and groundwater remediation

EVALUATION CRITERIA	DETAILED ANALYSIS
Ease of Undertaking Additional Remedial Actions, if necessary	This alternative should not limit or interfere with the ability to implement or perform future remedial actions.
Ability to Monitor Effectiveness of Remedy	Confirmatory sediment sampling and analysis is easily implementable to measure the effectiveness of the brook sediment excavation. Groundwater monitoring to demonstrate contaminant containment and mass reduction is easily implementable.
Ability to Obtain Approvals and Coordinate with Other Agencies	The remedial action will be designed and implemented under coordination with appropriate Federal and State agencies.
Availability of off-site Treatment, Storage and Disposal Services and Capacity	Facilities are available to treat or dispose of the excavated sediment within Massachusetts. However, there is also availability to re-use this material on-site at one of the landfill lobes beneath the final cover system.
Availability of Necessary Equipment and Specialists	Equipment, materials and services for this alternative are readily available.
Availability of Technology	Qualified engineers and contractors are available to design and implement this alternative.
COSTS - *net present value (7%) - 30 years*	
	LF-2a
Capital Costs	$17,500,000
Annual Operation, Maintenance and Monitoring	$2,900,000
Periodic Costs	$120,000
TOTAL	$20,520,000

TABLE 8-2b(ii)
DETAILED ANALYSIS OF REMEDIAL ALTERNATIVE
Remedial Investigation and Feasibility Study
Sutton Brook Disposal Area Superfund Site - Tewksbury, MA

LF-2b: Containment of waste, vent landfill gas, restoration of wetlands and brook, containment of groundwater with a vertical barrier and groundwater remediation

EVALUATION CRITERIA	DETAILED ANALYSIS
OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT	
Human Health Protection	The HHRA presumed that the Northern and Southern landfill lobes will be capped; thereby eliminating direct exposure to soils located in these areas. The results of the HHRA concluded if groundwater is used as a source of potable water, groundwater may also pose a risk to hypothetical future site residents or workers. Under this alternative, the landfill waste will be capped, sediments within the brook will be excavated, impacted groundwater immediately downgradient of the Southern lobe will be treated and prevented from discharging into the brook (preventing migration and potential re-contamination of the brook) and impacted groundwater from the Northern lobe will be addressed by in-situ natural attenuation. In conjunction with institutional controls, future risk of groundwater ingestion by site users will be controlled, therefore the site RAOs will be achieved.
Ecological Protection	The results of the ecological risk assessment indicated that VOCs and/or metals in sediment and surface water within Sutton Brook between the two landfill lobes may pose a potential risk to ecological receptors. Due to these potential risks, PRGs were established for the specific constituents determined to be "risk drivers" in sediment and surface water. Under this alternative, the landfill waste will be capped, the Southern lobe impacted groundwater will be controlled, minimizing discharge to the brook (preventing potential re-contamination of the brook sediment/surface water) and excavation of the impacted sediment will be conducted to reduce concentrations to meet RAOs.
COMPLIANCE WITH ARARs	
Chemical Specific	Potential chemical specific ARARs for this alternative are presented in Table E-1 in Appendix E; this alternative will be designed and implemented to comply with applicable chemical-specific ARARs.
Location Specific	Potential location specific ARARs for this alternative are presented in Table E-1 in Appendix E; this alternative will be designed and implemented to comply with applicable location-specific ARARs.
Action Specific	Action specific ARARs for this alternative are presented in Table E-1 in Appendix E; this alternative will be designed and implemented to comply with applicable action-specific ARARs.
LONG-TERM EFFECTIVENESS AND PERMANENCE	
Magnitude of Residual Risk	With the construction of a final cover system over the landfill lobes and the excavation of impacted sediment from the brook, the residual risks for direct exposure of landfill waste and impacted sediment are eliminated. However, given the potential for some wastes to have been placed near or at the water table surface, the potential will remain for some leaching of contaminants from the waste into groundwater. Prevention of further impacts to the brook through groundwater containment and focused groundwater remediation will minimize future residual risk to re-contaminating the brook sediment and/or surface water. In conjunction with institutional controls, future risk of groundwater ingestion by site users will be controlled. Therefore, residual risk is low for this alternative.

TABLE 8-2b(ii)
DETAILED ANALYSIS OF REMEDIAL ALTERNATIVE
Remedial Investigation and Feasibility Study
Sutton Brook Disposal Area Superfund Site - Tewksbury, MA

LF-2b: Containment of waste, vent landfill gas, restoration of wetlands and brook, containment of groundwater with a vertical barrier and groundwater remediation

EVALUATION CRITERIA	DETAILED ANALYSIS
Adequacy and Reliability of Controls	Capping of the landfill waste is an effective and reliable technology to prevent exposure to the waste and to reduce infiltration through the waste and leaching to groundwater. The combination of groundwater containment (via a vertical barrier), focused groundwater remediation and institutional controls will effectively and reliably limit human exposure to impacted groundwater until groundwater RAOs are met. Monitoring of the containment system and focused groundwater remediation will be required to demonstrate reliability.
REDUCTION OF TOXICITY, MOBILITY AND VOLUME THROUGH TREATMENT	
Treatment Process Used and Materials Treated	This alternative does not treat the landfill waste. Treatment of the excavated sediment is not anticipated prior to on-site disposal beneath the landfill final cover system; however, if deemed necessary based on the pre-design waste characterization results of the material being excavated, ex-situ treatment of soil may be implemented prior to on-site disposal. Materials addressed in groundwater through focused groundwater remediation (in situ or ex situ) will include VOCs, SVOCs & metals; If extraction and ex-situ treatment of groundwater are implemented, a combination of technologies such as air stripping, advanced oxidation processes and/or metals treatment, in addition to one or more pretreatment steps (to be determined during the design phase) will be utilized to treat the extracted groundwater.
Amount Destroyed or Treated	The landfill waste and excavated sediment are not anticipated to be treated. Groundwater will be remediated with in situ treatment enhancements/technologies and/or groundwater ex-situ treatment. Current dissolved concentrations indicate an estimated 2,700 to 4,500 lbs of VOCs in Northern and Southern lobe groundwater.
Degree of Expected Reductions in Toxicity, Mobility or Volume through Treatment	Compared to the other alternatives evaluated for the landfill lobes, this alternative provides a moderate level of reduction in toxicity, mobility and volume of contaminants through groundwater treatment.
Degree to which Treatment is Irreversible	The groundwater treatment/remediation will be permanent.
Type and Quantity of Residuals Remaining after Treatment	This alternative does not treat the landfill waste. Through excavation of the impacted sediment, no residuals presenting exposure risks will remain. In situ and/or ex-situ groundwater treatment and any resulting VOC vapors or end-products may produce a low volume of treatment residuals that will require off-site treatment/disposal at a licensed facility.
Degree to Which Treatment Reduces Principal Threats	Principal threats of direct exposure and potential leaching from waste to groundwater are addressed via landfill containment (cap). The principal threats/ exposure risks of groundwater migration and ingestion will be controlled through groundwater containment (via vertical barrier), groundwater treatment (in situ or ex situ), natural attenuation, and institutional controls.

TABLE 8-2b(ii)
DETAILED ANALYSIS OF REMEDIAL ALTERNATIVE
Remedial Investigation and Feasibility Study
Sutton Brook Disposal Area Superfund Site - Tewksbury, MA

LF-2b: Containment of waste, vent landfill gas, restoration of wetlands and brook, containment of groundwater with a vertical barrier and groundwater remediation

EVALUATION CRITERIA	DETAILED ANALYSIS
SHORT-TERM EFFECTIVENESS	
Protection of Community During Remedial Action	This alternative will have moderate short-term effects on the local community during the construction of the landfill final cover system due to an increase in local truck/ vehicular traffic (bringing in soil cover material). Limited short term effects are anticipated as a result of the sediment excavation or groundwater containment/remediation portions of this alternative.
Protection of Workers During Remedial Action	Work will be performed in accordance with applicable OSHA standards. Site-specific health and safety plan(s) will be developed to protect site workers.
Environmental Impacts	Impacts to the wetland resource areas are anticipated to be low to moderate during construction activities due to the location of the wetland resource areas surrounding the landfill lobes (erosion controls and stormwater management will be required to reduce impacts) and during the brook excavation, temporary re-directing/routing of the brook may be required to effectively remove the impacted sediment, potentially causing disruption to the existing ecological habitat. Once the landfill capping and brook excavation are complete, the groundwater containment/remediation components installed, and the area restored, operation and monitoring activities are anticipated to have minimal impacts. Available practical means such as erosion and stormwater control measures will also be implemented to minimize harm to wetland areas during construction.
Time Until Remedial Action Objectives are Achieved	Landfill waste RAOs will be achieved upon construction of the final cover system (design/approvals 1 year, construction 2 to 3 years) and the sediment RAOs will be achieved upon removal of the impacted sediment (confirmatory sediment sampling will be performed to document the achievement of RAOs) - (design/approvals - 1 year, construction/restoration 1 to 1.5 years). The estimated time to achieve groundwater RAOs is approximately 65 to 210 years
IMPLEMENTABILITY	
Ability to Construct and Operate the Technology	Construction of the landfill final cover system is a common technique that is straight forward to implement; the presence of wetland resource areas and the adjacent 100-year flood plain may present potential design challenges (stormwater management, etc.). Preliminary evaluation of stormwater/ drainage features at the site indicate that upon capping the landfill, use of the FDDA and Deep Marsh may be required for stormwater detention ponds. Excavation of impacted sediment from existing waterways is a fairly common construction activity; site specific engineering and erosion controls will be required to minimize environmental impacts. The installation of a vertical containment barrier and implementation of the focused groundwater remediation program involves common construction techniques. This alternative requires a lower level of operation, maintenance, and monitoring than other alternatives evaluated (e.g. LF-3).
Reliability of the Technology	Excavation of impacted sediment is an effective and reliable method since the material will be removed. Capping of the landfill waste is an effective and reliable technology to prevent direct exposure to the waste and to reduce infiltration through the waste into groundwater. The combination of groundwater containment (via a vertical barrier), focused groundwater remediation and institutional controls should effectively and reliably limit human exposure to impacted groundwater until groundwater RAOs are met.

TABLE 8-2b(ii)
DETAILED ANALYSIS OF REMEDIAL ALTERNATIVE
Remedial Investigation and Feasibility Study
Sutton Brook Disposal Area Superfund Site - Tewksbury, MA

LF-2b: Containment of waste, vent landfill gas, restoration of wetlands and brook, containment of groundwater with a vertical barrier and groundwater remediation

EVALUATION CRITERIA	DETAILED ANALYSIS
Ease of Undertaking Additional Remedial Actions, if necessary	This alternative should not limit or interfere with the ability to implement or perform future remedial actions.
Ability to Monitor Effectiveness of Remedy	Confirmatory sediment sampling and analysis is easily implementable to measure the effectiveness of the brook sediment excavation. Groundwater monitoring to demonstrate contaminant containment and mass reduction is easily implementable.
Ability to Obtain Approvals and Coordinate with Other Agencies	The remedial action will be designed and implemented under coordination with appropriate Federal and State agencies.
Availability of off-site Treatment, Storage and Disposal Services and Capacity	Facilities are available to treat or dispose of the excavated sediment within Massachusetts. However, there is also availability to re-use this material on-site at one of the landfill lobes beneath the final cover system. If groundwater extraction and ex-situ treatment are implemented, the treated groundwater can be discharged to surface water or to the local POTW.
Availability of Necessary Equipment and Specialists	Equipment, materials and services for this alternative are readily available.
Availability of Technology	Qualified engineers and contractors are available to design and implement this alternative.
COSTS - *net present value (7%) - 30 years*	
	LF-2b
Capital Costs	$19,700,000
Annual Operation, Maintenance and Monitoring	$5,400,000
Periodic Costs	$120,000
TOTAL	$25,220,000

TABLE 8-3a
SUMMARY OF REMEDIAL ALTERNATIVE
Remedial Investigation and Feasibility Study
Sutton Brook Disposal Area Superfund Site - Tewksbury, MA

LF-3: Containment of waste, vent landfill gas, restoration of wetlands and brook and contaminated groundwater collection and treatment

Media Addressed	Waste/ landfill gas/ leachate Brook sediment Groundwater
Remedy Components	
Containment	
Waste/Landfill gas/Leachate	Construction of a low permeability final cover system -
Brook sediment	--
Groundwater	--
Treatment/ Source Removal / Other	
Waste/soil	No treatment included
Landfill gas	Installation of a landfill gas system, including piping laterals
Leachate	None anticipated; monitoring only
Brook sediment	Excavation of impacted sediment in the brook (between the two landfill lobes) with on-site disposal beneath landfill final cover system
Groundwater	Contaminant mass reduction and hydraulic containment through groundwater extraction and ex-situ treatment - total combined extraction rate estaimated 245 gpm (Southern lobe - 7 wells for a total of 95 gpm and Northern lobe - 10 wells for a total of 150 gpm); Pre-design studies necessary to determine pumping rates; ex-situ treatment components may include air stripping, advanced oxidation, metals treatment, etc.
Institutional Controls	
Waste/Landfill gas/Leachate	Deed restriction to restrict future use/access of the landfill waste
Brook sediment	None required
Groundwater	Deed restriction to restrict future use of groundwater until RAOs are met
Monitoring Requirements	Post excavation confirmatory sediment sampling Routine monitoring of groundwater treatment system influent and effluent Routine monitoring of landfill gas, leachate, surface water and groundwater Annual Site Inspections
Operation and Maintenance Requirements	Review of site conditions and risks at five year intervals Maintenance of the final cover system (i.e. cap repairs, landscaping (mowing), etc.) O&M of the landfill gas system, groundwater monitoring well system, and groundwater treatment system
Area/ Volume of Media Addressed by Alternative	
Waste/ leachate & landfill gas	Northern Lobe - 30 acres or 1.9 million cy Southern Lobe - 10 acres or 0.3 million cy
Brook sediment	24,000 sq ft or 890 cy
Groundwater	Extraction of 95 gpm (Southern lobe) and 150 gpm (Northern lobe) for a total of 245 gpm (estimated)

TABLE 8-3a
SUMMARY OF REMEDIAL ALTERNATIVE
Remedial Investigation and Feasibility Study
Sutton Brook Disposal Area Superfund Site - Tewksbury, MA

LF-3: Containment of waste, vent landfill gas, restoration of wetlands and brook and contaminated groundwater collection and treatment

Estimated Timing	
Design and Construction	
Waste/ leachate & landfill gas	2 to 3 years
Brook sediment	2 to 2.5 years
Groundwater	2 years
Attainment of RAOs	
Waste/ leachate & landfill gas	Upon construction of final cover system (3 years)
Brook sediment	Upon removal of impacted sediment (2 to 2.5 years)
Groundwater	52 to 164 years (variation due to different compounds)
Anticipated Reuse Outcomes	Passive recreation

Refer to Figure 8-3 for conceptual layout

TABLE 8-3b
DETAILED ANALYSIS OF REMEDIAL ALTERNATIVE
Remedial Investigation and Feasibility Study
Sutton Brook Disposal Area Superfund Site - Tewksbury, MA

LF-3: Containment of waste, vent landfill gas, restoration of wetlands and brook and contaminated groundwater collection and treatment

EVALUATION CRITERIA	DETAILED ANALYSIS
OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT	
Human Health Protection	The HHRA presumed that the Northern and Southern landfill lobes will be capped; thereby eliminating direct exposure to soils located in these areas. The results of the HHRA concluded if groundwater is used as a source of potable water, groundwater may also pose a risk to hypothetical future site residents or workers. Under this alternative, the landfill waste will be capped and impacted groundwater will be hydraulically controlled and treated (preventing migration and potential re-contamination of the brook), therefore the potential human health risks will be eliminated and RAOs will be achieved.
Ecological Protection	The results of the ecological risk assessment indicated that VOCs and/or metals in sediment and surface water within Sutton Brook between the two landfill lobes may pose potential risk to ecological receptors. Due to these potential future risks, PRGs were established for the specific constituents determined to the "risk drivers" in sediment and surface water. Under this alternative, the landfill waste will be capped, the southern lobe impacted groundwater will be hydraulically contained (preventing potential re-contamination of the brook sediment/surface water) and excavation of the impacted sediment will be conducted to reduce concentrations to meet RAOs.
COMPLIANCE WITH ARARs	
Chemical Specific	Potential chemical specific ARARs for this alternative are presented in Table E-1 in Appendix E; this alternative will be designed and implemented to comply with applicable chemical-specific ARARs.
Location Specific	Potential location specific ARARs for this alternative are presented in Table E-1 in Appendix E; this alternative will be designed and implemented to comply with applicable location-specific ARARs.
Action Specific	Action specific ARARs for this alternative are presented in Table E-1 in Appendix E; this alternative will be designed and implemented to comply with applicable action-specific ARARs.
LONG-TERM EFFECTIVENESS AND PERMANENCE	
Magnitude of Residual Risk	With the construction of a final cover system over the landfill lobes and the excavation of impacted sediment from the brook, the residual risks for direct exposure of landfill waste and impacted sediment are eliminated. However, given the potential for some wastes to have been placed near or at the water table surface, the potential will remain for some leaching of contaminants from the waste into groundwater. Prevention of further impacts to the brook through groundwater extraction and ex-situ treatment will minimize future residual risk to re-contaminating the brook sediment and/or surface water. In conjunction with institutional controls, future risk of groundwater ingestion by site users will be controlled. Therefore, residual risk is low for this alternative.
Adequacy and Reliability of Controls	Capping of the landfill waste is an effective and reliable technology to prevent direct exposure to the waste and to reduce infiltration through the waste and leaching to groundwater. The combination of groundwater hydraulic containment through groundwater extraction and ex-situ treatment and institutional controls will effectively and reliably limit human exposure to impacted groundwater until groundwater RAOs are met.

TABLE 8-3b
DETAILED ANALYSIS OF REMEDIAL ALTERNATIVE
Remedial Investigation and Feasibility Study
Sutton Brook Disposal Area Superfund Site - Tewksbury, MA

LF-3: Containment of waste, vent landfill gas, restoration of wetlands and brook and contaminated groundwater collection and treatment

EVALUATION CRITERIA	DETAILED ANALYSIS
REDUCTION OF TOXICITY, MOBILITY AND VOLUME THROUGH TREATMENT	
Treatment Process Used and Materials Treated	This alternative does not treat the landfill waste. Treatment of the excavated sediment is not anticipated prior to on-site disposal beneath the landfill final cover system; however, if deemed necessary based on the pre-design waste characterization results of the material being excavated, ex-situ treatment of soil may be implemented prior to on-site disposal. Materials treated in groundwater through ex-situ groundwater treatment will include VOCs, SVOCs & metals; a combination of technologies such as air stripping, advanced oxidation processes and/or metals treatment, in addition to one or more pretreatment steps (to be determined during the design phase) may be utilized to treat the extracted groundwater.
Amount Destroyed or Treated	The landfill waste and excavated sediment are not anticipated to be treated. Groundwater will be treated/destroyed with ex-situ treatment processes. Current dissolved concentrations indicate an estimated 2,700 to 4,500 lbs of VOCs in Northern and Southern lobe groundwater available for treatment.
Degree of Expected Reductions in Toxicity, Mobility or Volume through Treatment	Compared to other alternatives evaluated for the landfill lobes, this alternative provides a moderate level of reduction in toxicity, and volume and a high level of reduction in mobility of dissolved contaminants through groundwater extraction and treatment.
Degree to which Treatment is Irreversible	The groundwater treatment will be permanent.
Type and Quantity of Residuals Remaining after Treatment	This alternative does not treat the landfill waste. Through excavation of the impacted sediment, no residuals presenting exposure risks will remain. Treatment of the groundwater plume and any resulting VOC vapors will produce a moderate to high volume of treatment residuals that will require off-site treatment/disposal at a licensed facility.
Degree to Which Treatment Reduces Principal Threats	Principal threats of direct exposure and potential leaching from waste to groundwater are not addressed via treatment for this alternative (containment and excavation); however, through groundwater extraction and ex-situ treatment, and institutional controls, the principal threats/ exposure risks of groundwater migration and ingestion will be reduced.
SHORT-TERM EFFECTIVENESS	
Protection of Community During Remedial Action	This alternative will have moderate short-term effects on the local community during the construction of the landfill final cover system due to an increase in local truck/ vehicular traffic (bringing in soil cover material). Limited short term effects are anticipated as a result of the sediment excavation or groundwater treatment system installation portions of this alternative.
Protection of Workers During Remedial Action	Work will be performed in accordance with applicable OSHA standards. Site-specific health and safety plan(s) will be developed to protect site workers.
Environmental Impacts	Impacts to the wetland resource areas are anticipated to be moderate during construction activities due to the location of the wetland resource areas surrounding the landfill lobes (erosion controls and stormwater management will be required to reduce impacts) and during the brook excavation, temporary re-directing/routing of the brook may be required to effectively remove the impacted sediment, potentially causing disruption to the existing ecological habitat. Once the landfill capping and brook excavation are complete, the groundwater hydraulic containment/ ex-situ treatment system installed, and the area restored, operation and monitoring activities are anticipated to have minimal environmental impacts. Available practical means such as erosion and stormwater control measures will also be implemented to minimize harm to wetland areas during construction.

TABLE 8-3b
DETAILED ANALYSIS OF REMEDIAL ALTERNATIVE
Remedial Investigation and Feasibility Study
Sutton Brook Disposal Area Superfund Site - Tewksbury, MA

LF-3: Containment of waste, vent landfill gas, restoration of wetlands and brook and contaminated groundwater collection and treatment

EVALUATION CRITERIA	DETAILED ANALYSIS
Time Until Remedial Action Objectives are Achieved	Landfill waste RAOs will be achieved upon construction of the final cover system (design/approvals 1 year, construction 2 to 3 years) and the sediment RAOs will be achieved upon removal of the impacted sediment (confirmatory sediment sampling will be performed to document the achievement of RAOs) - (design/approvals - 1 year, construction/restoration 1 to 1.5 years) . The estimated time to achieve groundwater RAOs is approximately 52 to 164 years
IMPLEMENTABILITY	
Ability to Construct and Operate the Technology	Construction of a landfill final cover system is a common technique that is straight forward to implement; the presence of wetland resource areas and the adjacent 100-year flood plain may present potential design challenges (stormwater management, etc.). Preliminary evaluation of stormwater/ drainage features at the site indicate that upon capping the landfill, use of the FDDA and Deep Marsh will likely be required for stormwater detention ponds. Excavation of impacted sediment from existing waterways is a fairly common construction activity; site specific engineering and erosion controls will be required to minimize environmental impacts. The installation of a groundwater treatment system involves common construction techniques. This alternative requires a higher level of operation, maintenance and monitoring compared to other alternatives evaluated (e.g. LF-2 and LF-4).
Reliability of the Technology	Excavation of impacted sediment is an effective and reliable method since the material will be removed. Capping of the landfill waste is an effective and reliable technology to prevent direct exposure to the waste and to reduce infiltration through the waste into groundwater. The combination of groundwater treatment and institutional controls should limit human exposure to impacted groundwater until groundwater RAOs are met. This alternative, however, has a reduced level of reliability in containing the groundwater in comparison to alternative LF-2 due to the potential for mechanical failure of equipment over time, providing the potential for groundwater to migrate into the brook and/or downgradient.
Ease of Undertaking Additional Remedial Actions, if necessary	This alternative should not limit or interfere with the ability to implement or perform future remedial actions.
Ability to Monitor Effectiveness of Remedy	Confirmatory sediment sampling and analysis is easily implementable to measure the effectiveness of the brook sediment excavation. Groundwater monitoring to demonstrate contaminant containment and reduction is easily implementable.
Ability to Obtain Approvals and Coordinate with Other Agencies	The remedial action will be designed and implemented under coordination with appropriate Federal and State agencies.
Availability of off-site Treatment, Storage and Disposal Services and Capacity	Facilities are available to treat or dispose of the excavated sediment within Massachusetts. However, there is also availability to re-use this material on-site at one of the landfill lobes beneath the final cover system. Treated groundwater can be discharged to surface water or to the local POTW.
Availability of Necessary Equipment and Specialists	Equipment, materials and services for this alternative are readily available.
Availability of Technology	Qualified engineers and contractors are available to design and implement this alternative.
COSTS - *net present value (7%) - 30 years*	
Capital Costs	$24,900,000
Annual Operation, Maintenance and Monitoring	$15,900,000 to $26,100,000
Periodic Costs	$130,000
TOTAL	$40,930,000 to $51,130,000

LF-3 - O&M Range incorporates: 30 years of system operation with 30 years of groundwater monitoring - low: discharge to surface water, high: discharge to POTW

TABLE 8-4a
SUMMARY OF REMEDIAL ALTERNATIVE
Remedial Investigation and Feasibility Study
Sutton Brook Disposal Area Superfund Site - Tewksbury, MA

LF-4: Containment of waste, vent landfill gas, re-routing of the brook, excavation of impacted sediment hot spots, partial containment of groundwater (vertical barrier) with groundwater remediation

Media Addressed	Waste/ landfill gas/ leachate Brook sediment Groundwater
Remedy Components	
Containment	
Waste/Landfill gas/Leachate	Construction of a low permeability final cover system
Brook sediment	--
Groundwater	Partial containment of groundwater with a vertical barrier along the southern perimeter of the southern lobe (estimated length = 1,500 ft, depth = 30 ft)
Treatment / Excavation	
Waste/soil	No treatment included.
Landfill gas	Installation of a landfill gas system, including piping laterals
Leachate	None anticipated; monitoring only
Brook sediment	Selective excavation of impacted sediment (i.e. hot spots) in the brook (between the two landfill lobes) with on-site disposal Re-routing of the brook along the southern edge of the southern landfill lobe
Groundwater	Active and focused groundwater treatment following source control construction. Pre-design studies of in situ remedial measures or groundwater extraction and treatment to be conducted. If groundwater extraction is implemented, the estimated extraction rate is 15 gpm and ex-situ treatment components may include air stripping, advanced oxidation, metals treatment, etc.
Institutional Controls	
Waste/Landfill gas/Leachate	Deed restriction to restrict future use/access of the landfill waste
Brook sediment	--
Groundwater	Deed restriction to restrict future use of groundwater
Monitoring Requirements	Post excavation confirmatory sediment sampling in the brook Routine monitoring of groundwater treatment system influent and effluent (if groundwater extraction and ex-situ treatment implemented) Routine monitoring of landfill gas, leachate, surface water and groundwater Annual Site Inspections
Operation and Maintenance Requirements	Review of site conditions and risks at five year intervals Maintenance of the final cover system (i.e. cap repairs, landscaping (mowing), etc.) O&M of the landfill gas system, groundwater monitoring well system, and groundwater remediation system (as applicable)

TABLE 8-4a
SUMMARY OF REMEDIAL ALTERNATIVE
Remedial Investigation and Feasibility Study
Sutton Brook Disposal Area Superfund Site - Tewksbury, MA

LF-4: Containment of waste, vent landfill gas, re-routing of the brook, excavation of impacted sediment hot spots, partial containment of groundwater (vertical barrier) with groundwater remediation

Area/ Volume of Media Addressed by Alternative	
Waste/ leachate & landfill gas	Northern Lobe - 30 acres or 1.9 million cy Southern Lobe - 10 acres or 0.3 million cy
Brook sediment	5,100 sq ft or 200 cy
Groundwater	At downgradient end of containment barrier
Estimated Timing	
Design and Construction	
Waste/ leachate & landfill gas	2 to 3 years
Brook sediment	3 to 4 years
Groundwater	Following landfill cover and barrier construction
Attainment of RAOs	
Waste/ leachate & landfill gas	Upon construction of final cover system (3 years)
Brook sediment	Upon completion of construction activities (excavation of hot spot sediment in existing brook and re-routing of the brook (3 to 4 years)
Groundwater	65 to 210 years (variation due to different compounds)
Anticipated Reuse Outcomes	Passive recreation

Refer to Figure 8-4 for conceptual layout

TABLE 8-4b
DETAILED ANALYSIS OF REMEDIAL ALTERNATIVE
Remedial Investigation and Feasibility Study
Sutton Brook Disposal Area Superfund Site - Tewksbury, MA

LF-4: Containment of waste, vent landfill gas, re-routing of the brook, excavation of impacted sediment hot spots, containment of groundwater (vertical barrier) with groundwater remediation

EVALUATION CRITERIA	DETAILED ANALYSIS
OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT	
Human Health Protection	The HHRA presumed that the Northern and Southern landfill lobes will be capped; thereby eliminating direct exposure to soils located in these areas. The results of the HHRA concluded if groundwater is used as a source of potable water, groundwater may also pose a risk to hypothetical future site residents or workers. Under this alternative, the landfill waste will be capped and impacted groundwater immediately adjacent to the Southern lobe will be remediated and prevented from discharging into the brook (preventing migration and potential re-contamination of the brook) and impacted groundwater from the Northern lobe will be addressed by in-situ natural attenuation, therefore the potential human health risks will be controlled and RAOs will be achieved.
Ecological Protection	The results of the ecological risk assessment indicated that VOCs and/or metals in sediment and surface water within Sutton Brook between the two landfill lobes may pose potential risk to ecological receptors. Due to these potential risks, PRGs were established for the specific constituents determined to be "risk drivers" in sediment and surface water. Under this alternative, the landfill waste will be capped, hot spot areas within the brook will be excavated, the brook will be re-routed around the Southern Lobe, and impacted groundwater from the Southern lobe will be controlled/treated, minimizing discharge to the newly re-routed brook. Through these remedial actions, RAOs will be achieved.
COMPLIANCE WITH ARARs	
Chemical Specific	Chemical specific ARARs for this alternative are presented in Table E-1 in Appendix E; this alternative will be designed and implemented to comply with applicable chemical specific ARARs.
Location Specific	Potential location specific ARARs for this alternative are presented in Table E-1 in Appendix E. Resource areas which will require alteration include Bordering Land Subject to Flooding, Inland Bank, Land Under Water, Riverfront Area, and Bordering Vegetated Wetlands. Due to the issues involved with re-routing the brook (with respect to altering and re-creating these resource areas and re-creating the 100-year flood plain), specifically the lack of space available to fully mitigate (both the function and value) of the loss of resource areas, in conjunction with a major disruption to the existing hydrogeological features and ecological habitats, this alternative **will most likely not** meet applicable location-specific ARARs.
Action Specific	Action specific ARARs for this alternative are presented in Table E-1 in Appendix E; this alternative will be designed and implemented to comply with applicable action-specific ARARs.

TABLE 8-4b
DETAILED ANALYSIS OF REMEDIAL ALTERNATIVE
Remedial Investigation and Feasibility Study
Sutton Brook Disposal Area Superfund Site - Tewksbury, MA

LF-4: Containment of waste, vent landfill gas, re-routing of the brook, excavation of impacted sediment hot spots, containment of groundwater (vertical barrier) with groundwater remediation

EVALUATION CRITERIA	DETAILED ANALYSIS
LONG-TERM EFFECTIVENESS AND PERMANENCE	
Magnitude of Residual Risk	With the construction of a final cover system over the landfill lobes, the excavation of hot spot areas of impacted sediment from the former brook and the re-creation of the brook around the southern edge of the landfill, the residual risks for direct exposure of landfill waste and impacted sediment are reduced. Further impacts to the newly re-routed brook through groundwater containment (vertical barrier) and focused groundwater treatment will reduce future residual risk to contaminating the re-routed brook sediment and/or surface water and, in conjunction with institutional controls, will control future risk of groundwater ingestion by future site users. Therefore, residual risk is low for this alternative.
Adequacy and Reliability of Controls	Capping of the landfill waste is an effective and reliable technology to prevent exposure to the waste and to reduce infiltration through the waste leaching to groundwater. Re-routing of the brook around the Southern lobe, in conjunction with the vertical groundwater containment barrier, will effectively and reliably minimize future contamination of the brook sediment and/or surface water. The combination of groundwater containment (via a vertical barrier), focused groundwater treatment and institutional controls should effectively and reliably limit human exposure to impacted groundwater until groundwater RAOs are achieved. Monitoring of the containment system and focused groundwater treatment will be required to demonstrate reliability.
REDUCTION OF TOXICITY, MOBILITY AND VOLUME THROUGH TREATMENT	
Treatment Process Used and Materials Treated	This alternative does not treat the landfill waste. Treatment of the excavated sediment is not anticipated prior to on-site disposal beneath the landfill final cover system; however, if deemed necessary based on the pre-design waste characterization results of the material being excavated, ex-situ treatment of soil may be implemented prior to on-site disposal. Materials treated in groundwater through focused groundwater treatment will include VOCs, SVOCs & metals; in situ measures could actively treat these COCs and if extraction and ex-situ treatment of groundwater are implemented, a combination of technologies such as air stripping, advanced oxidation processes and/or metals treatment, in addition to one or more pretreatment steps (to be determined during the design phase) will be utilized to treat the extracted groundwater.
Amount Destroyed or Treated	The landfill waste and excavated sediment are not anticipated to be treated. Groundwater will be treated/destroyed by in situ measures and/or groundwater ex situ treatment. Current dissolved concentrations indicate an estimated 2,700 to 4,500 lbs of VOCs in Northern and Southern lobe groundwater.

TABLE 8-4b
DETAILED ANALYSIS OF REMEDIAL ALTERNATIVE
Remedial Investigation and Feasibility Study
Sutton Brook Disposal Area Superfund Site - Tewksbury, MA

LF-4: Containment of waste, vent landfill gas, re-routing of the brook, excavation of impacted sediment hot spots, containment of groundwater (vertical barrier) with groundwater remediation

EVALUATION CRITERIA	DETAILED ANALYSIS
Degree of Expected Reductions in Toxicity, Mobility or Volume through Treatment	Compared to the other alternatives evaluated for the landfill lobes, this alternative provides a moderate level of reduction in toxicity, mobility and volume of contaminants through groundwater treatment.
Degree to which Treatment is Irreversible	The groundwater treatment will be permanent.
Type and Quantity of Residuals Remaining after Treatment	This alternative does not treat the landfill waste. Through excavation of the impacted sediment, no residuals presenting exposure risks will remain. If groundwater extraction and ex-situ treatment is implemented, treatment of groundwater and any resulting VOC vapors will produce a low volume of treatment residuals that will require off-site treatment/disposal at a licensed facility.
Degree to Which Treatment Reduces Principal Threats	Principal threats of direct exposure and potential leaching from waste to groundwater are addressed via landfill containment (cap). The principal threats/ exposure risks of groundwater migration and ingestion will be controlled through groundwater containment (via vertical barrier), groundwater treatment, natural attenuation, and institutional controls.
SHORT-TERM EFFECTIVENESS	
Protection of Community During Remedial Action	This alternative will have moderate to high short-term effects on the local community during the construction of the landfill final cover system and the re-routing of the brook due to an increase in local truck/ vehicular traffic (bringing in soil cover material, lengthier construction timeframe). Limited short term effects are anticipated as a result of the groundwater containment/treatment portions of this alternative.
Protection of Workers During Remedial Action	Work will be performed in accordance with applicable OSHA standards. Site-specific health and safety plan(s) will be developed to protect site workers.
Environmental Impacts	Impacts to the wetland resource areas are anticipated to be high during construction activities due to the destruction of the existing wetland/marsh area to the south of the Southern lobe during the brook re-creation (disrupting ecological habitat) and due to the location of the wetland resource areas surrounding the landfill lobes (erosion controls and stormwater management will be required to reduce impacts). Once the landfill capping, brook re-creation, former brook excavation and filling are complete, the groundwater containment/treatment components installed, and the area restored, groundwater operation and monitoring activities are anticipated to have limited impacts.

TABLE 8-4b
DETAILED ANALYSIS OF REMEDIAL ALTERNATIVE
Remedial Investigation and Feasibility Study
Sutton Brook Disposal Area Superfund Site - Tewksbury, MA

LF-4: Containment of waste, vent landfill gas, re-routing of the brook, excavation of impacted sediment hot spots, containment of groundwater (vertical barrier) with groundwater remediation

EVALUATION CRITERIA	DETAILED ANALYSIS
Time Until Remedial Action Objectives are Achieved	Landfill waste RAOs will be achieved upon construction of the final cover system (design/ approval 1 year, construction 2 to 3 years) and the sediment RAOs will be achieved upon re-routing of the brook, removal of the impacted sediment and restoration of the former brook area - (design/ approvals 2 years, construction/restoration 1 to 2 years) . The estimated time to achieve groundwater RAOs is approximately 65 to 210 years
IMPLEMENTABILITY	
Ability to Construct and Operate the Technology	Construction of a landfill final cover system is a common technique that is straight forward to implement; the presence of wetland resource areas and the adjacent 100-year flood plain may present potential design challenges for the cover system (stormwater management, etc.). Preliminary evaluation of stormwater/ drainage features at the site indicate that upon capping the landfill, use of the FDDA and Deep Marsh may be required for stormwater detention ponds. Excavation of impacted sediment from existing waterways is a fairly common construction activity; site specific engineering and erosion controls will be required to minimize environmental impacts. Resource areas which will require alteration with re-routing the brook include Bordering Land Subject to Flooding, Inland Bank, Land Under Water, Riverfront Area, and Bordering Vegetated Wetlands. Therefore, all work performed in these areas will present numerous challenges with access and disruption. The installation of a vertical containment barrier and implementation of the focused groundwater treatment involves common construction techniques.
Reliability of the Technology	In conjunction with groundwater containment and treatment, re-routing of the brook and excavation of hot-spot impacted sediment are effective and reliable to eliminate current and potential future risks. Capping of the landfill waste is an effective and reliable technology to prevent direct exposure to the waste and to reduce infiltration through the waste into groundwater. The combination of groundwater containment (via a vertical barrier), focused groundwater treatment and institutional controls should effectively and reliably limit human exposure to impacted groundwater until groundwater RAOs are met.
Ease of Undertaking Additional Remedial Actions, if necessary	This alternative should not limit or interfere with the ability to implement or perform future remedial actions.
Ability to Monitor Effectiveness of Remedy	Confirmatory sediment sampling and analysis is easily implementable to measure the effectiveness of the brook sediment excavation. Groundwater monitoring to demonstrate contaminant containment and mass reduction is easily implementable.

TABLE 8-4b
DETAILED ANALYSIS OF REMEDIAL ALTERNATIVE
Remedial Investigation and Feasibility Study
Sutton Brook Disposal Area Superfund Site - Tewksbury, MA

LF-4: Containment of waste, vent landfill gas, re-routing of the brook, excavation of impacted sediment hot spots, containment of groundwater (vertical barrier) with groundwater remediation

EVALUATION CRITERIA	DETAILED ANALYSIS
Ability to Obtain Approvals and Coordinate with Other Agencies	With the potential ARAR issues in regards to the Wetlands Protection Act, this alternative may have difficulty obtaining substantial compliance with federal and state agencies.
Availability of off-site Treatment, Storage and Disposal Services and Capacity	Facilities are available to treat or dispose of the excavated sediment within Massachusetts. However, there is also availability to re-use this material on-site at one of the landfill lobes beneath the final cover system. If groundwater extraction and ex-situ treatment are implemented, the treated groundwater can be discharged to surface water or to the local POTW.
Availability of Necessary Equipment and Specialists	Equipment, materials and services for this alternative are available.
Availability of Technology	Qualified engineers and contractors are available to design and implement this alternative.
COSTS - *net present value (7%) - 30 years*	
Capital Costs	$25,900,000
Annual Operation, Maintenance and Monitoring	$5,400,000
Periodic Costs	$120,000
TOTAL	$31,420,000

TABLE 8-5a
SUMMARY OF REMEDIAL ALTERNATIVE
Remedial Investigation and Feasibility Study
Sutton Brook Disposal Area Superfund Site - Tewksbury, MA

FDDA-1: No Action

Media Addressed	None
Remedy Components	
Containment	None included
Treatment/ Source Removal	None included
Institutional Controls	None included
Monitoring Requirements	Annual site inspections
Operation and Maintenance Requirements	Review of site conditions and risks at five year intervals
Area/ Volume of Media Addressed by Alternative	None
Estimated Timing	
Design and Construction	None required
Attainment of RAOs	This alternative will not achieve RAOs.
Anticipated Reuse Outcomes	Portion of area to be used as a stormwater management basin for the Northern lobe final cover system

TABLE 8-5b
DETAILED ANALYSIS OF REMEDIAL ALTERNATIVE
Remedial Investigation and Feasibility Study
Sutton Brook Disposal Area Superfund Site - Tewksbury, MA

FDDA-1: No Action

EVALUATION CRITERIA	DETAILED ANALYSIS
OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT	
Human Health Protection	The results of the human health risk assessment indicated that VOCs and SVOCs in soil may pose a potential risk to receptors. The potential for volatilization of select VOCs in groundwater may pose a potential risk to future site residents or facility workers. If groundwater is used as a source of potable water, groundwater in the FDDA may also pose a potential risk to future site residents or facility workers. Under this alternative, no remedial actions will be conducted to reduce concentrations in soil or groundwater to RAOs, therefore the potential future risk to trespassers, site residents, facility workers and/or construction workers will remain and RAOs will not be achieved.
Ecological Protection	The results of the ecological risk assessment indicated that select SVOCs and VOCs in soil within the FDDA may pose potential risk to ecological receptors. Under this alternative, no remedial actions will be conducted to reduce concentrations to meet cleanup goals therefore the potential future risk to ecological receptors will remain and RAOs will not be achieved.
COMPLIANCE WITH ARARs	
Chemical Specific	Under existing conditions, concentrations of select compounds in soil and groundwater exceed chemical specific ARARs. Contaminant concentrations in soil and groundwater are not anticipated to reduce significantly in the foreseeable future; therefore, chemical specific ARARs will not be met for this alternative.
Location Specific	Location specific ARARs do not apply for this alternative since there are no remedial activities associated with this alternative that will cause adverse impacts to natural resources.
Action Specific	Action specific ARARs do not apply for this alternative since there are no remedial activities associated with this alternative.
LONG-TERM EFFECTIVENESS AND PERMANENCE	
Magnitude of Residual Risk	Since there are no active remedial actions or institutional controls associated with this alternative, potential future exposure to site residents, facility workers, construction workers and ecological receptors to contaminants in soil and groundwater will continue to pose a potential residual risk.
Adequacy and Reliability of Controls	No controls are proposed for this alternative.
REDUCTION OF TOXICITY, MOBILITY AND VOLUME THROUGH TREATMENT	
Treatment Process Used and Materials Treated	No active treatment is proposed for this alternative.
Amount Destroyed or Treated	None
Degree of Expected Reductions in Toxicity, Mobility or Volume through Treatment	No active treatment is proposed for this alternative, therefore, no reduction in toxicity, mobility or volume through treatment will be achieved with this alternative.

TABLE 8-5b
DETAILED ANALYSIS OF REMEDIAL ALTERNATIVE
Remedial Investigation and Feasibility Study
Sutton Brook Disposal Area Superfund Site - Tewksbury, MA

FDDA-1: No Action

EVALUATION CRITERIA	DETAILED ANALYSIS
Degree to which Treatment is Irreversible	No treatment is proposed.
Type and Quantity of Residuals Remaining after Treatment	Existing conditions will remain since no treatment is proposed.
Degree to Which Treatment Reduces Principal Threats	No treatment is proposed.
SHORT-TERM EFFECTIVENESS	
Protection of Community During Remedial Action	Not applicable since no remedial actions are included in this alternative.
Protection of Workers During Remedial Action	Not applicable since no remedial actions are included in this alternative.
Environmental Impacts	Not applicable since no remedial actions are included in this alternative.
Time Until Remedial Action Objectives are Achieved	No remedial actions will be implemented to reduce concentrations in soil or groundwater to cleanup goals Therefore, RAO's will not be achieved through implementation of this alternative.
IMPLEMENTABILITY	
Ability to Construct and Operate the Technology	Not applicable since no remedial actions are included in this alternative.
Reliability of the Technology	Not applicable since no remedial actions are included in this alternative.
Ease of Undertaking Additional Remedial Actions, if necessary	This alternative will not limit or interfere with the ability to implement or perform future remedial actions.
Ability to Monitor Effectiveness of Remedy	Not applicable since no remedial actions or monitoring are included in this alternative.
Ability to Obtain Approvals and Coordinate with Other Agencies	Not applicable since no remedial actions are included in this alternative; therefore, no approvals or coordination required.
Availability of off-site Treatment, Storage and Disposal Services and Capacity	Not applicable for this alternative.
Availability of Necessary Equipment and Specialists	No equipment or specialists required for this alternative.
Availability of Technology	Not applicable since no remedial technologies will be used.
COSTS - *net present value (7%)*	
Capital Costs	$0
Annual Operation, Maintenance and Monitoring	$41,000
Periodic Costs	$43,000
TOTAL	$84,000

TABLE 8-6a
SUMMARY OF REMEDIAL ALTERNATIVE
Remedial Investigation and Feasibility Study
Sutton Brook Disposal Area Superfund Site - Tewksbury, MA

FDDA-2: Containment of soil (with cap) and hydraulic containment of groundwater
(through extraction and ex-situ treatment)

Media Addressed	Soil Groundwater
Remedy Components	
Containment	
Soil	Construction of a low permeability engineered cap
Groundwater	Hydraulic containment of groundwater through extraction and ex-situ treatment (anticipated total extraction rate of 20 gpm from 4 wells)
Treatment/ Source Removal	
Soil	None included
Groundwater	Ex-situ treatment components may include air stripping, advanced oxidation, metals treatment, etc.
Institutional Controls	
Soil	Deed restriction to limit direct exposure and future use of the impacted soil
Groundwater	Deed restriction to restrict future use of impacted groundwater until RAOs are met
Monitoring Requirements	Routine monitoring of groundwater treatment system influent and effluent Periodic monitoring of area groundwater Annual Site Inspections (including cap evaluation)
Operation and Maintenance Requirements	Review of site conditions and risks at five year intervals Maintenance of the engineered cap (i.e. cap repairs) O&M of the FDDA groundwater monitoring well system and groundwater treatment system
Area/ Volume of Media Addressed by Alternative	
Soil	45,000 sq ft (area of soil containment barrier/ cap)
Groundwater	4 extraction wells at 5 gpm, for a total of 20 gpm
Estimated Timing	
Design and Construction	
Soil	1 to 2 years
Groundwater	1 to 2 years
Attainment of RAOs	
Soil	Upon construction of engineered cap, preventing direct contact with impacted soil (2 years)
Groundwater	30 to 134 years
Anticipated Reuse Outcomes	Portion of area to be used as a stormwater management basin for the Northern lobe final cover system

Refer to Figure 8-5 for conceptual layout

TABLE 8-6b
DETAILED ANALYSIS OF REMEDIAL ALTERNATIVE
Remedial Investigation and Feasibility Study
Sutton Brook Disposal Area Superfund Site - Tewksbury, MA

FDDA-2: Containment of soil (with cap) and hydraulic containment of groundwater (through extraction and ex-situ treatment)

EVALUATION CRITERIA	DETAILED ANALYSIS
OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT	
Human Health Protection	The results of the human health risk assessment indicated that VOCs and SVOCs in soil may pose a potential risk to receptors. The potential for volatilization of select VOCs in groundwater may pose a potential risk to future site residents or facility workers. If groundwater is used as a source of potable water, groundwater in the FDDA may also pose a potential risk to future site residents or facility workers. Under this alternative, an engineered barrier will be constructed to eliminate human exposure via direct contact and volatilization from soil and groundwater. A groundwater extraction and ex-situ treatment system to hydraulically contain impacted groundwater and reduce the mass of contaminants in groundwater will also be implemented. Hydraulic containment of groundwater will prevent downgradient migration and exposure. Institutional controls will also be implemented to control ingestion and direct exposure to soil and groundwater. I
Ecological Protection	The results of the ecological risk assessment indicated that select SVOCs and VOCs in soil within the FDDA may pose potential risk to ecological receptors. Under this alternative, containment of the impacted soil through an engineered barrier will be constructed to control ecological exposure.
COMPLIANCE WITH ARARs	
Chemical Specific	Under existing conditions, concentrations of select compounds in soil and groundwater exceed chemical specific ARARs. This alternative will prevent exposure to the impacted material, but will not meet the PRGs established and therefore not comply with the chemical specific ARARs.
Location Specific	Potential location specific ARARs for this alternative are presented in Table E-2 in Appendix E; this alternative will be designed and implemented to comply with applicable location-specific ARARs.
Action Specific	Action specific ARARs for this alternative are presented in Table E-2 in Appendix E; this alternative will be designed and implemented to comply with applicable action-specific ARARs.
LONG-TERM EFFECTIVENESS AND PERMANENCE	
Magnitude of Residual Risk	The impacted soil will remain beneath the containment barrier, which will reduce the potential for future leaching into groundwater over time. Hydraulic containment of impacted groundwater will reduce residual risk, preventing downgradient exposure while actively reducing the mass of dissolved contaminants in groundwater. However, since impacted soil will remain in the FDDA, residual risk is moderate to high compared to other alternatives.
Adequacy and Reliability of Controls	Assuming effective implementation, institutional controls should effectively limit human exposure to impacted soil and groundwater until RAOs are achieved. Monitoring of the extraction system's effectiveness in hydraulically containing the plume will be required to determine the reliability of the groundwater component of this alternative and routine inspection that the containment barrier is intact will be required to determine the reliability of the soil component of this alternative.

TABLE 8-6b
DETAILED ANALYSIS OF REMEDIAL ALTERNATIVE
Remedial Investigation and Feasibility Study
Sutton Brook Disposal Area Superfund Site - Tewksbury, MA

FDDA-2: Containment of soil (with cap) and hydraulic containment of groundwater (through extraction and ex-situ treatment)

EVALUATION CRITERIA	DETAILED ANALYSIS
REDUCTION OF TOXICITY, MOBILITY AND VOLUME THROUGH TREATMENT	
Treatment Process Used and Materials Treated	This alternative does not treat the impacted soil. Materials treated within groundwater through the hydraulic containment extraction and ex-situ treatment system will include VOCs, SVOCs & metals via a combination of technologies such as air stripping, advanced oxidation processes and/or metals treatment, in addition to one or more pretreatment steps (to be determined during remedial design phase).
Amount Destroyed or Treated	No soil will be treated, but an estimated total extraction rate of 20 gpm of groundwater will be treated through the hydraulic containment groundwater extraction and ex-situ treatment system. Current dissolved concentrations indicate an estimated 1,600 to 2,000 lbs of VOCs in FDDA groundwater available for treatment. With the soil remaining in-situ, the potential exists for future leaching of additional contaminants from soil to groundwater.
Degree of Expected Reductions in Toxicity, Mobility or Volume through Treatment	Compared to other alternatives evaluated for the FDDA, this alternative provides a minimal level of reduction in toxicity, and volume and a moderate level of reduction in mobility of contaminants through treatment.
Degree to which Treatment is Irreversible	No soil will be actively treated. The groundwater treatment will be permanent.
Type and Quantity of Residuals Remaining after Treatment	Treatment of the groundwater plume and any resulting VOC vapors will result in a minimal volume of treatment residuals that will require off-site treatment/disposal at a licensed facility.
Degree to Which Treatment Reduces Principal Threats	Principal threats of soil exposure and potential leaching from soil to groundwater are not addressed via treatment for this alternative; however, in conjunction with institutional controls, the extraction and treatment of contaminants in groundwater will reduce the principal threats/ exposure risks.
SHORT-TERM EFFECTIVENESS	
Protection of Community During Remedial Action	Construction of the soil containment barrier and construction and operation of the on-site groundwater treatment facility will not have significant short-term impacts on the local community.
Protection of Workers During Remedial Action	Work will be performed in accordance with applicable OSHA standards. Site-specific health and safety plan(s) will be developed to protect site workers.
Environmental Impacts	Impacts to the wetland resource areas are anticipated to be moderate (compared to other alternatives) during construction activities due to the location of the extraction wells and the containment barrier within and/or adjacent to the resource area. Once the containment barrier and the groundwater treatment system are installed, operation and monitoring activities are anticipated to have limited impacts. Available practical means such as erosion and stormwater control measures will also be implemented to minimize harm to wetland areas during construction.
Time Until Remedial Action Objectives are Achieved	The estimated time to achieve RAOs with this alternative is approximately 30 to 134 years

TABLE 8-6b
DETAILED ANALYSIS OF REMEDIAL ALTERNATIVE
Remedial Investigation and Feasibility Study
Sutton Brook Disposal Area Superfund Site - Tewksbury, MA

FDDA-2: Containment of soil (with cap) and hydraulic containment of groundwater (through extraction and ex-situ treatment)

EVALUATION CRITERIA	DETAILED ANALYSIS
IMPLEMENTABILITY	
Ability to Construct and Operate the Technology	The installation of wells and piping for the hydraulic containment groundwater treatment system involves common construction techniques; however due to the location of the impacted groundwater within and adjacent to the wetland resource area, this alternative poses difficulty in implementation to reduce environmental impacts and in designing the treatment system layout. Prior to implementation, pre-design pilot studies will be required to determine groundwater capture zones. Construction of a soil containment barrier involves common construction techniques. Stormwater/ drainage features will be required as part of the design.
Reliability of the Technology	Hydraulic containment through groundwater extraction is a demonstrated and reliable method for capturing and collecting impacted groundwater. In addition, available ex-situ treatment components are effective in treating groundwater to meet discharge limits. Institutional controls and containment barriers are common and reliable technologies to reduce/eliminate exposure to impacted soil and groundwater.
Ease of Undertaking Additional Remedial Actions, if necessary	Utilizing the area as a stormwater management basin for the Northern lobe final cover system and leaving the soil in place will present significant difficulty in undertaking additional remedial actions due to access restrictions.
Ability to Monitor Effectiveness of Remedy	Groundwater monitoring to demonstrate contaminant reduction is easily implementable. Treatment system effluent will be monitored on a routine basis to evaluate the effectiveness of the treatment system and document that discharge requirements are being met. Routine inspection of the soil containment barrier is easily implementable as well.
Ability to Obtain Approvals and Coordinate with Other Agencies	The remedial action will be designed and implemented under coordination with appropriate Federal and State agencies.
Availability of off-site Treatment, Storage and Disposal Services and Capacity	No off-site treatment, storage or disposal services required for the soil component of the alternative. Discharge of the treated groundwater will be to surface water or the local POTW.
Availability of Necessary Equipment and Specialists	Equipment, materials and services for this alternative are readily available.
Availability of Technology	Qualified engineers and contractors are available to design and implement this alternative.
COSTS - *net present value (7%)*	
Capital Costs	$3,100,000
Annual Operation, Maintenance and Monitoring	$4,300,000 to $5,100,000
Periodic Costs	$130,000
TOTAL	$7,530,000 to $8,330,000

O&M cost range based on discharge method - low end to surface water, high end to POTW

TABLE 8-7a
SUMMARY OF REMEDIAL ALTERNATIVE
Remedial Investigation and Feasibility Study
Sutton Brook Disposal Area Superfund Site - Tewksbury, MA

FDDA-3: Excavation, treatment and/or disposal of soil with hydraulic containment of groundwater (through extraction and ex-situ treatment)

Media Addressed	Soil Groundwater
Remedy Components	
Containment	
Soil	--
Groundwater	Hydraulic containment of groundwater through extraction and ex-situ treatment (anticipated flow rate of 24 gpm)
Treatment/ Source Removal	
Soil	Excavation, with on-site disposal beneath the landfill low permeability final cover system. Depending on waste characterization results, treatment of soil may be required prior to disposal.
Groundwater	Ex-situ treatment components may include air stripping, advanced oxidation, metals treatment, etc.
Institutional Controls	
Soil	None required
Groundwater	Deed restriction to restrict future use of groundwater until RAOs are met
Monitoring Requirements	Post excavation confirmatory soil sampling Routine monitoring of groundwater treatment system influent and effluent Periodic monitoring of area groundwater Annual Site Inspections
Operation and Maintenance Requirements	Review of site conditions and risks at five year intervals O&M of the FDDA groundwater monitoring well system and groundwater treatment system
Area/ Volume of Media Addressed by Alternative	
Soil	38,300 sq ft or 8,900 cy
Groundwater	4 extraction wells at 6 gpm, for a total of 24 gpm
Estimated Timing	
Design and Construction	
Soil	1 year
Groundwater	1 to 2 years
Attainment of RAOs	
Soil	Upon removal of soil from FDDA and disposal beneath the landfill final cover system (1 to 2 years)
Groundwater	24 to 89 years
Anticipated Reuse Outcomes	Portion of area to be used as a stormwater management basin for the Northern lobe final cover system

Refer to Figure 8-6 for conceptual layout

TABLE 8-7b
DETAILED ANALYSIS OF REMEDIAL ALTERNATIVE
Remedial Investigation and Feasibility Study
Sutton Brook Disposal Area Superfund Site - Tewksbury, MA

FDDA-3: Excavation, treatment and/or disposal of soil with hydraulic containment of groundwater (through extraction and ex-situ treatment)

EVALUATION CRITERIA	DETAILED ANALYSIS
OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT	
Human Health Protection	The results of the human health risk assessment indicated that VOCs and SVOCs in soil may pose a potential risk to receptors. The potential for volatilization of select VOCs in groundwater may pose a potential risk to future site residents or facility workers. If groundwater is used as a source of potable water, groundwater in the FDDA may also pose a risk to future site residents or facility workers. Under this alternative, excavation of the impacted soil will be conducted to reduce concentrations to meet RAOs, therefore eliminating the potential human health risks associated with the impacted soil and achieving site RAOs for soil. In addition, a groundwater extraction and existing treatment system to hydraulically contain impacted groundwater and reduce the mass of contaminants in groudnwater will also be implemented. Hydraulic containment of groundwater will prevent downgradient migration and exposure. Institutional controls will also be implemented to reduce/prevent exposure to groundwater.
Ecological Protection	The results of the ecological risk assessment indicated that select SVOCs and VOCs in soil within the FDDA may pose potential risk to ecological receptors. Under this alternative, excavation of the impacted soil will be conducted to meet cleanup goals. Therefore the potential future risk to ecological receptors will be eliminated and RAOs for soil will be achieved.
COMPLIANCE WITH ARARs	
Chemical Specific	Potential chemical specific ARARs for this alternative are presented in Table E-2 in Appendix E; this alternative will be designed and implemented to comply with applicable chemical-specific ARARs.
Location Specific	Potential location specific ARARs for this alternative are presented in Table E-2 in Appendix E; this alternative will be designed and implemented to comply with applicable location-specific ARARs.
Action Specific	Action specific ARARs for this alternative are presented in Table E-2 in Appendix E; this alternative will be designed and implemented to comply with applicable action-specific ARARs.
LONG-TERM EFFECTIVENESS AND PERMANENCE	
Magnitude of Residual Risk	The removal of impacted soil will significantly reduce residual risks due to this media. Hydraulic containment of impacted groundwater will significantly reduce residual risk, preventing downgradient exposure, while reducing the mass of contaminants in groundwater. Therefore, residual risk is low compared to other alternatives (e.g., FDDA-2).
Adequacy and Reliability of Controls	Excavation of impacted soil will provide long-term effectiveness and permanence since the material will be removed. Post excavation confirmatory soil samples will be collected to document the reliability of the removal. Assuming effective implementation, institutional controls should effectively limit human exposure to impacted groundwater until groundwater RAOs are achieved. Monitoring of the extraction system's effectiveness in hydraulically containing the plume will be required to measure the reliability of the groundwater component of this alternative.

TABLE 8-7b
DETAILED ANALYSIS OF REMEDIAL ALTERNATIVE
Remedial Investigation and Feasibility Study
Sutton Brook Disposal Area Superfund Site - Tewksbury, MA

FDDA-3: Excavation, treatment and/or disposal of soil with hydraulic containment of groundwater (through extraction and ex-situ treatment)

EVALUATION CRITERIA	DETAILED ANALYSIS
REDUCTION OF TOXICITY, MOBILITY AND VOLUME THROUGH TREATMENT	
Treatment Process Used and Materials Treated	Treatment of the excavated soil may or may not be required prior to disposal; depending on the waste characterization results of the material being excavated, ex-situ treatment of soil may be implemented prior to disposal. Materials treated within groundwater through the hydraulic containment extraction and ex-situ treatment system will include VOCs, SVOCs & metals via a combination of technologies such as air stripping, advanced oxidation processes and/or metals treatment, in addition to one or more pretreatment steps (to be determined during remedial design phase).
Amount Destroyed or Treated	Treatment of a portion of the excavated soil may be required prior to disposal; however, the volume or concentrations will be dependent on waste characterization analysis. An estimated total extraction rate of 24 gpm of groundwater will be treated through the hydraulic containment groundwater extraction and ex-situ treatment system. Current dissolved concentrations indicate an estimated 1,600 to 2,000 lbs of VOCs in FDDA groundwater available for treatment.
Degree of Expected Reductions in Toxicity, Mobility or Volume through Treatment	Treatment of a portion of the excavated soil may be required prior to disposal; however, the volume or concentrations will be dependent on waste characterization analysis. Compared to other alternatives evaluated for the FDDA, this alternative provides a moderate level of reduction in toxicity, mobility and volume of contaminants through groundwater treatment.
Degree to which Treatment is Irreversible	The groundwater and if required, soil treatment will be permanent.
Type and Quantity of Residuals Remaining after Treatment	Through excavation of the impacted soil, no residuals presenting exposure risks will remain. Treatment of the groundwater plume and any resulting VOC vapors will result in a low to moderate volume of treatment residuals that will require off-site treatment/disposal at a licensed facility.
Degree to Which Treatment Reduces Principal Threats	Principal threats of soil exposure and potential leaching from soil to groundwater are not addressed via treatment for this alternative; however, through source excavation, institutional controls, and hydraulic containment of groundwater (through groundwater extraction and treatment), the principal threats/ exposure risks will be controlled.
SHORT-TERM EFFECTIVENESS	
Protection of Community During Remedial Action	This alternative will not have significant short-term effects on the local community. Re-use/disposal of the material on-site is anticipated beneath the landfill final cover system; however, should off-site treatment be required, local truck/ vehicular traffic will increase during implementation.
Protection of Workers During Remedial Action	Work will be performed in accordance with applicable OSHA standards. Site-specific health and safety plan(s) will be developed to protect site workers.
Environmental Impacts	Impacts to the wetland resource areas are anticipated to be moderate during construction activities due to the location of the extraction wells and the excavation extent within and/or adjacent to the wetland resource area. Once the excavation is complete, the groundwater treatment system is installed, and the area restored, operation and monitoring activities are anticipated to have limited to no impacts. Available practical means such as erosion and stormwater control measures will also be implemented to minimize harm to wetland areas during construction.

TABLE 8-7b
DETAILED ANALYSIS OF REMEDIAL ALTERNATIVE
Remedial Investigation and Feasibility Study
Sutton Brook Disposal Area Superfund Site - Tewksbury, MA

FDDA-3: Excavation, treatment and/or disposal of soil with hydraulic containment of groundwater (through extraction and ex-situ treatment)

EVALUATION CRITERIA	DETAILED ANALYSIS
Time Until Remedial Action Objectives are Achieved	Soil RAOs will be achieved upon removal of the impacted soil; confirmatory soil sampling will be performed to document the achievement of soil RAOs. The estimated time to achieve groundwater RAOs is approximately 24 to 89 years
IMPLEMENTABILITY	
Ability to Construct and Operate the Technology	Soil excavation involves common techniques that are straight forward to implement. Erosion controls will be required as part of the design and implementation to reduce environmental impacts to the adjacent wetlands. The installation of wells and piping for the hydraulic containment groundwater treatment system involves common construction techniques; however due to the location of the impacted groundwater within and adjacent to the wetland resource area, this alternative poses difficulty in implementation to reduce environmental impacts and in designing the treatment system layout. Prior to implementation, pre-design pilot studies will be required to determine groundwater capture zones.
Reliability of the Technology	Excavation of impacted soil is a reliable technology to quickly and effectively eliminate exposure risks and remove mass. Implementation of institutional controls is a common and reliable component of the remedy to control exposure to impacted groundwater. Hydraulic containment through groundwater extraction is a demonstrated and reliable method for capturing and collecting impacted groundwater. In addition, available ex-situ treatment components are effective in treating groundwater to meet discharge limits.
Ease of Undertaking Additional Remedial Actions, if necessary	This alternative will not limit or interfere with the ability to implement or perform future remedial actions.
Ability to Monitor Effectiveness of Remedy	Confirmatory soil sampling and analysis is easily implementable to measure the effectiveness of the soil component of this alternative. Groundwater monitoring to demonstrate contaminant reduction is easily implementable. Treatment system effluent will be monitored on a routine basis to evaluate the effectiveness of the treatment system and document that discharge requirements are being met.
Ability to Obtain Approvals and Coordinate with Other Agencies	The remedial action will be designed and implemented under coordination with appropriate Federal and State agencies.
Availability of off-site Treatment, Storage and Disposal Services and Capacity	Facilities are available to treat or dispose of the excavated material within the northeast. However, it is assumed that excavated soil will be reused/disposed of on-site at one of the landfill lobes beneath the final cover system. Discharge of the treated groundwater will be to surface water or the local POTW.

TABLE 8-7b
DETAILED ANALYSIS OF REMEDIAL ALTERNATIVE
Remedial Investigation and Feasibility Study
Sutton Brook Disposal Area Superfund Site - Tewksbury, MA

FDDA-3: Excavation, treatment and/or disposal of soil with hydraulic containment of groundwater (through extraction and ex-situ treatment)

EVALUATION CRITERIA	DETAILED ANALYSIS
Availability of Necessary Equipment and Specialists	Equipment, materials and services for this alternative are readily available.
Availability of Technology	Qualified engineers and contractors are available to design and implement this alternative.
COSTS - *net present value (7%)*	
Capital Costs	$3,400,000
Annual Operation, Maintenance and Monitoring	$4,100,000 to $5,700,000
Periodic Costs	$120,000
TOTAL	$7,620,000 to $9,220,000

O&M cost range based on discharge method - low end to surface water, high end to POTW

TABLE 8-8a
SUMMARY OF REMEDIAL ALTERNATIVE
Remedial Investigation and Feasibility Study
Sutton Brook Disposal Area Superfund Site - Tewksbury, MA

FDDA-4: Excavation, treatment and/or disposal of soil with groundwater remediation (focused mass reduction)

Media Addressed	Soil Groundwater
Remedy Components	
Containment	
Soil	--
Groundwater	--
Treatment/ Source Removal	
Soil	Excavation, with on-site disposal beneath the landfill low permeability final cover system. Depending on waste characterization results, treatment of soil may be required prior to disposal.
Groundwater	Phased groundwater approach with monitored natural attenuation. Monitoring to be conducted to determine if additional measures are needed.
Institutional Controls	
Soil	None required
Groundwater	Deed restriction to restrict future use of groundwater until RAOs are met
Monitoring Requirements	Post excavation confirmatory soil sampling MNA monitoring of area groundwater & evaluation of groundwater contaminant levels Annual Site Inspections
Operation and Maintenance Requirements	Review of site conditions and risks at five year intervals O&M of the FDDA groundwater monitoring well system
Area/ Volume of Media Addressed by Alternative	
Soil	38,300 sq ft or 8,900 cy
Groundwater	MNA - entire area (1.6 acres)
Estimated Timing	
Design and Construction	
Soil	1 year
Groundwater	Refer to phased groundwater remedy flowchart
Attainment of RAOs	
Soil	Upon removal of soil from FDDA and disposal beneath the landfill final cover system (1 to 2 years)
Groundwater	36 to 103 years
Anticipated Reuse Outcomes	Portion of area to be used as a stormwater management basin for the Northern lobe final cover system

Refer to Figure 8-7 for conceptual layout

TABLE 8-8b
DETAILED ANALYSIS OF REMEDIAL ALTERNATIVE
Remedial Investigation and Feasibility Study
Sutton Brook Disposal Area Superfund Site - Tewksbury, MA

FDDA-4: Excavation, treatment and/or disposal of soil with groundwater treatment (focused mass reduction)

EVALUATION CRITERIA	DETAILED ANALYSIS
OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT	
Human Health Protection	The results of the human health risk assessment indicated that VOCs and SVOCs in soil may pose a potential risk to receptors. The potential for volatilization of select VOCs in groundwater may pose a potential risk to future site residents or facility workers. If groundwater is used as a source of potable water, groundwater in the FDDA may also pose a risk to future site residents or facility workers. Under this alternative, excavation of the impacted soil will be conducted to reduce concentrations to meet RAOs therefore eliminating the potential human health risks associated with the impacted soil and achieving site RAOs for soil. In situ natural attenuation mechanisms will be monitored to address groundwater impacts following a phased approach to the groundwater remedy.
Ecological Protection	The results of the ecological risk assessment indicated that select SVOCs and VOCs in soil within the FDDA may pose potential risk to ecological receptors. Under this alternative, excavation of the impacted soil will be conducted to meet cleanup goals therefore the potential future risk to ecological receptors will be eliminated and RAOs for soil will be achieved.
COMPLIANCE WITH ARARs	
Chemical Specific	Potential chemical specific ARARs for this alternative are presented in Table E-2 in Appendix E; this alternative will be designed and implemented to comply with applicable chemical-specific ARARs.
Location Specific	Potential location specific ARARs for this alternative are presented in Table E-2 in Appendix E; this alternative will be designed and implemented to comply with applicable location-specific ARARs.
Action Specific	Action specific ARARs for this alternative are presented in Table E-2 in Appendix E; this alternative will be designed and implemented to comply with applicable action-specific ARARs.
LONG-TERM EFFECTIVENESS AND PERMANENCE	
Magnitude of Residual Risk	Removal of the impacted soil through excavation will significantly reduce residual risk associated with the impacted soil and minimize the potential for future leaching of contaminants from soil to groundwater. A phased groundwater remedial action will further reduce residual risk over time. Therefore, residual risk is low to moderate compared to other alternatives.
Adequacy and Reliability of Controls	Excavation of impacted soil will provide long-term effectiveness and permanence since the material will be removed. Post excavation confirmatory soil samples will be collected to document the reliability of the removal. Assuming effective implementation, institutional controls should effectively limit human exposure to impacted groundwater until groundwater RAOs are achieved. Monitoring of the MNA program's effectiveness will be required to measure the reliability of the groundwater component of this alternative.

TABLE 8-8b
DETAILED ANALYSIS OF REMEDIAL ALTERNATIVE
Remedial Investigation and Feasibility Study
Sutton Brook Disposal Area Superfund Site - Tewksbury, MA

FDDA-4: Excavation, treatment and/or disposal of soil with groundwater treatment (focused mass reduction)

EVALUATION CRITERIA	DETAILED ANALYSIS
REDUCTION OF TOXICITY, MOBILITY AND VOLUME THROUGH TREATMENT	
Treatment Process Used and Materials Treated	Treatment of the excavated soil may or may not be required prior to on-site disposal; depending on the waste characterization results of the material being excavated, ex-situ treatment of soil may be implemented prior to disposal beneath the landfill final cover system. Natural attenuation processes, including biodegradation, dispersion, dilution, adsorption, volatilization and/or chemical and biological stabilization or destruction of contaminants, will address groundwater COPCs in situ. Following the phased approach, this alternative may also include an active groundwater treatment component.
Amount Destroyed or Treated	Treatment of a portion of the excavated soil may be required prior to disposal; however, the volume or concentrations will be dependent on waste characterization analysis. Current dissolved concentrations indicate an estimated 1,600 to 2,000 lbs of VOCs in FDDA groundwater. Natural attenuation processes will address the dissolved plume through biodegradation, dispersion, dilution, adsorption, volatilization and/or chemical and biological stabilization or destruction. Active groundwater treatment system will be implemented, if needed following the phased approach.
Degree of Expected Reductions in Toxicity, Mobility or Volume through Treatment	Treatment of a portion of the excavated soil may be required prior to disposal beneath the landfill final cover system; however, the volume or concentrations will be dependent on waste characterization analysis.
Degree to which Treatment is Irreversible	If required, groundwater and soil treatment will be permanent.
Type and Quantity of Residuals Remaining after Treatment	Through excavation of the impacted soil, no residuals presenting exposure risks will remain. With natural attenuation of groundwater, there will be no residuals requiring disposal.
Degree to Which Treatment Reduces Principal Threats	Principal threats of soil exposure and potential leaching from soil to groundwater are not addressed via treatment for this alternative; however, through source excavation, institutional controls, and natural attenuation mechanisms, the principal threats/ exposure risks will be controlled.
SHORT-TERM EFFECTIVENESS	
Protection of Community During Remedial Action	This alternative will not have significant short-term effects on the local community. Re-use/disposal of soil on-site is anticipated beneath the landfill final cover system; however, should off-site treatment be required, local truck/ vehicular traffic will increase during implementation.
Protection of Workers During Remedial Action	Work will be performed in accordance with applicable OSHA standards. Site-specific health and safety plan(s) will be developed to protect site workers.
Environmental Impacts	Impacts to the wetland resource areas are anticipated to be low to moderate during construction activities due to the location of the excavation extent within and/or adjacent to the wetland resource area. Once the excavation is complete and the area restored, monitoring activities are anticipated to have limited to no impacts. Available practical means such as erosion and stormwater control measures will also be implemented to minimize harm to wetland areas during construction.

TABLE 8-8b
DETAILED ANALYSIS OF REMEDIAL ALTERNATIVE
Remedial Investigation and Feasibility Study
Sutton Brook Disposal Area Superfund Site - Tewksbury, MA

FDDA-4: Excavation, treatment and/or disposal of soil with groundwater treatment (focused mass reduction)

EVALUATION CRITERIA	DETAILED ANALYSIS
Time Until Remedial Action Objectives are Achieved	Soil RAOs will be achieved upon removal of the impacted soil; confirmatory soil sampling will be performed to document the achievement of RAOs. The estimated time to achieve groundwater RAOs is approximately 36 to 103 years
IMPLEMENTABILITY	
Ability to Construct and Operate the Technology	Soil excavation involves common techniques that are straight forward to implement. Erosion controls will be required as part of the design and implementation to reduce environmental impacts to the adjacent wetlands. If implemented, the installation of wells and piping for the focused groundwater extraction and ex-situ treatment system involves common construction techniques. Prior to implementation, pre-design pilot studies will be required to determine groundwater capture zones.
Reliability of the Technology	Excavation of impacted soil is a reliable technology to quickly and effectively eliminate exposure risks and remove mass. Implementation of institutional controls is a common and reliable component of the remedy to eliminate exposure to impacted groundwater and natural attenuation processes have demonstrated effective reduction in FDDA groundwater.
Ease of Undertaking Additional Remedial Actions, if necessary	This alternative would not limit or interfere with the ability to implement or perform future remedial actions.
Ability to Monitor Effectiveness of Remedy	Confirmatory soil sampling and analysis is easily implementable to measure the effectiveness of the soil component of this alternative. Groundwater monitoring to demonstrate contaminant reduction is easily implementable. Treatment system effluent (if required) will be monitored on a routine basis to evaluate the effectiveness of the treatment system and document that discharge requirements are being met.
Ability to Obtain Approvals and Coordinate with Other Agencies	The remedial action will be designed and implemented under coordination with appropriate Federal and State agencies.
Availability of off-site Treatment, Storage and Disposal Services and Capacity	Facilities are available to treat or dispose of the excavated material within the northeast. However, it is assumed that excavated soil will be reused on-site at one of the landfill lobes beneath the final cover system. If groundwater extraction and ex-situ treatment is implemented (through phased approach), discharge of the treated groundwater will be to surface water or the local POTW.
Availability of Necessary Equipment and Specialists	Equipment, materials and services for this alternative are readily available.
Availability of Technology	Qualified engineers and contractors are available to design and implement this alternative.
COSTS - *net present value (7%)*	
Capital Costs	$1,000,000
Annual Operation, Maintenance and Monitoring	$1,700,000
Periodic Costs	$110,000
TOTAL	$2,810,000

TABLE 8-9a
SUMMARY OF REMEDIAL ALTERNATIVE
Remedial Investigation and Feasibility Study
Sutton Brook Disposal Area Superfund Site - Tewksbury, MA

FDDA-5: Excavation, treatment and/or disposal of soil with groundwater extraction and ex-situ treatment for area-wide contaminant reduction/restoration

Media Addressed	Soil Groundwater
Remedy Components	
Containment	
Soil	--
Groundwater	--
Treatment/ Source Removal	
Soil	Excavation, with on-site disposal beneath the landfill low permeability final cover system. Depending on waste characterization results, treatment of soil may be required prior to disposal.
Groundwater	Ex-situ treatment components may include air stripping, advanced oxidation, metals treatment, etc.; anticipated flowrate of 50 gpm.
Institutional Controls	
Soil	None required
Groundwater	Deed restriction to restrict future use of groundwater until RAOs are met
Monitoring Requirements	Post excavation confirmatory soil sampling Routine monitoring of groundwater treatment system influent and effluent Periodic monitoring of area groundwater Annual Site Inspections
Operation and Maintenance Requirements	Review of site conditions and risks at five year intervals O&M of the FDDA groundwater monitoring well system and groundwater treatment system
Area/ Volume of Media Addressed by Alternative	
Soil	38,300 sq ft or 8,900 cy
Groundwater	5 extraction wells at 10 gpm, for a total of 50 gpm
Estimated Timing	
Design and Construction	
Soil	1 year
Groundwater	1 to 2 years
Attainment of RAOs	
Soil	Upon removal of soil from FDDA and disposal beneath the landfill final cover system (1 to 2 years)
Groundwater	23 to 85 years
Anticipated Reuse Outcomes	Portion of area to be used as a stormwater management basin for the Northern lobe final cover system

Refer to Figure 8-8 for conceptual layout

TABLE 8-9b
DETAILED ANALYSIS OF REMEDIAL ALTERNATIVE
Remedial Investigation and Feasibility Study
Sutton Brook Disposal Area Superfund Site - Tewksbury, MA

FDDA-5: Excavation, treatment and/or disposal of soil with groundwater extraction and ex-situ treatment for area-wide contaminant reduction

EVALUATION CRITERIA	DETAILED ANALYSIS
OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT	
Human Health Protection	The results of the human health risk assessment indicated that VOCs and SVOCs in soil may pose a potential risk to receptors. The potential for volatilization of select VOCs in groundwater may pose a potential risk to future site residents or facility workers. If groundwater is used as a source of potable water, groundwater in the FDDA may also pose a risk to future site residents or facility workers. Under this alternative, excavation of the impacted soil will be conducted to reduce concentrations to meet RAOs therefore eliminating the potential human health risks associated with the impacted soil and achieving site RAOs for soil. In addition to soil excavation, a groundwater extraction and treatment system for area-wide contaminant reduction/restoration and institutional controls will also be implemented to address impacted groundwater.
Ecological Protection	The results of the ecological risk assessment indicated that select SVOCs and VOCs in soil within the FDDA may pose potential risk to ecological receptors. Under this alternative, excavation of the impacted soil will be conducted to reduce concentrations to meet cleanup goals. Therefore the potential future risk to ecological receptors will be eliminated and RAOs for soil will be achieved.
COMPLIANCE WITH ARARs	
Chemical Specific	Potential chemical specific ARARs for this alternative are presented in Table E-2 in Appendix E; this alternative will be designed and implemented to comply with applicable chemical-specific ARARs.
Location Specific	Potential location specific ARARs for this alternative are presented in Table E-2 in Appendix E; this alternative will be designed and implemented to comply with applicable location-specific ARARs.
Action Specific	Action specific ARARs for this alternative are presented in Table E-2 in Appendix E; this alternative will be designed and implemented to comply with applicable action-specific ARARs.
LONG-TERM EFFECTIVENESS AND PERMANENCE	
Magnitude of Residual Risk	Area-wide contaminant reduction of impacted groundwater through groundwater extraction and ex-situ treatment will significantly reduce residual risk, preventing downgradient exposure and actively treating impacted groundwater. In addition, removal of the impacted soil through excavation will significantly reduce any residual risk associated with the impacted soil. Therefore, residual risk is low compared to other alternatives.

TABLE 8-9b
DETAILED ANALYSIS OF REMEDIAL ALTERNATIVE
Remedial Investigation and Feasibility Study
Sutton Brook Disposal Area Superfund Site - Tewksbury, MA

FDDA-5: Excavation, treatment and/or disposal of soil with groundwater extraction and ex-situ treatment for area-wide contaminant reduction

EVALUATION CRITERIA	DETAILED ANALYSIS
Adequacy and Reliability of Controls	Excavation of impacted soil will provide long-term effectiveness and permanence since the material will be removed. Post excavation confirmatory soil samples will be collected to document the reliability of the alternative. Assuming effective implementation, institutional controls should effectively limit human exposure to impacted groundwater until groundwater RAOs are achieved. Monitoring of the extraction system's effectiveness in reducing contaminant mass will be required to measure the reliability of the groundwater component of this alternative.
REDUCTION OF TOXICITY, MOBILITY AND VOLUME THROUGH TREATMENT	
Treatment Process Used and Materials Treated	Treatment of the excavated soil may or may not be required prior to disposal; depending on the waste characterization results of the material being excavated, ex-situ treatment of soil may be implemented prior to disposal. Materials treated within groundwater through the extraction and ex-situ treatment system will include VOCs, SVOCs & metals via a combination of technologies such as air stripping, advanced oxidation processes and/or metals treatment, in addition to one or more pretreatment steps (to be determined during remedial design phase).
Amount Destroyed or Treated	Treatment of a portion of the excavated soil may be required prior to disposal; however, the volume or concentrations will be dependent on waste characterization analysis. An estimated total extraction rate of 50 gpm of groundwater will be treated through the groundwater extraction and ex-situ treatment system. Current dissolved concentrations indicate an estimated 1,600 to 2,000 lbs of VOCs in FDDA groundwater available for treatment.
Degree of Expected Reductions in Toxicity, Mobility or Volume through Treatment	Treatment of a portion of the excavated soil may be required prior to disposal; however, the volume or concentrations will be dependent on waste characterization analysis. Compared to other alternatives evaluated for the FDDA, this alternative provides a moderate to high level of reduction in toxicity, mobility and volume of contaminants through groundwater treatment.
Degree to which Treatment is Irreversible	The groundwater and, if required, soil treatment will be permanent.
Type and Quantity of Residuals Remaining after Treatment	Through excavation of the impacted soil, no residuals presenting exposure risks will remain. Treatment of the groundwater plume and any resulting VOC vapors will result in a moderate to high volume of treatment residuals that will require off-site treatment/disposal at a licensed facility.
Degree to Which Treatment Reduces Principal Threats	Principal threats of soil exposure and potential leaching from soil to groundwater are not addressed via treatment for this alternative; however, through excavation, institutional controls, and groundwater extraction and treatment, the principal threats/ exposure risks will be eliminated over time.
SHORT-TERM EFFECTIVENESS	
Protection of Community During Remedial Action	This alternative will not have significant short-term effects on the local community. Re-use/disposal of the material on-site is anticipated beneath the landfill final cover system; however, should off-site treatment be required, local truck/ vehicular traffic will increase during implementation.

TABLE 8-9b
DETAILED ANALYSIS OF REMEDIAL ALTERNATIVE
Remedial Investigation and Feasibility Study
Sutton Brook Disposal Area Superfund Site - Tewksbury, MA

FDDA-5: Excavation, treatment and/or disposal of soil with groundwater extraction and ex-situ treatment for area-wide contaminant reduction

EVALUATION CRITERIA	DETAILED ANALYSIS
Protection of Workers During Remedial Action	Work will be performed in accordance with applicable OSHA standards. Site-specific health and safety plan(s) will be developed to protect site workers.
Environmental Impacts	Impacts to the wetland resource areas are anticipated to be moderate to high during construction activities due to the location of the extraction wells and the excavation extent within and/or adjacent to the wetland resource area. Once the excavation is complete, the groundwater treatment system is installed, and the area restored, operation and monitoring activities are anticipated to have limited impacts. Available practical means such as erosion and stormwater control measures will also be implemented to minimize harm to wetland areas during construction.
Time Until Remedial Action Objectives are Achieved	Soil RAOs will be achieved upon removal of the impacted soil; confirmatory soil sampling will be performed to document the achievement of RAOs. The estimated time to achieve groundwater RAOs is approximately 23 to 85 years
IMPLEMENTABILITY	
Ability to Construct and Operate the Technology	Soil excavation involves common techniques that are straight forward to implement. Erosion controls will be required as part of the design and implementation to reduce environmental impacts to the adjacent wetlands. The installation of wells and piping for the groundwater treatment system involves common construction techniques; however due to the location of the impacted groundwater within and adjacent to the wetland resource area, this alternative poses difficulty in implementation to reduce environmental impacts and in designing the treatment system layout. Prior to implementation, pre-design pilot studies will be required to measure groundwater capture zones.
Reliability of the Technology	Excavation of impacted soil is a reliable technology to quickly and effectively eliminated exposure risks. Implementation of institutional controls is a common and reliable component of the remedy to control exposure to impacted groundwater. Contaminant mass reduction through groundwater extraction is a demonstrated and reliable method for capturing and collecting impacted groundwater. In addition, available ex-situ treatment components (are effective in treating groundwater to meet remedial goals.
Ease of Undertaking Additional Remedial Actions, if necessary	This alternative will not limit or interfere with the ability to implement or perform future remedial actions.
Ability to Monitor Effectiveness of Remedy	Confirmatory soil sampling and analysis is easily implementable to measure the effectiveness of the soil component of this alternative. Groundwater monitoring to demonstrate contaminant reduction is easily implementable. Treatment system effluent will be monitored on a routine basis to evaluate the effectiveness of the treatment system and document that discharge requirements are being met.
Ability to Obtain Approvals and Coordinate with Other Agencies	The remedial action will be designed and implemented under coordination with appropriate Federal and State agencies.

TABLE 8-9b
DETAILED ANALYSIS OF REMEDIAL ALTERNATIVE
Remedial Investigation and Feasibility Study
Sutton Brook Disposal Area Superfund Site - Tewksbury, MA

FDDA-5: Excavation, treatment and/or disposal of soil with groundwater extraction and ex-situ treatment for area-wide contaminant reduction

EVALUATION CRITERIA	DETAILED ANALYSIS
Availability of off-site Treatment, Storage and Disposal Services and Capacity	Facilities are available to treat or dispose of the excavated material within the northeast. However, it is assumed that excavated soil will be reused on-site at one of the landfill lobes beneath the final cover system. Discharge of the treated groundwater will be to surface water or the local POTW.
Availability of Necessary Equipment and Specialists	Equipment, materials and services for this alternative are readily available.
Availability of Technology	Qualified engineers and contractors are available to design and implement this alternative.
COSTS - *net present value (7%)*	
Capital Costs	$4,500,000
Annual Operation, Maintenance and Monitoring	$5,300,000 to $7,700,000
Periodic Costs	$130,000
TOTAL	$9,930,000 to $12,330,000

O&M cost range based on discharge method - low end to surface water, high end to POTW

TABLE 8-10a
SUMMARY OF REMEDIAL ALTERNATIVE
Remedial Investigation and Feasibility Study
Sutton Brook Disposal Area Superfund Site - Tewksbury, MA
GSA-1: No Action

Media Addressed	None
Remedy Components	
Containment	None included
Treatment/ Source Removal	None included
Institutional Controls	None included
Monitoring Requirements	Annual site inspections
Operation and Maintenance Requirements	Review of site conditions and risks at five year intervals
Area/ Volume of Media Addressed by Alternative	None
Estimated Timing	
Design and Construction	None required
Attainment of RAOs	This alternative will not achieve site RAO's.
Anticipated Reuse Outcomes	Passive recreation

TABLE 8-10b
DETAILED ANALYSIS OF REMEDIAL ALTERNATIVE
Remedial Investigation and Feasibility Study
Sutton Brook Disposal Area Superfund Site - Tewksbury, MA
GSA-1: No Action

EVALUATION CRITERIA	DETAILED ANALYSIS
OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT	
Human Health Protection	The results of the human health risk assessment indicated that select metals and PAHs in soils may pose a potential future risk to site residents, facility workers and/or construction workers. Under this alternative, no remedial actions will be conducted to reduce concentrations of PAHs or metals in soil to cleanup goals. Therefore the potential future risk to site residents, facility workers and/or construction workers will remain and RAOs will not be achieved.
Ecological Protection	The results of the ecological risk assessment indicated that current and potential future risks to ecological receptors are present in soil in the GSA. Under this alternative, no remedial actions will be conducted to reduce concentrations in soil to cleanup goals. Therefore the potential future risk to ecological receptors will remain and RAOs will not be achieved.
COMPLIANCE WITH ARARs	
Chemical Specific	Under existing conditions, constituents in soil exceed chemical specific ARARs. Contaminant concentrations in soil are not anticipated to reduce over time; therefore, chemical specific ARARs will not be met for this alternative.
Location Specific	Location specific ARARs do not apply for this alternative since there are no remedial activities associated with this alternative that will cause adverse impacts to natural resources.
Action Specific	Action specific ARARs do not apply for this alternative since there are no remedial activities associated with this alternative.
LONG-TERM EFFECTIVENESS AND PERMANENCE	
Magnitude of Residual Risk	Since there are no active remedial actions or institutional controls associated with this alternative, potential future exposure to site residents, facility workers, construction workers and ecological receptors to contaminants in soil will continue to pose a potential residual risk.
Adequacy and Reliability of Controls	No controls are proposed for this alternative.
REDUCTION OF TOXICITY, MOBILITY AND VOLUME THROUGH TREATMENT	
Treatment Process Used and Materials Treated	No active treatment is proposed for this alternative.
Amount Destroyed or Treated	None
Degree of Expected Reductions in Toxicity, Mobility or Volume through Treatment	No active treatment is proposed for this alternative, therefore, no reduction in toxicity, mobility or volume through treatment will be achieved.
Degree to which Treatment is Irreversible	No treatment is proposed.
Type and Quantity of Residuals Remaining after Treatment	Existing conditions will remain since no treatment is proposed.
Degree to Which Treatment Reduces Principal Threats	No treatment is proposed.

TABLE 8-10b
DETAILED ANALYSIS OF REMEDIAL ALTERNATIVE
Remedial Investigation and Feasibility Study
Sutton Brook Disposal Area Superfund Site - Tewksbury, MA
GSA-1: No Action

EVALUATION CRITERIA	DETAILED ANALYSIS
SHORT-TERM EFFECTIVENESS	
Protection of Community During Remedial Action	Not applicable since no remedial actions are included in this alternative.
Protection of Workers During Remedial Action	Not applicable since no remedial actions are included in this alternative.
Environmental Impacts	Not applicable since no remedial actions are included in this alternative.
Time Until Remedial Action Objectives are Achieved	No active remedial actions will be implemented to reduce concentrations in soil to RAOs. Therefore, RAO's will not be achieved through this alternative.
IMPLEMENTABILITY	
Ability to Construct and Operate the Technology	Not applicable since no remedial actions are included in this alternative.
Reliability of the Technology	Not applicable since no remedial actions are included in this alternative.
Ease of Undertaking Additional Remedial Actions, if necessary	This alternative will not limit or interfere with the ability to implement or perform future remedial actions.
Ability to Monitor Effectiveness of Remedy	Not applicable since no remedial actions or monitoring are included in this alternative.
Ability to Obtain Approvals and Coordinate with Other Agencies	Not applicable since no remedial actions are included in this alternative; therefore, no approvals or coordination required.
Availability of off-site Treatment, Storage and Disposal Services and Capacity	Not applicable for this alternative.
Availability of Necessary Equipment and Specialists	No equipment or specialists required for this alternative.
Availability of Technology	Not applicable since no remedial technologies will be used.
COSTS - *net present value (7%)*	
Capital Costs	$0
Annual Operation, Maintenance and Monitoring	$40,000
Periodic Costs	$10,000
TOTAL	$50,000

TABLE 8-11a
SUMMARY OF REMEDIAL ALTERNATIVE
Remedial Investigation and Feasibility Study
Sutton Brook Disposal Area Superfund Site _ Tewksbury, MA
GSA-2: Excavation with Treatment and/or Disposal of Soil

Media Addressed	Soil
Remedy Components	
Containment	
Soil	None included
Treatment/ Source Removal	
Soil	Excavation, with on-site disposal beneath the landfill low permeability final cover system. Treatment of soil prior to disposal is not anticipated; however, waste characterization will be performed to determine if treatment is required.
Institutional Controls	
Soil	None included
Monitoring Requirements	Post excavation confirmatory soil sampling
Operation and Maintenance Requirements	None anticipated
Area/ Volume of Media Addressed by Alternative	
Soil	8,150 sq ft or 530 cy
Estimated Timing	
Design and Construction	1 year
Attainment of RAOs	Upon removal of soil from the area and disposal beneath the landfill final cover system (1 to 2 years)
Anticipated Reuse Outcomes	Passive recreation

Refer to Figure 8-9 for conceptual layout

TABLE 8-11b
DETAILED ANALYSIS OF REMEDIAL ALTERNATIVE
Remedial Investigation and Feasibility Study
Sutton Brook Disposal Area Superfund Site - Tewksbury, MA
GSA-2: Excavation with Treatment and/or Disposal of Soil

EVALUATION CRITERIA	DETAILED ANALYSIS
OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT	
Human Health Protection	The results of the human health risk assessment indicated that select metals and PAHs in soils may pose a potential future risk to site residents, facility workers and/or construction workers. Under this alternative, excavation of the impacted soil will be conducted to reduce concentrations to meet cleanup goals, therefore the potential future risk to site residents, facility workers and construction workers will be eliminated and RAOs will be achieved.
Ecological Protection	The results of the ecological risk assessment indicated that current and potential future risks to ecological receptors are present in soil in the GSA. Under this alternative, excavation of the impacted soil will be conducted to reduce concentrations to meet cleanup goals, therefore the potential future risk to ecological receptors will be eliminated and RAOs will be achieved.
COMPLIANCE WITH ARARs	
Chemical Specific	Under existing conditions, constituents in soil exceed chemical specific ARARs. This alternative will be designed and implemented to comply with the chemical specific ARARs.
Location Specific	Location specific ARARs do not apply for this alternative since there are no remedial activities associated with this alternative that will cause adverse impacts to natural resources.
Action Specific	Action specific ARARs for this alternative are presented in Table E-3 in Appendix E; this alternative will be designed and implemented to comply with applicable action-specific ARARs.
LONG-TERM EFFECTIVENESS AND PERMANENCE	
Magnitude of Residual Risk	Removal of the impacted material through excavation will significantly reduce any residual risk.
Adequacy and Reliability of Controls	Excavation of impacted soil will provide long-term effectiveness and permanence since the material will be removed from the GSA and disposed of beneath the landfill final cover system. Post excavation confirmatory soil samples will be collected to document the reliability of the alternative.
REDUCTION OF TOXICITY, MOBILITY AND VOLUME THROUGH TREATMENT	
Treatment Process Used and Materials Treated	Treatment of the excavated soil may or may not be required prior to disposal; depending on the waste characterization results of the material being excavated, ex-situ treatment of soil may be implemented prior to disposal.
Amount Destroyed or Treated	Treatment of a portion of the excavated soil may be required prior to disposal; however, the volume or concentrations will be dependent on waste characterization analysis.
Degree of Expected Reductions in Toxicity, Mobility or Volume through Treatment	No active treatment of the excavated material is anticipated for this alternative; however, through re-use/disposal of the material beneath a landfill cap, the toxicity, mobility and volume of impacted material in the GSA is significantly reduced.
Degree to which Treatment is Irreversible	No treatment is anticipated with this alternative.

TABLE 8-11b
DETAILED ANALYSIS OF REMEDIAL ALTERNATIVE
Remedial Investigation and Feasibility Study
Sutton Brook Disposal Area Superfund Site - Tewksbury, MA
GSA-2: Excavation with Treatment and/or Disposal of Soil

EVALUATION CRITERIA	DETAILED ANALYSIS
Type and Quantity of Residuals Remaining after Treatment	No active treatment of the excavated material is anticipated for this alternative.
Degree to Which Treatment Reduces Principal Threats	No active treatment of the excavated material is anticipated for this alternative; however, through excavation of the impacted material, the principal threats will be eliminated.
SHORT-TERM EFFECTIVENESS	
Protection of Community During Remedial Action	This alternative will not have significant short-term effects on the local community. Re-use/disposal of the material on-site is anticipated beneath the landfill final cover system; however, should off-site treatment be required, local truck/vehicular traffic will increase during implementation.
Protection of Workers During Remedial Action	Work will be performed in accordance with applicable OSHA standards. Site-specific health and safety plan(s) will be developed to protect site workers.
Environmental Impacts	Limited environmental impacts are anticipated.
Time Until Remedial Action Objectives are Achieved	RAOs will be achieved upon removal of the impacted soil (1 to 2 years); confirmatory soil sampling will be performed to document the achievement of RAOs.
IMPLEMENTABILITY	
Ability to Construct and Operate the Technology	Soil excavation involves common techniques that are straight forward to implement.
Reliability of the Technology	Excavation of impacted soil is a reliable technology to quickly and effectively control exposure risks.
Ease of Undertaking Additional Remedial Actions, if necessary	This alternative will not limit or interfere with the ability to implement or perform future remedial actions.
Ability to Monitor Effectiveness of Remedy	Confirmatory soil sampling and analysis is easily implementable to measure the effectiveness of the remedy.
Ability to Obtain Approvals and Coordinate with Other Agencies	The remedial action will be designed and implemented under coordination with appropriate Federal and State agencies.
Availability of off-site Treatment, Storage and Disposal Services and Capacity	Facilities are available to treat or dispose of the excavated material within the northeast. However, it is assumed that excavated soil will be reused on-site at one of the landfill lobes beneath the final cover system.
Availability of Necessary Equipment and Specialists	Equipment, materials and services for this alternative are readily available.
Availability of Technology	Qualified engineers and contractors are readily available to design and implement this alternative.
COSTS - *net present value (7%)*	
Capital Costs	$184,000
Annual Operation, Maintenance and Monitoring	$0
Periodic Costs	$16,000
TOTAL	$200,000

TABLE 8-12a
SUMMARY OF REMEDIAL ALTERNATIVE
Remedial Investigation and Feasibility Study
Sutton Brook Disposal Area Superfund Site - Tewksbury, MA
DGGW-1: No Action

Media Addressed	None
Remedy Components	
Containment	None included
Treatment/ Source Removal	None included
Institutional Controls	None included
Monitoring Requirements	Annual site inspections
Operation and Maintenance Requirements	Review of site conditions and risks at five year intervals
Area/ Volume of Media Addressed by Alternative	None
Estimated Timing	
Design and Construction	None required
Attainment of RAOs	This alternative will not achieve site RAO's.
Anticipated Reuse Outcomes	Passive recreation

TABLE 8-12b
DETAILED ANALYSIS OF REMEDIAL ALTERNATIVE
Remedial Investigation and Feasibility Study
Sutton Brook Disposal Area Superfund Site - Tewksbury, MA
DGGW-1: No Action

EVALUATION CRITERIA	DETAILED ANALYSIS
OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT	
Human Health Protection	The results of the human health risk assessment indicated the potential risk through the potable use of site groundwater exists to future site residents and facility workers. Under this alternative, no remedial actions will be conducted to reduce residual concentrations in downgradient groundwater to RAOs. Therefore the potential future risk of potable groundwater use will remain and RAOs will not be achieved.
Ecological Protection	The results of the ecological risk assessment indicated no significant risks to ecological receptors as a result of downgradient groundwater.
COMPLIANCE WITH ARARs	
Chemical Specific	Under existing conditions, concentrations of select compounds in downgradient groundwater exceed chemical specific ARARs. No active treatment technologies are implemented with this alternative; therefore, chemical specific ARARs will not be met for this alternative.
Location Specific	Location specific ARARs do not apply for this alternative since there are no remedial activities associated with this alternative that will cause adverse impacts to natural resources.
Action Specific	Action specific ARARs do not apply for this alternative since there are no remedial activities associated with this alternative.
LONG-TERM EFFECTIVENESS AND PERMANENCE	
Magnitude of Residual Risk	Since there are no active remedial actions or institutional controls associated with this alternative, potential future exposure to contaminants in groundwater will continue to pose a residual risk.
Adequacy and Reliability of Controls	No controls are proposed for this alternative.
REDUCTION OF TOXICITY, MOBILITY AND VOLUME THROUGH TREATMENT	
Treatment Process Used and Materials Treated	No active treatment is proposed for this alternative.
Amount Destroyed or Treated	No active treatment is proposed for this alternative.
Degree of Expected Reductions in Toxicity, Mobility or Volume through Treatment	No reduction in toxicity, mobility or volume through treatment will be achieved with this alternative.
Degree to which Treatment is Irreversible	No active treatment is proposed.
Type and Quantity of Residuals Remaining after Treatment	No active treatment is proposed.
Degree to Which Treatment Reduces Principal Threats	No active treatment is proposed and therefore the potential risks of groundwater consumption still remain.
SHORT-TERM EFFECTIVENESS	
Protection of Community During Remedial Action	Not applicable since no remedial actions are included in this alternative.
Protection of Workers During Remedial Action	Not applicable since no remedial actions are included in this alternative.

TABLE 8-12b
DETAILED ANALYSIS OF REMEDIAL ALTERNATIVE
Remedial Investigation and Feasibility Study
Sutton Brook Disposal Area Superfund Site - Tewksbury, MA
DGGW-1: No Action

EVALUATION CRITERIA	DETAILED ANALYSIS
Environmental Impacts	Not applicable since no remedial actions are included in this alternative.
Time Until Remedial Action Objectives are Achieved	No active remedial actions will be implemented to reduce concentrations in downgradient groundwater to PRGs. Therefore, RAOs will not be achieved through this alternative.
IMPLEMENTABILITY	
Ability to Construct and Operate the Technology	Not applicable since no remedial actions are included in this alternative.
Reliability of the Technology	Not applicable since no remedial actions are included in this alternative.
Ease of Undertaking Additional Remedial Actions, if necessary	This alternative will not limit or interfere with the ability to implement or perform future remedial actions.
Ability to Monitor Effectiveness of Remedy	Not applicable since no remedial actions or monitoring are included in this alternative.
Ability to Obtain Approvals and Coordinate with Other Agencies	Not applicable since no remedial actions are included in this alternative; therefore, no approvals or coordination required.
Availability of off-site Treatment, Storage and Disposal Services and Capacity	Not applicable for this alternative.
Availability of Necessary Equipment and Specialists	No equipment or specialists required for this alternative.
Availability of Technology	Not applicable since no remedial technologies will be used.
COSTS - *net present value (7%)*	
Capital Costs	$0
Annual Operation, Maintenance and Monitoring	$41,000
Periodic Costs	$43,000
TOTAL	$84,000

TABLE 8-13a
SUMMARY OF REMEDIAL ALTERNATIVE
Remedial Investigation and Feasibility Study
Sutton Brook Disposal Area Superfund Site _ Tewksbury, MA
DGGW-2: In-situ Remediation

Media Addressed	Groundwater
Remedy Components	
Containment	
Groundwater	--
Treatment	
Groundwater	No active treatment; natural attenuation mechanisms will be monitored to demonstrate reducing COPC concentrations. Additional measures may be implemented based on the monitoring results.
Institutional Controls	
Groundwater	Deed restriction to restrict future use of groundwater until RAOs are met
Monitoring Requirements	Monitoring of area groundwater Annual Site Inspections
Operation and Maintenance Requirements	Review of site conditions and risks at five year intervals O&M of the DGGW groundwater monitoring well system
Area/ Volume of Media Addressed by Alternative	
Groundwater	MNA - entire area (16.8 acres)
Estimated Timing	
Design and Construction	Refer to phased groundwater remedy flowchart
Attainment of RAOs	With Source Control - 67 to 79 years Without Source Control - 81 to 98 years
Anticipated Reuse Outcomes	Passive recreation

TABLE 8-13b
DETAILED ANALYSIS OF REMEDIAL ALTERNATIVE
Remedial Investigation and Feasibility Study
Sutton Brook Disposal Area Superfund Site - Tewksbury, MA
DGGW-2: In-situ Remediation

EVALUATION CRITERIA	DETAILED ANALYSIS
OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT	
Human Health Protection	The results of the human health risk assessment indicated the potential risk through the potable use of site groundwater exists to future site residents and facility workers. Under this alternative, in-situ natural attenuation mechanisms will be monitored to address impacted groundwater following a phased approach to the groundwater remedy. Until the RAOs are achieved, institutional controls will be in place to prevent groundwater use/exposure, controlling human risks.
Ecological Protection	The results of the ecological risk assessment indicated no significant risks to ecological receptors as a result of downgradient groundwater.
COMPLIANCE WITH ARARs	
Chemical Specific	Under existing conditions, concentrations of select compounds in groundwater exceed chemical specific ARARs. Implementation of this alternative will be expected to reduce contaminant concentrations in downgradient groundwater and over time, achieve chemical-specific ARARs.
Location Specific	Potential location specific ARARs for this alternative are presented in Table E-4 in Appendix E; this alternative provides the least amount of disruption to ecological receptors and the wetland resource area during implementation. In-situ remedial activities can be implemented to comply with applicable location-specific ARARs.
Action Specific	Potential action specific ARARs for this alternative are presented in Table E-4 in Appendix E. In-situ remedial activities can be implemented to comply with applicable action-specific ARARs.
LONG-TERM EFFECTIVENESS AND PERMANENCE	
Magnitude of Residual Risk	Until the achievement of site RAOs, implementation of institutional controls will reduce potential use and exposure to impacted groundwater. Therefore, residual risk is low.
Adequacy and Reliability of Controls	Assuming effective implementation and enforcement, institutional controls should effectively limit human exposure to impacted groundwater until the RAOs are achieved.
REDUCTION OF TOXICITY, MOBILITY AND VOLUME THROUGH TREATMENT	
Treatment Process Used and Materials Treated	Natural attenuation processes, including biodegradation, dispersion, dilution, adsorption, volatilization and/or chemical and biological stabilization or destruction of contaminants, will address groundwater COPCs in situ.
Amount Destroyed or Treated	Natural attenuation processes are anticipated to reduce the contaminants over time; current dissolved concentrations indicate an estimated 200 lbs of VOCs in downgradient groundwater.
Degree of Expected Reductions in Toxicity, Mobility or Volume through Treatment	Alternative does not include active treatment technologies. The degree to which this alternative will reduce the toxicity, mobility and volume of contaminants through natural attenuation is moderate, compared to other alternatives evaluated.
Degree to which Treatment is Irreversible	Alternative does not include active treatment technologies. Natural attenuation mechanisms are permanent.

TABLE 8-13b
DETAILED ANALYSIS OF REMEDIAL ALTERNATIVE
Remedial Investigation and Feasibility Study
Sutton Brook Disposal Area Superfund Site - Tewksbury, MA
DGGW-2: In-situ Remediation

EVALUATION CRITERIA	DETAILED ANALYSIS
Type and Quantity of Residuals Remaining after Treatment	No residuals will remain through in-situ natural attenuation processes.
Degree to Which Treatment Reduces Principal Threats	The principal threats/exposure risks from groundwater will be controlled/reduced through natural attenuation and institutional controls.
SHORT-TERM EFFECTIVENESS	
Protection of Community During Remedial Action	No impacts to the community are anticipated for this alternative.
Protection of Workers During Remedial Action	Work will be performed in accordance with applicable OSHA standards. Site-specific health and safety plan(s) will be developed to protect site workers.
Environmental Impacts	Impacts to the wetland resource areas are anticipated to be limited during monitoring activities.
Time Until Remedial Action Objectives are Achieved	RAOs will be achieved through natural attenuation processes; estimated timeframe of With Source Control - 67 to 79 years Without Source Control - 81 to 98 years
IMPLEMENTABILITY	
Ability to Construct and Operate the Technology	No construction activities are planned for this alternative other than installation of additional monitoring wells; monitoring activities are easily implementable.
Reliability of the Technology	Site characterization data indicate that natural attenuation processes are effectively degrading contaminants. Refer to Section 7.2 in the FS text for MNA discussion.
Ease of Undertaking Additional Remedial Actions, if necessary	This alternative will not limit or interfere with the ability to implement or perform future remedial actions.
Ability to Monitor Effectiveness of Remedy	Groundwater sampling and analysis to evaluate contaminant levels is easily implementable.
Ability to Obtain Approvals and Coordinate with Other Agencies	The remedial action will be designed and implemented under coordination with appropriate Federal and State agencies.
Availability of off-site Treatment, Storage and Disposal Services and Capacity	Not applicable for this alternative.
Availability of Necessary Equipment and Specialists	Equipment, materials and services for this alternative are readily available.
Availability of Technology	Qualified engineers and contractors are available to design and implement this alternative.
COSTS - *net present value (7%)*	
Capital Costs	$230,000
Annual Operation, Maintenance and Monitoring	$1,400,000
Periodic Costs	$120,000
TOTAL	$1,750,000

TABLE 8-14a
SUMMARY OF REMEDIAL ALTERNATIVE
Remedial Investigation and Feasibility Study
Sutton Brook Disposal Area Superfund Site - Tewksbury, MA
DGGW-3: Groundwater Containment with Extraction, Treatment and Discharge

Media Addressed	Groundwater
Remedy Components	
Containment	
Groundwater	Hydraulic containment of groundwater with extraction and ex-situ treatment (anticipated extraction rate of 75 gpm).
Treatment	
Groundwater	Ex-situ treatment components may include air stripping, advanced oxidation, metals treatment, etc.
Institutional Controls	
Groundwater	Deed restriction to restrict future use of groundwater until RAOs are met
Monitoring Requirements	Routine monitoring of groundwater treatment system influent and effluent Periodic monitoring of area groundwater Annual Site Inspections
Operation and Maintenance Requirements	Review of site conditions and risks at five year intervals O&M of the DGGW groundwater monitoring well system and groundwater treatment system
Area/ Volume of Media Addressed by Alternative	
Groundwater	3 extraction wells at 25 gpm, for a total of 75 gpm
Estimated Timing	
Design and Construction	2 years
Attainment of RAOs	With Source Control - 57 to 68 years Without Source Control - 70 to 86 years
Anticipated Reuse Outcomes	Passive recreation

Refer to Figure 8-10 for conceptual layout

TABLE 8-14b
DETAILED ANALYSIS OF REMEDIAL ALTERNATIVE
Remedial Investigation and Feasibility Study
Sutton Brook Disposal Area Superfund Site - Tewksbury, MA
DGGW-3: Hydraulic Containment through Groundwater Extraction, Treatment and Discharge

EVALUATION CRITERIA	DETAILED ANALYSIS
OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT	
Human Health Protection	The results of the human health risk assessment indicated the potential risk through the potable use of site groundwater exists to future site residents and facility workers. Under this alternative, hydraulic containment of impacted groundwater through groundwater extraction and ex-situ treatment will be implemented to control plume migration and meet RAOs over time. Until the RAOs are achieved, institutional controls will be in place to prevent groundwater use/exposure, controlling human risks.
Ecological Protection	The results of the ecological risk assessment indicated no significant risks to ecological receptors as a result of downgradient groundwater.
COMPLIANCE WITH ARARs	
Chemical Specific	Under existing conditions, concentrations of select compounds in groundwater exceed chemical specific ARARs. Implementation of this alternative will be expected to reduce contaminant concentrations in downgradient groundwater and over time, achieve chemical-specific ARARs.
Location Specific	Potential location specific ARARs for this alternative are presented in Table E-4 in Appendix E; this alternative will provide disruption to ecological receptors and the wetland resource area during implementation; however, the design, construction and operation of this alternative can be implemented to comply with applicable location-specific ARARs.
Action Specific	Potential action specific ARARs for this alternative are presented in Table E-4 in Appendix E; the design, construction and operation of this alternative can be implemented to comply with applicable action-specific ARARs.
LONG-TERM EFFECTIVENESS AND PERMANENCE	
Magnitude of Residual Risk	Until the achievement of site RAOs implementation of institutional controls will reduce potential use and exposure to impacted groundwater. Therefore, residual risk is low.
Adequacy and Reliability of Controls	Assuming effective implementation and enforcement, institutional controls should effectively limit human exposure to impacted groundwater until the RAOs are achieved. Monitoring of the extraction system's effectiveness in hydraulically containing the plume will be required to measure the reliability of the alternative. Extraction and treatment system components will require maintenance, upkeep and potentially replacement overtime to ensure reliability.
REDUCTION OF TOXICITY, MOBILITY AND VOLUME THROUGH TREATMENT	
Treatment Process Used and Materials Treated	Materials treated within groundwater through the hydraulic containment extraction and ex-situ treatment system will include VOCs, SVOCs & metals via a combination of technologies such as air stripping, advanced oxidation processes and/or metals treatment, in addition to one or more pretreatment steps (to be determined during remedial design phase).
Amount Destroyed or Treated	An estimated total extraction rate of 75 gpm of groundwater will be treated through the hydraulic containment groundwater extraction and ex-situ treatment system. Current dissolved concentrations indicate an estimated 200 lbs of VOCs in downgradient groundwater available for treatment.

TABLE 8-14b
DETAILED ANALYSIS OF REMEDIAL ALTERNATIVE
Remedial Investigation and Feasibility Study
Sutton Brook Disposal Area Superfund Site - Tewksbury, MA
DGGW-3: Hydraulic Containment through Groundwater Extraction, Treatment and Discharge

EVALUATION CRITERIA	DETAILED ANALYSIS
Degree of Expected Reductions in Toxicity, Mobility or Volume through Treatment	The degree to which this alternative will reduce the toxicity and mobility of contaminants is high and the degree to which it will reduce the volume of contaminants is moderate, compared to other DGGW alternatives evaluated.
Degree to which Treatment is Irreversible	Treatment of groundwater will be permanent.
Type and Quantity of Residuals Remaining after Treatment	Treatment of the groundwater plume and any resulting VOC vapors will produce a moderate volume of treatment residuals that may require off-site treatment/disposal at a licensed facility.
Degree to Which Treatment Reduces Principal Threats	In conjunction with institutional controls, upon treatment of contaminants in groundwater, the potential human risks to on-site downgradient groundwater will be eliminated.
SHORT-TERM EFFECTIVENESS	
Protection of Community During Remedial Action	Construction and operation of an on-site groundwater treatment facility will not have significant short-term impacts on the local community; however, there may be a slight increase in vehicular traffic to the site during construction activities.
Protection of Workers During Remedial Action	Work will be performed in accordance with applicable OSHA standards. Site-specific health and safety plan(s) will be developed to protect site workers.
Environmental Impacts	Impacts to the wetland resource areas are anticipated to be moderate to high during construction activities due to the location of the extraction wells within the resource area (requiring destruction of wetlands to install - estimated at 5,050 sq ft). Once the system is installed, operation and monitoring activities is anticipated to have limited impacts. Available practical means such as erosion and stormwater control measures will also be implemented to minimize harm to wetland areas during construction.
Time Until Remedial Action Objectives are Achieved	The estimated time to achieve groundwater RAOs is approximately With Source Control - 57 to 68 years Without Source Control - 70 to 86 years
IMPLEMENTABILITY	
Ability to Construct and Operate the Technology	The installation of wells and piping involves common construction techniques; however due to the location of the impacted groundwater within the wetland resource area, this alternative poses difficulty in implementation to reduce environmental impacts and in designing the treatment system layout (access roads to extraction wells, burial of extraction and electrical lines, etc.). Prior to implementation, pre-design pilot studies will be required to evaluate groundwater capture zones.
Reliability of the Technology	Groundwater extraction is a demonstrated and reliable method for capturing and collecting impacted groundwater. In addition, the ex-situ treatment components are effective in treating groundwater to the remedial goals.
Ease of Undertaking Additional Remedial Actions, if necessary	This alternative will not limit or interfere with the ability to implement or perform future remedial actions.
Ability to Monitor Effectiveness of Remedy	Groundwater monitoring to demonstrate hydraulic containment and to determine contaminant levels is easily implementable. Treatment system effluent will be monitored on a routine basis to evaluate the effectiveness of the treatment system and document that discharge requirements are being met.
Ability to Obtain Approvals and Coordinate with Other Agencies	The remedial action will be designed and implemented under coordination with appropriate Federal and State agencies.

TABLE 8-14b
DETAILED ANALYSIS OF REMEDIAL ALTERNATIVE
Remedial Investigation and Feasibility Study
Sutton Brook Disposal Area Superfund Site - Tewksbury, MA

DGGW-3: Hydraulic Containment through Groundwater Extraction, Treatment and Discharge

EVALUATION CRITERIA	DETAILED ANALYSIS
Availability of off-site Treatment, Storage and Disposal Services and Capacity	Discharge of the treated groundwater will be to surface water or the local POTW.
Availability of Necessary Equipment and Specialists	Equipment, materials and services for this alternative are readily available.
Availability of Technology	Qualified engineers and contractors are available to design and implement this alternative.
COSTS - *net present value (7%)*	
Capital Costs	$2,900,000
Annual Operation, Maintenance and Monitoring	$6,800,000 to $9,800,000
Periodic Costs	$130,000
TOTAL	$9,830,000 to $12,830,000

DGGW-3 O&M Range incorporates: 30 years of system operation with 30 years of groundwater monitoring - low: discharge to surface water, high: discharge to POTW

TABLE 8-15a
SUMMARY OF REMEDIAL ALTERNATIVE
Remedial Investigation and Feasibility Study
Sutton Brook Disposal Area Superfund Site - Tewksbury, MA

DGGW-4: Groundwater Extraction and Ex-situ Treatment for Area-wide Contaminant Reduction

Media Addressed	Groundwater
Remedy Components	
Containment	
Groundwater	--
Treatment	
Groundwater	Area-wide contaminant reduction via extraction and ex-situ treatment of groundwater. Ex-situ treatment components may include air stripping, advanced oxidation, metals treatment, etc. Anticipated extraction rate of 140 gpm.
Institutional Controls	
Groundwater	Deed restriction to restrict future use of groundwater until RAOs are met
Monitoring Requirements	Routine monitoring of groundwater treatment system influent and effluent Periodic monitoring of area groundwater Annual Site Inspections
Operation and Maintenance Requirements	Review of site conditions and risks at five year intervals O&M of the DGGW groundwater monitoring well system and groundwater treatment system
Area/ Volume of Media Addressed by Alternative	
Groundwater	14 extraction wells at 10 gpm, for a total of 140 gpm
Estimated Timing	
Design and Construction	2 years
Attainment of RAOs	With Source Control - 40 to 49 years Without Source Control - 53 to 66 years
Anticipated Reuse Outcomes	Passive recreation

Refer to Figure 8-11 for conceptual layout

TABLE 8-15b
DETAILED ANALYSIS OF REMEDIAL ALTERNATIVE
Remedial Investigation and Feasibility Study
Sutton Brook Disposal Area Superfund Site - Tewksbury, MA

DGGW-4: Groundwater Extraction and Ex-situ Treatment for Area-wide Contaminant Reduction

EVALUATION CRITERIA	DETAILED ANALYSIS
OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT	
Human Health Protection	The results of the human health risk assessment indicated the potential risk through the potable use of site groundwater exists to future site residents and facility workers. Under this alternative, groundwater extraction and ex-situ treatment for area-wide contaminant reduction will be implemented to control plume migration and aggressively treat groundwater to meet RAOs in an expedited timeframe. Until the RAOs are achieved, institutional controls will be in place to prevent groundwater use/exposure, controlling human risks.
Ecological Protection	The results of the ecological risk assessment indicated no significant risks to ecological receptors as a result of downgradient groundwater.
COMPLIANCE WITH ARARs	
Chemical Specific	Under existing conditions, concentrations of select compounds in groundwater exceed chemical specific ARARs. Implementation of this alternative will be expected to reduce contaminant concentrations in downgradient groundwater and over time, achieve chemical-specific ARARs.
Location Specific	Potential location specific ARARs for this alternative are presented in Table E-4 in Appendix E; this alternative will provide significant disruption to ecological receptors and the wetland resource area during implementation. However, the design, construction and operation of this alternative can be implemented to comply with applicable location-specific ARARs.
Action Specific	Potential action specific ARARs for this alternative are presented in Table E-4 in Appendix E; the design, construction and operation of this alternative can be implemented to comply with applicable action-specific ARARs.
LONG-TERM EFFECTIVENESS AND PERMANENCE	
Magnitude of Residual Risk	Until the achievement of site RAOs implementation of institutional controls will reduce potential use and exposure to impacted groundwater. Therefore, residual risk is low.
Adequacy and Reliability of Controls	Assuming effective implementation and enforcement, institutional controls should effectively limit human exposure to impacted groundwater until the RAOs are achieved. The groundwater treatment system will adequately and reliably reduce the concentrations in downgradient groundwater. Extraction and treatment system components will require maintenance, upkeep and potentially replacement overtime to ensure reliability over time.
REDUCTION OF TOXICITY, MOBILITY AND VOLUME THROUGH TREATMENT	
Treatment Process Used and Materials Treated	Materials treated within groundwater through the hydraulic containment extraction and ex-situ treatment system will include VOCs, SVOCs & metals via a combination of technologies such as air stripping, advanced oxidation processes and/or metals treatment, in addition to one or more pretreatment steps (to be determined during remedial design phase).
Amount Destroyed or Treated	An estimated total extraction rate of 140 gpm of groundwater will be treated through the groundwater extraction and ex-situ treatment system. Current dissolved concentrations indicate an estimated 200 lbs of VOCs in downgradient groundwater available for treatment.

TABLE 8-15b
DETAILED ANALYSIS OF REMEDIAL ALTERNATIVE
Remedial Investigation and Feasibility Study
Sutton Brook Disposal Area Superfund Site - Tewksbury, MA

DGGW-4: Groundwater Extraction and Ex-situ Treatment for Area-wide Contaminant Reduction

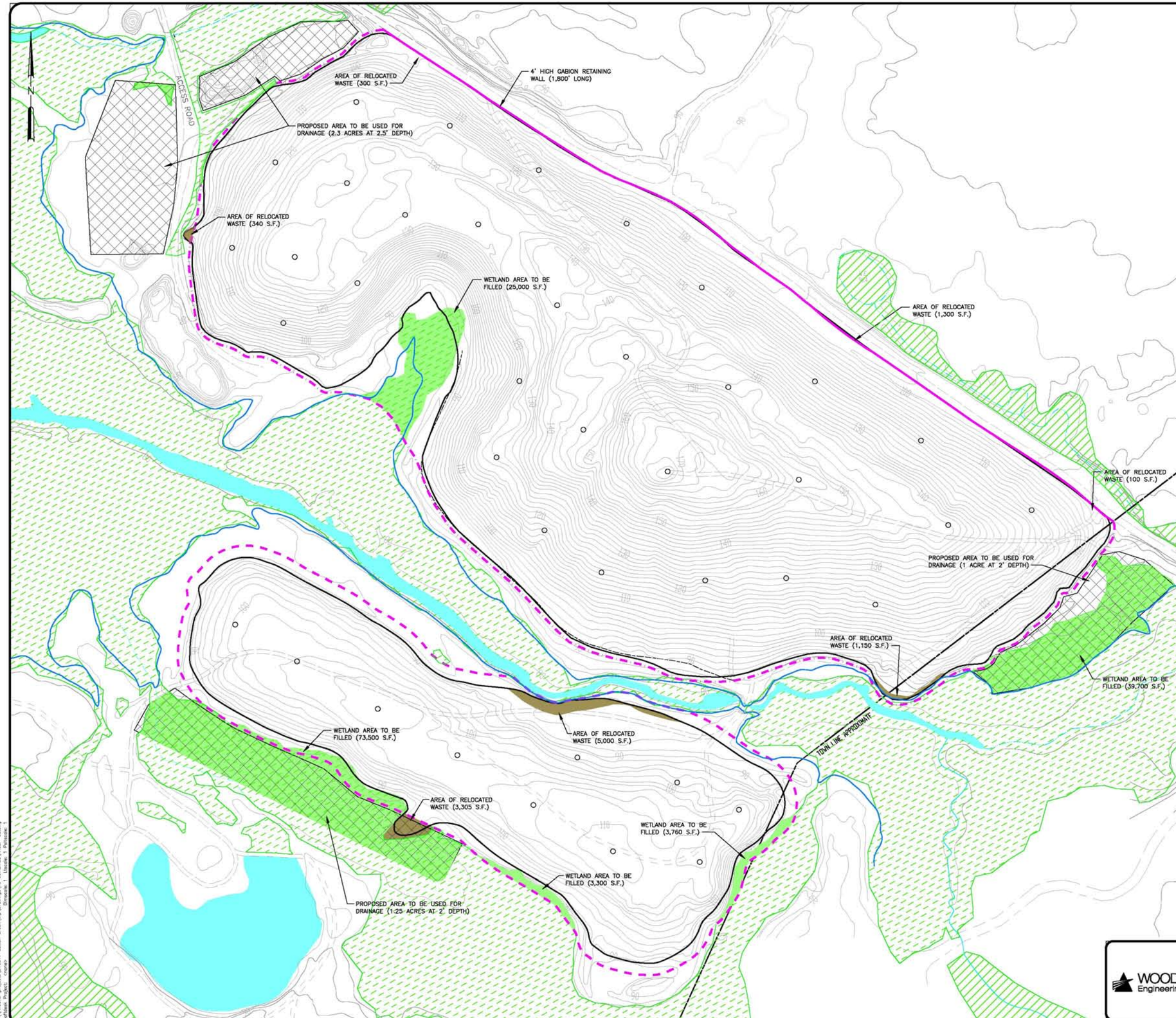
EVALUATION CRITERIA	DETAILED ANALYSIS
Degree of Expected Reductions in Toxicity, Mobility or Volume through Treatment	Compared to other alternatives evaluated for downgradient groundwater, this alternative provides a high level of reduction in toxicity, mobility and volume of contaminants through ex-situ treatment.
Degree to which Treatment is Irreversible	Treatment of groundwater will be permanent.
Type and Quantity of Residuals Remaining after Treatment	Treatment of the groundwater plume and any resulting VOC vapors may produce a high volume of treatment residuals that will require off-site treatment/disposal at a licensed facility.
Degree to Which Treatment Reduces Principal Threats	In conjunction with institutional controls, upon treatment of contaminants in groundwater, the potential human risks to on-site downgradient groundwater will be eliminated.
SHORT-TERM EFFECTIVENESS	
Protection of Community During Remedial Action	Construction and operation of an on-site groundwater treatment facility will not have significant short-term impacts on the local community; however, there may be a slight increase in vehicular traffic to the site during construction activities.
Protection of Workers During Remedial Action	Work will be performed in accordance with applicable OSHA standards. Site-specific health and safety plan(s) will be developed to protect site workers.
Environmental Impacts	Impacts to the wetland resource areas are anticipated to be high during construction activities due to the location of the extraction wells within the resource area (requiring destruction of almost an acre of wetlands to install). Once the system is installed, operation and monitoring activities are anticipated to have limited to no impacts. Available practical means such as erosion and stormwater control measures will also be implemented to minimize harm to wetland areas during construction.
Time Until Remedial Action Objectives are Achieved	The estimated time to achieve groundwater RAOs is approximately With Source Control - 40 to 49 years Without Source Control - 53 to 66 years
IMPLEMENTABILITY	
Ability to Construct and Operate the Technology	The installation of wells and piping involves common construction techniques; however due to the location of the impacted groundwater within the wetland resource area, this alternative poses difficulty in implementation to reduce environmental impacts and in designing the treatment system layout (access roads to extraction wells, burial of extraction and electrical lines, etc.). Prior to implementation, pre-design pilot studies will be required to evaluate adequate groundwater capture zones.
Reliability of the Technology	Groundwater extraction is a demonstrated and reliable method for capturing and collecting impacted groundwater. In addition, the ex-situ treatment components are effective in treating groundwater to the remedial goals.
Ease of Undertaking Additional Remedial Actions, if necessary	This alternative will not limit or interfere with the ability to implement or perform future remedial actions.
Ability to Monitor Effectiveness of Remedy	Groundwater monitoring to demonstrate hydraulic containment and to determine contaminant levels is easily implementable. Treatment system effluent will be monitored on a routine basis to evaluate the effectiveness of the treatment system and document that discharge requirements are being met.
Ability to Obtain Approvals and Coordinate with Other Agencies	The remedial action will be designed and implemented under coordination with appropriate Federal and State agencies.

TABLE 8-15b
DETAILED ANALYSIS OF REMEDIAL ALTERNATIVE
Remedial Investigation and Feasibility Study
Sutton Brook Disposal Area Superfund Site - Tewksbury, MA

DGGW-4: Groundwater Extraction and Ex-situ Treatment for Area-wide Contaminant Reduction

EVALUATION CRITERIA	DETAILED ANALYSIS
Availability of off-site Treatment, Storage and Disposal Services and Capacity	Discharge of the treated groundwater will be to surface water or the local POTW.
Availability of Necessary Equipment and Specialists	Equipment, materials and services for this alternative are readily available.
Availability of Technology	Qualified engineers and contractors are available to design and implement this alternative.
COSTS - *net present value (7%)*	
Capital Costs	$4,500,000
Annual Operation, Maintenance and Monitoring	$6,500,000 to $12,200,000
Periodic Costs	$130,000
TOTAL	$11,130,000 to $16,830,000

DGGW-4 O&M Range incorporates: Low - 30 years of system operation (discharge to surface water) with 30 years of groundwater monitoring and High: 30 years of system operation (discharge to POTW) with 30 years of groundwater monitoring

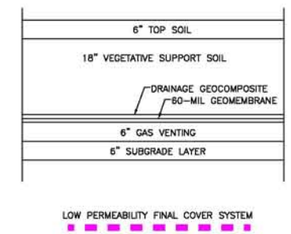


LEGEND

- INTERPRETIVE LIMITS OF SOLID WASTE
- APPROXIMATE 100-YEAR FLOOD LINE
- WETLAND BOUNDARY DELINEATED IN ACCORDANCE WITH US ACOE 1987 METHODS
- WETLAND AREA DELINEATED BY AERIAL PHOTOGRAPH INTERPRETATION
- CONCEPTUAL LOCATION FOR STORMWATER MANAGEMENT BASINS
- CONCEPTUAL EXTENT OF WETLAND RESOURCE AREA THAT MAY REQUIRE FILLING DUE TO FINAL COVER SYSTEM CONSTRUCTION
- PRELIMINARY EXTENT OF SOLID WASTE THAT MAY REQUIRE RELOCATION TO CONSTRUCT THE LANDFILL FINAL COVER SYSTEM
- CONCEPTUAL EXTENT OF LANDFILL FINAL COVER SYSTEM
- CONCEPTUAL LAYOUT OF LANDFILL GAS VENT WELLS

NOTE:

THE LOW PERMEABILITY COVER SYSTEM USED FOR CONCEPTUAL DESIGN AND RELATIVE COST PURPOSES IS DEPICTED BELOW.



NORTHERN LOBE		SOUTHERN LOBE	
WETLANDS FILLED (S.F.)	WASTE RELOCATED (S.F.)	WETLANDS FILLED (S.F.)	WASTE RELOCATED (S.F.)
64,700	3,200	80,500	7,000

0 100 200
SCALE IN FEET

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FIGURE 8-1

CONCEPTUAL LANDFILL FINAL COVER SYSTEM

SUTTON BROOK DISPOSAL AREA

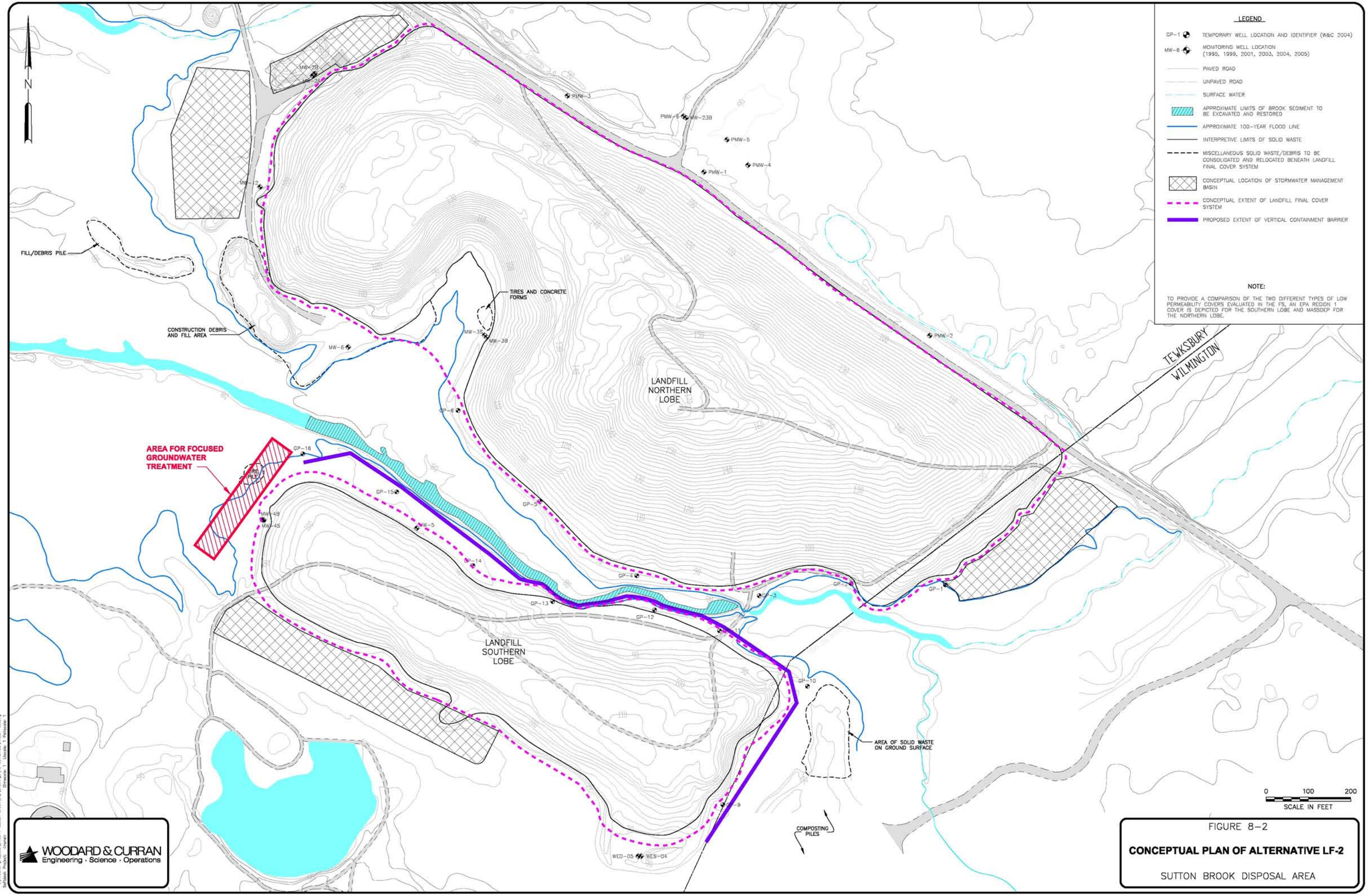

FIGURE 8-2

CONCEPTUAL PLAN OF ALTERNATIVE LF-2

SUTTON BROOK DISPOSAL AREA

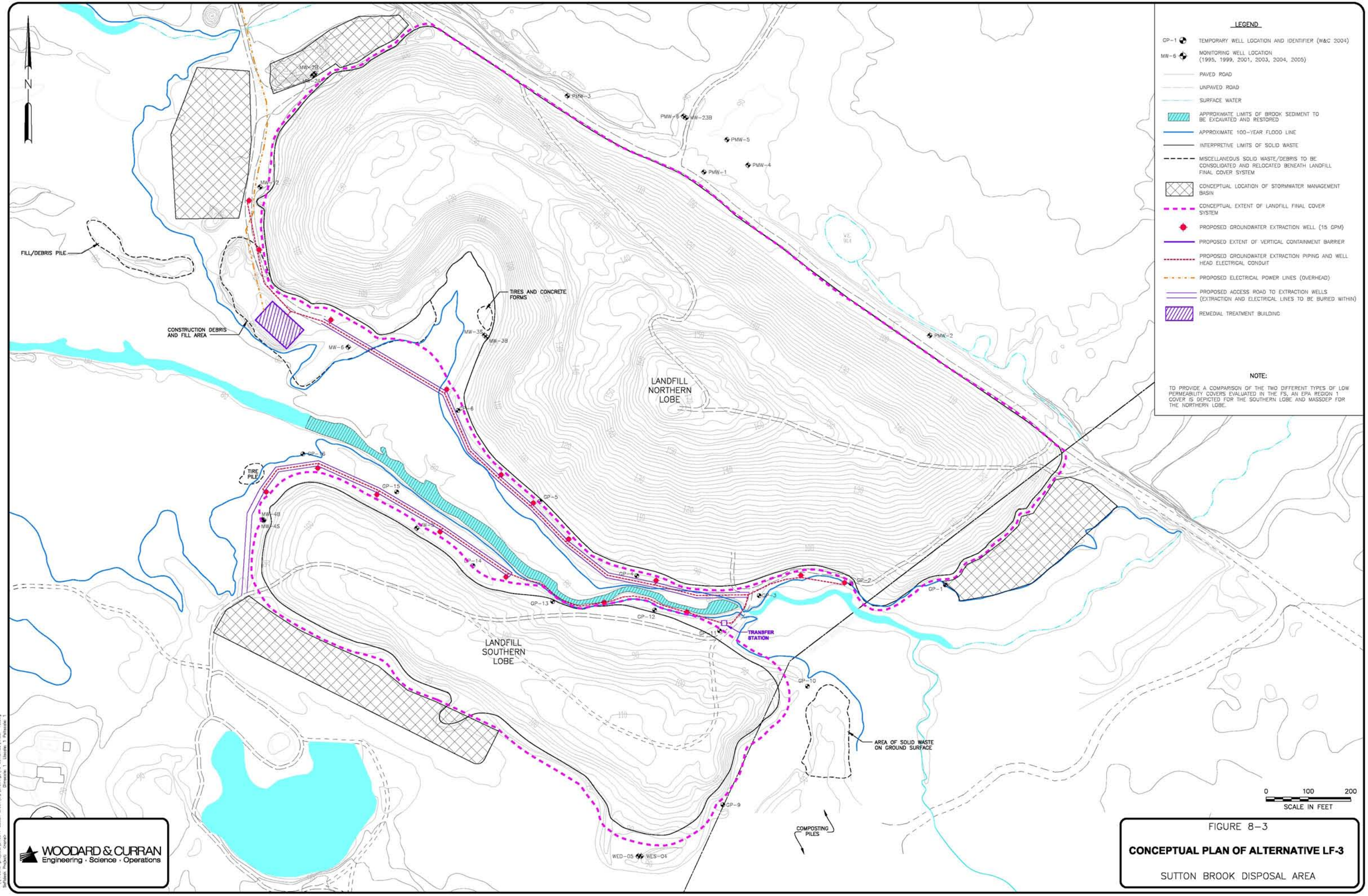

FIGURE 8-3

CONCEPTUAL PLAN OF ALTERNATIVE LF-3

SUTTON BROOK DISPOSAL AREA

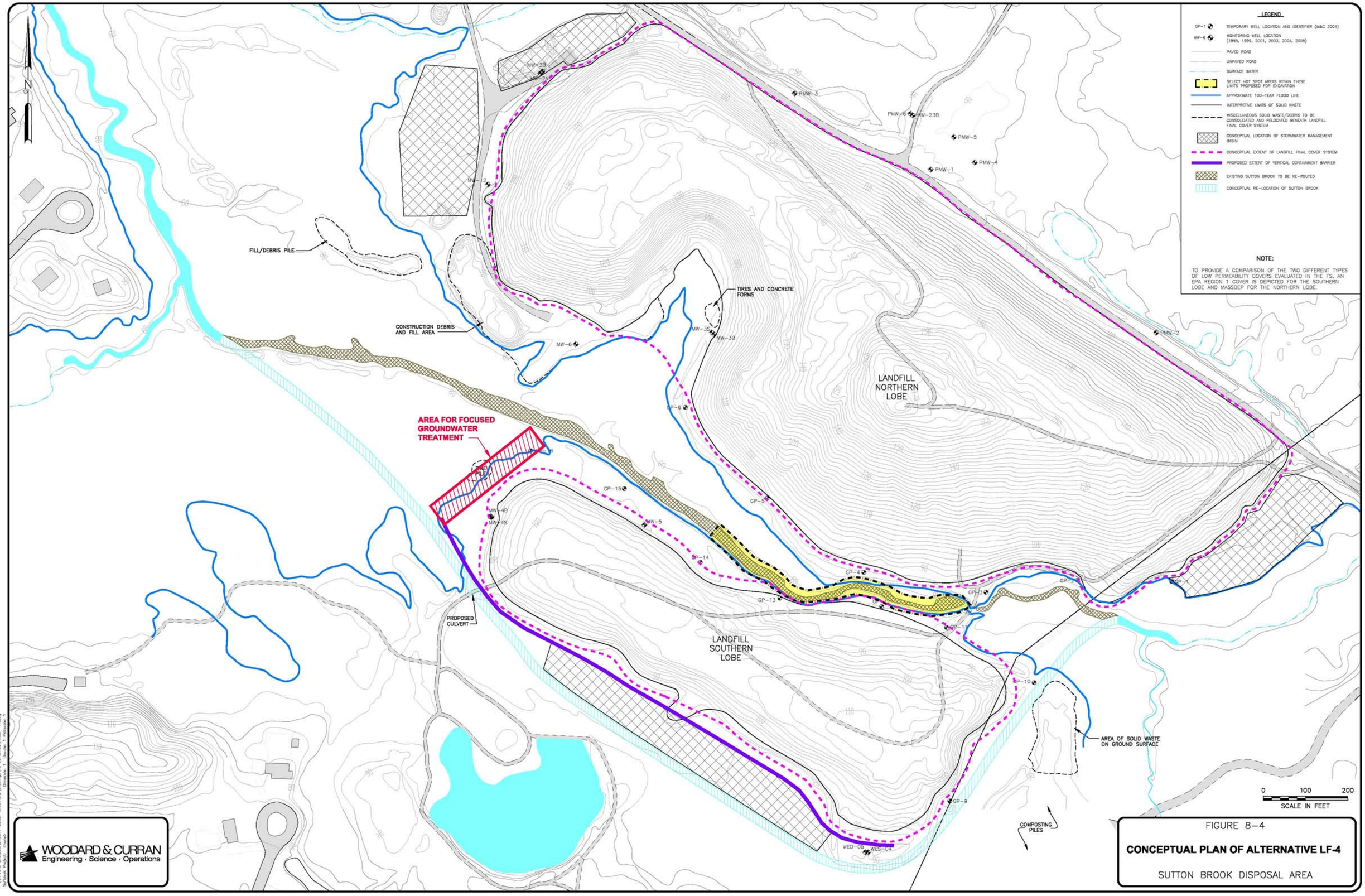

FIGURE 8-4

CONCEPTUAL PLAN OF ALTERNATIVE LF-4

SUTTON BROOK DISPOSAL AREA

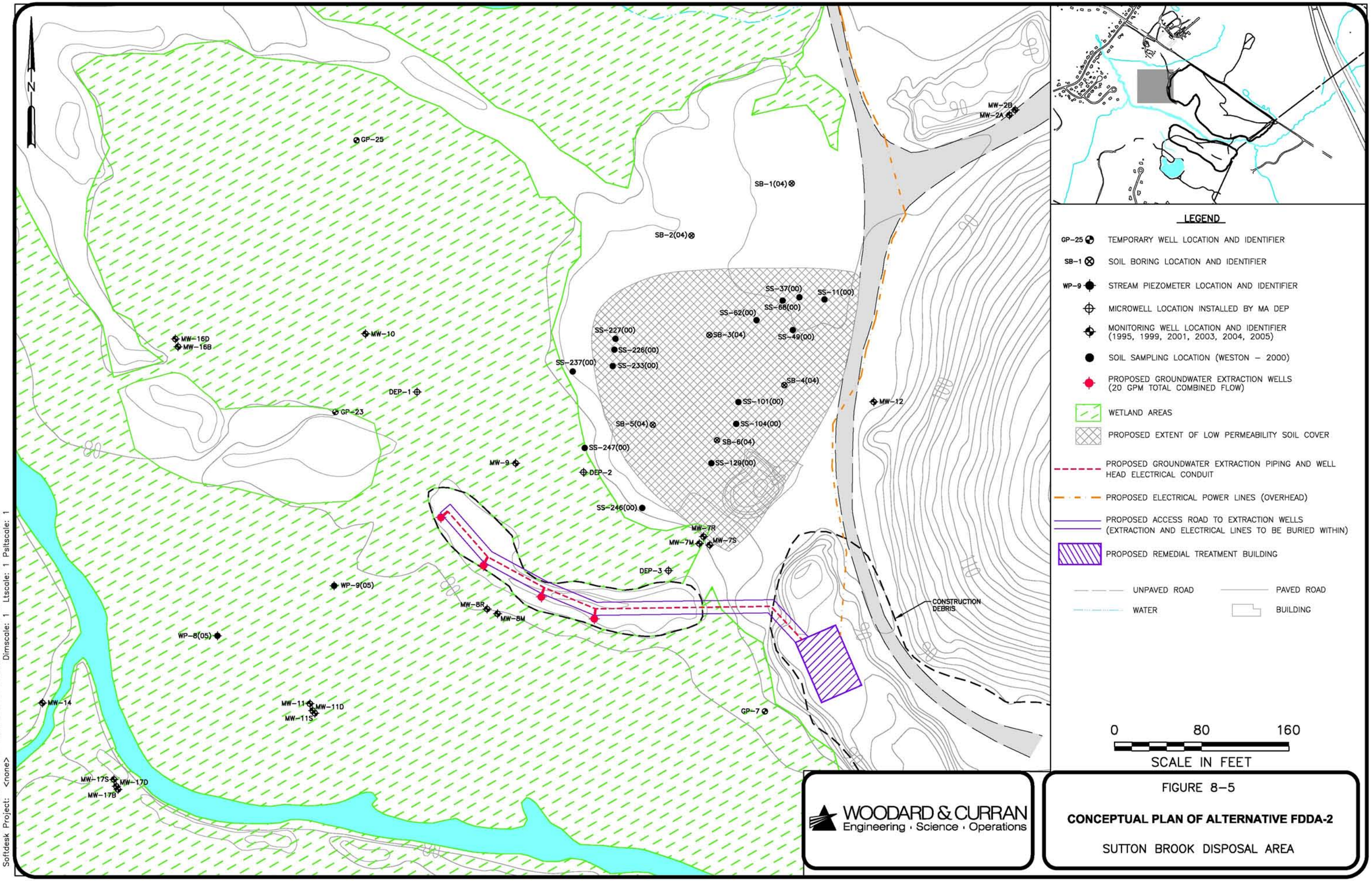

FIGURE 8-5

CONCEPTUAL PLAN OF ALTERNATIVE FDDA-2

SUTTON BROOK DISPOSAL AREA

IMAGE Files: <No Images>
XREF Files: ANSBB-01.dwg ANSBBD01.dwg
\\Andover\projects\210517 Sutton Brook\wip\Drawings\FS Combined\ANSBF-12.dwg
Softdesk Project: <none> Dimscale: 1 Ltscale: 1 Psltscale: 1
1" 1/2" 0" 1"

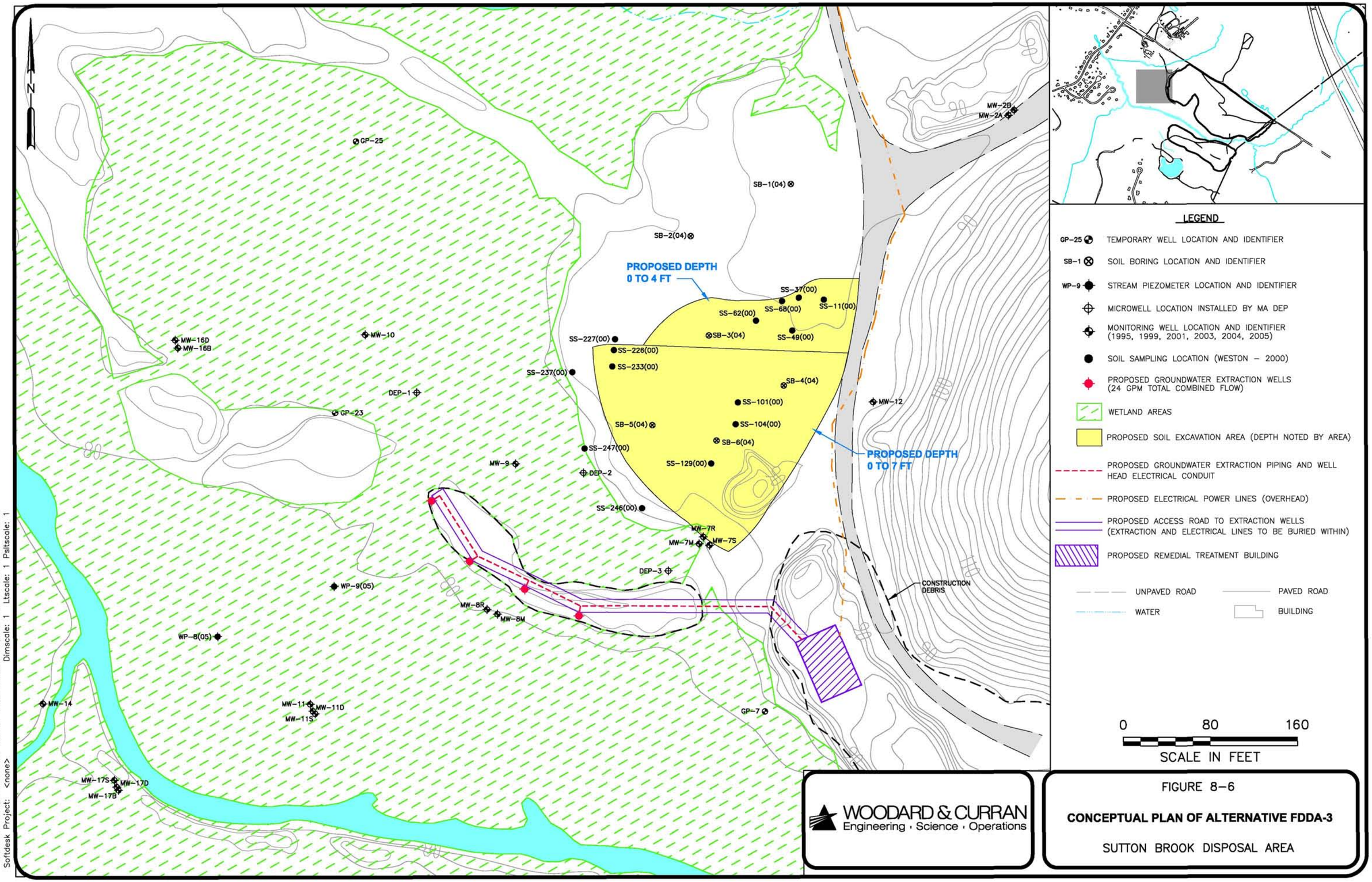

FIGURE 8-6

CONCEPTUAL PLAN OF ALTERNATIVE FDDA-3

SUTTON BROOK DISPOSAL AREA

IMAGE Files: <No Images>
XREF Files: ANSBB-01.dwg ANSBBD01.dwg
\\Andover\projects\210517 Sutton Brook\wip\Drawings\FS Combined\ANSBF-13.dwg
Dimscale: 1 Ltscale: 1 Psltscale: 1
Softdesk Project: <none>
1" 1/2" 0" 1"

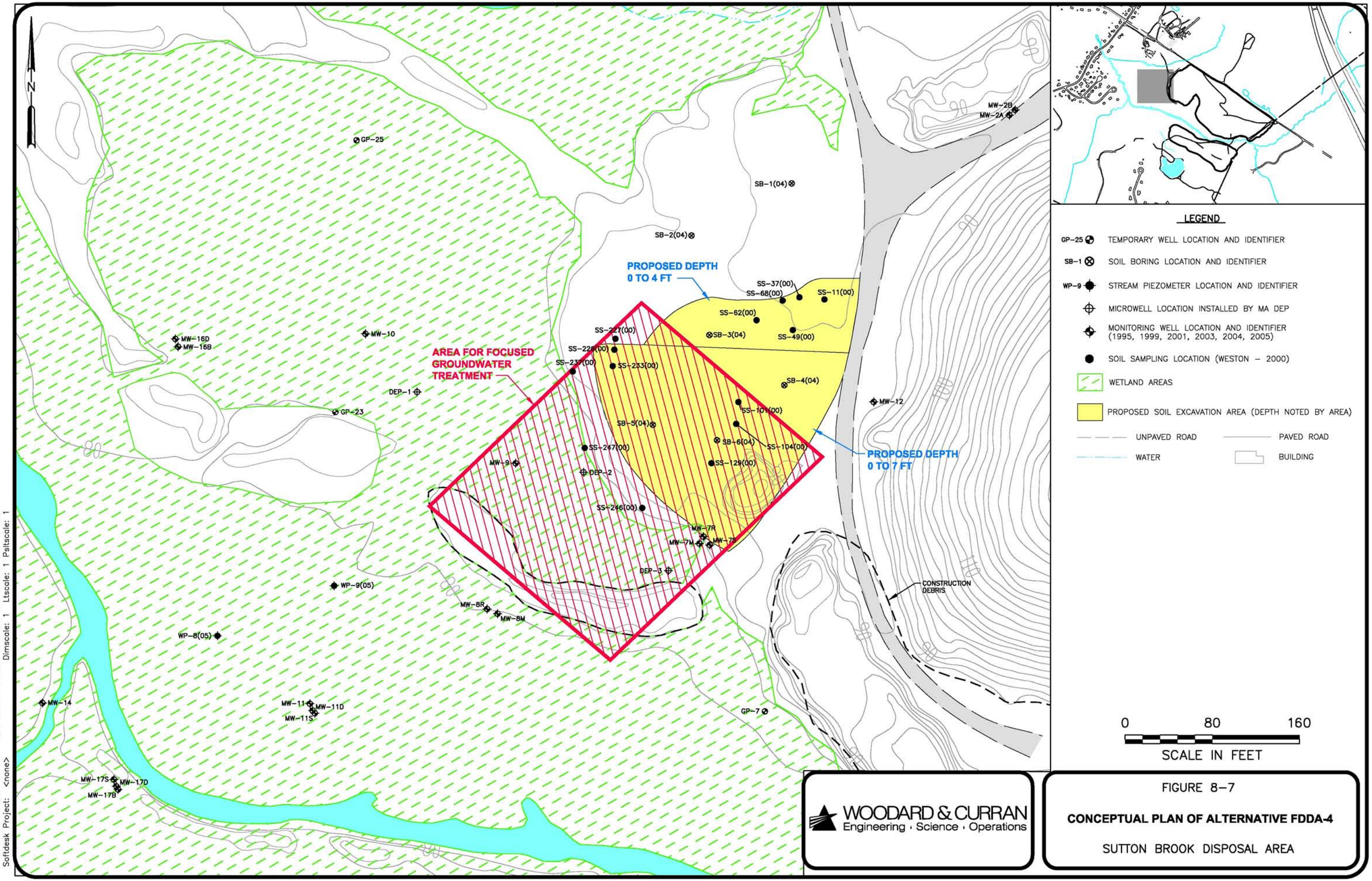

FIGURE 8–7

CONCEPTUAL PLAN OF ALTERNATIVE FDDA-4

SUTTON BROOK DISPOSAL AREA

IMAGE Files: <No Images>
XREF Files: ANSBB-01.dwg ANSBBD01.dwg
\\Andover\projects\210517 Sutton Brook\wip\Drawings\FS Combined\ANSBF-14.dwg
Dimscale: 1 Ltscale: 1 Psltscale: 1
Softdesk Project: <none>
1" 1/2" 0" 1"

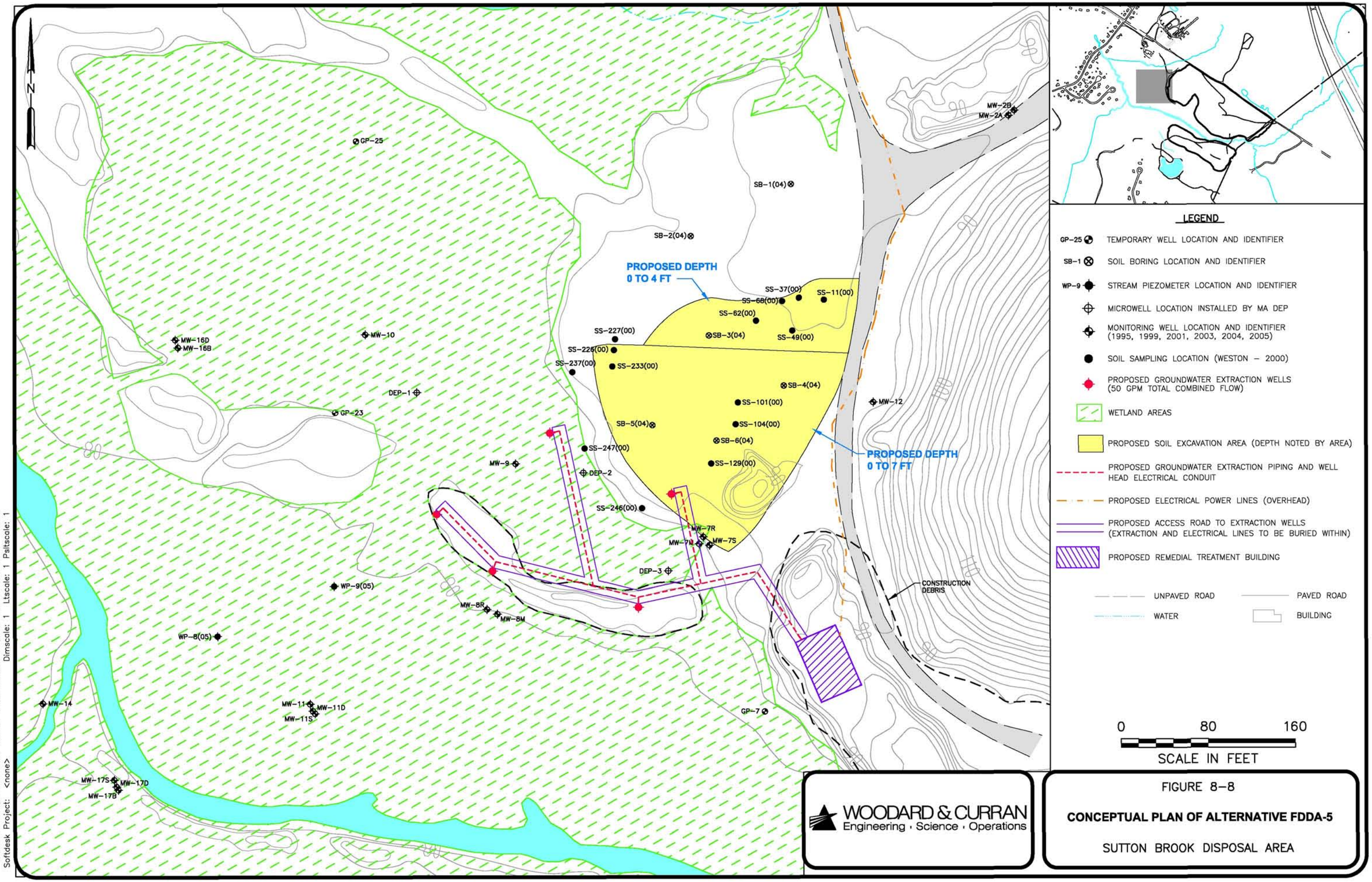

FIGURE 8-8

CONCEPTUAL PLAN OF ALTERNATIVE FDDA-5

SUTTON BROOK DISPOSAL AREA

IMAGE Files: <No Images>
XREF Files: ANSBB-01.dwg ANSBBD01.dwg
\\Andover\projects\210517 Sutton Brook\wip\Drawings\FS Combined\ANSBF-15.dwg
Dimscale: 1 Ltscale: 1 Psltscale: 1
Softdesk Project: <none>
1" 1/2" 0" 1"

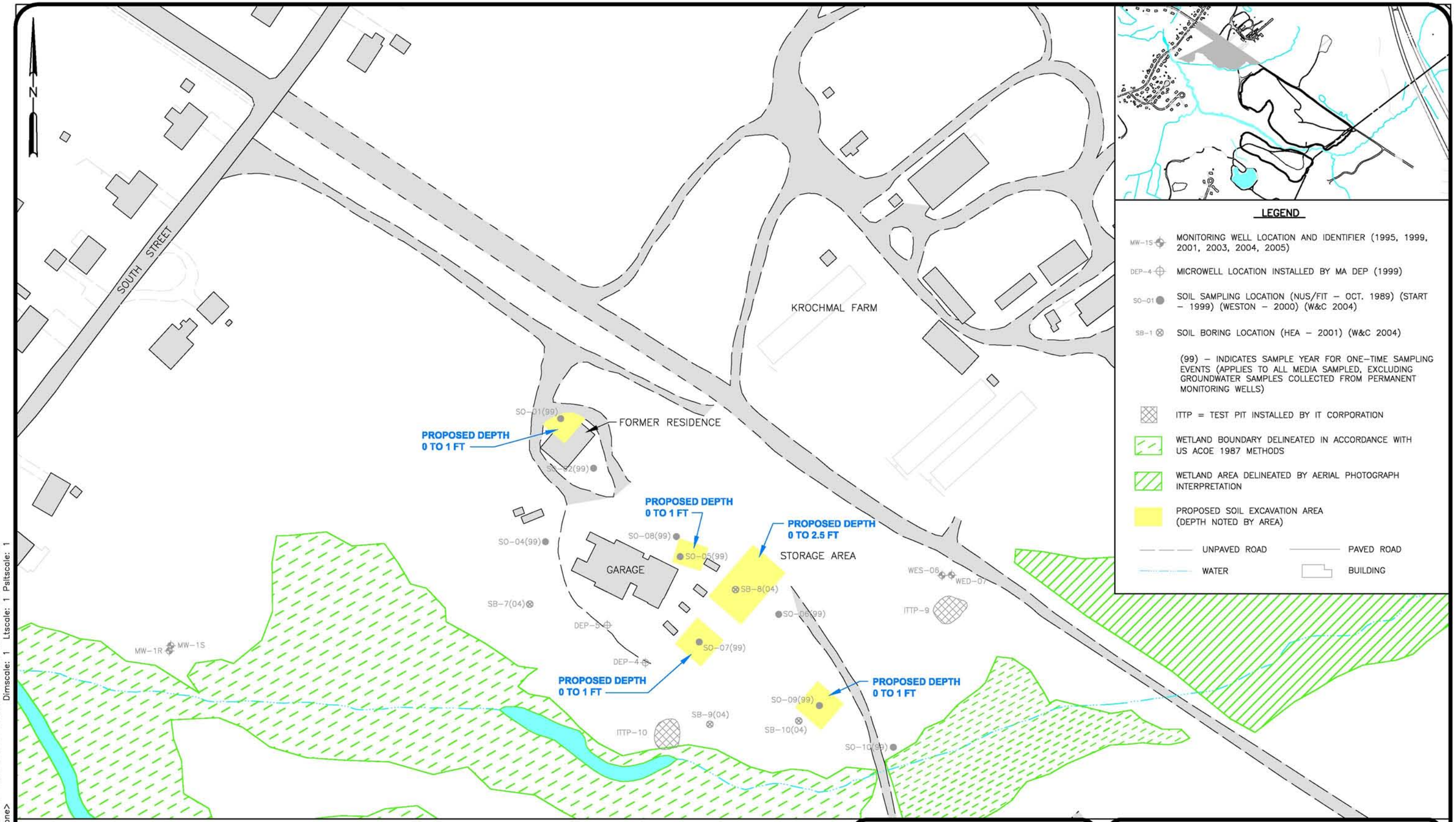

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FIGURE 8-9

CONCEPTUAL PLAN OF ALTERNATIVE GSA-2

SUTTON BROOK DISPOSAL AREA

IMAGE Files: <No Images>
XREF Files: ANSBB-01.dwg ANSBBD01.dwg
\\Andover\projects\210517 Sutton Brook\wip\Drawings\FS Combined\ANSBF-16.dwg
Softdesk Project: <none> Dimscale: 1 Ltscale: 1 Psltscale: 1
1" 1/2" 0" 1"

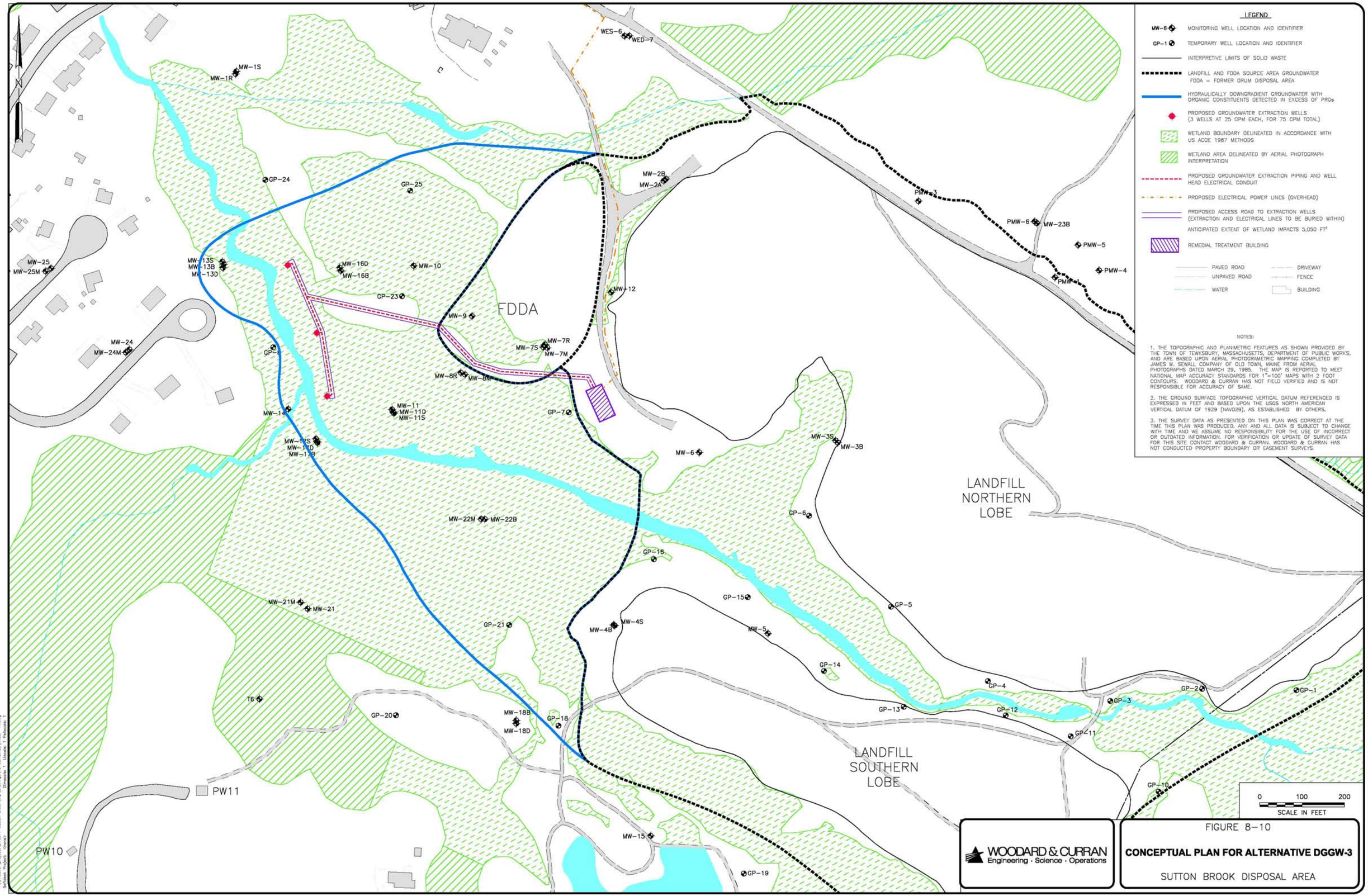
LEGEND
MW-8 MONITORING WELL LOCATION AND IDENTIFIER
GP-1 TEMPORARY WELL LOCATION AND IDENTIFIER
INTERPRETIVE LIMITS OF SOLID WASTE
LANDFILL AND FDDA SOURCE AREA GROUNDWATER
FDDA = FORMER DRUM DISPOSAL AREA
HYDRAULICALLY DOWNGRADIENT GROUNDWATER WITH ORGANIC CONSTITUENTS DETECTED IN EXCESS OF PRGs
PROPOSED GROUNDWATER EXTRACTION WELLS (3 WELLS AT 25 GPM EACH, FOR 75 GPM TOTAL)
WETLAND BOUNDARY DELINEATED IN ACCORDANCE WITH US ACOE 1987 METHODS
WETLAND AREA DELINEATED BY AERIAL PHOTOGRAPH INTERPRETATION
PROPOSED GROUNDWATER EXTRACTION PIPING AND WELL HEAD ELECTRICAL CONDUIT
PROPOSED ELECTRICAL POWER LINES (OVERHEAD)
PROPOSED ACCESS ROAD TO EXTRACTION WELLS (EXTRACTION AND ELECTRICAL LINES TO BE BURIED WITHIN)
ANTICIPATED EXTENT OF WETLAND IMPACTS 5,050 FT²
REMEDIAL TREATMENT BUILDING
PAVED ROAD
UNPAVED ROAD
WATER
DRIVEWAY
FENCE
BUILDING
NOTES:
1. THE TOPOGRAPHIC AND PLANIMETRIC FEATURES AS SHOWN PROVIDED BY THE TOWN OF TEWKSBURY, MASSACHUSETTS, DEPARTMENT OF PUBLIC WORKS, AND ARE BASED UPON AERIAL PHOTOGRAMETRIC MAPPING COMPLETED BY JAMES W. SEWALL COMPANY OF OLD TOWN, MAINE FROM AERIAL PHOTOGRAPHS DATED MARCH 29, 1985. THE MAP IS REPORTED TO MEET NATIONAL MAP ACCURACY STANDARDS FOR 1"=100' MAPS WITH 2 FOOT CONTOURS. WOODARD & CURRAN HAS NOT FIELD VERIFIED AND IS NOT RESPONSIBLE FOR ACCURACY OF SAME.
2. THE GROUND SURFACE TOPOGRAPHIC VERTICAL DATUM REFERENCED IS EXPRESSED IN FEET AND BASED UPON THE USGS NORTH AMERICAN VERTICAL DATUM OF 1929 (NAVD29), AS ESTABLISHED BY OTHERS.
3. THE SURVEY DATA AS PRESENTED ON THIS PLAN WAS CORRECT AT THE TIME THIS PLAN WAS PRODUCED. ANY AND ALL DATA IS SUBJECT TO CHANGE WITH TIME AND WE ASSUME NO RESPONSIBILITY FOR THE USE OF INCORRECT OR OUTDATED INFORMATION. FOR VERIFICATION OR UPDATE OF SURVEY DATA FOR THIS SITE CONTACT WOODARD & CURRAN. WOODARD & CURRAN HAS NOT CONDUCTED PROPERTY BOUNDARY OR EASEMENT SURVEYS.
FDDA
LANDFILL NORTHERN LOBE
LANDFILL SOUTHERN LOBE
PW11
PW10
0 100 200
SCALE IN FEET
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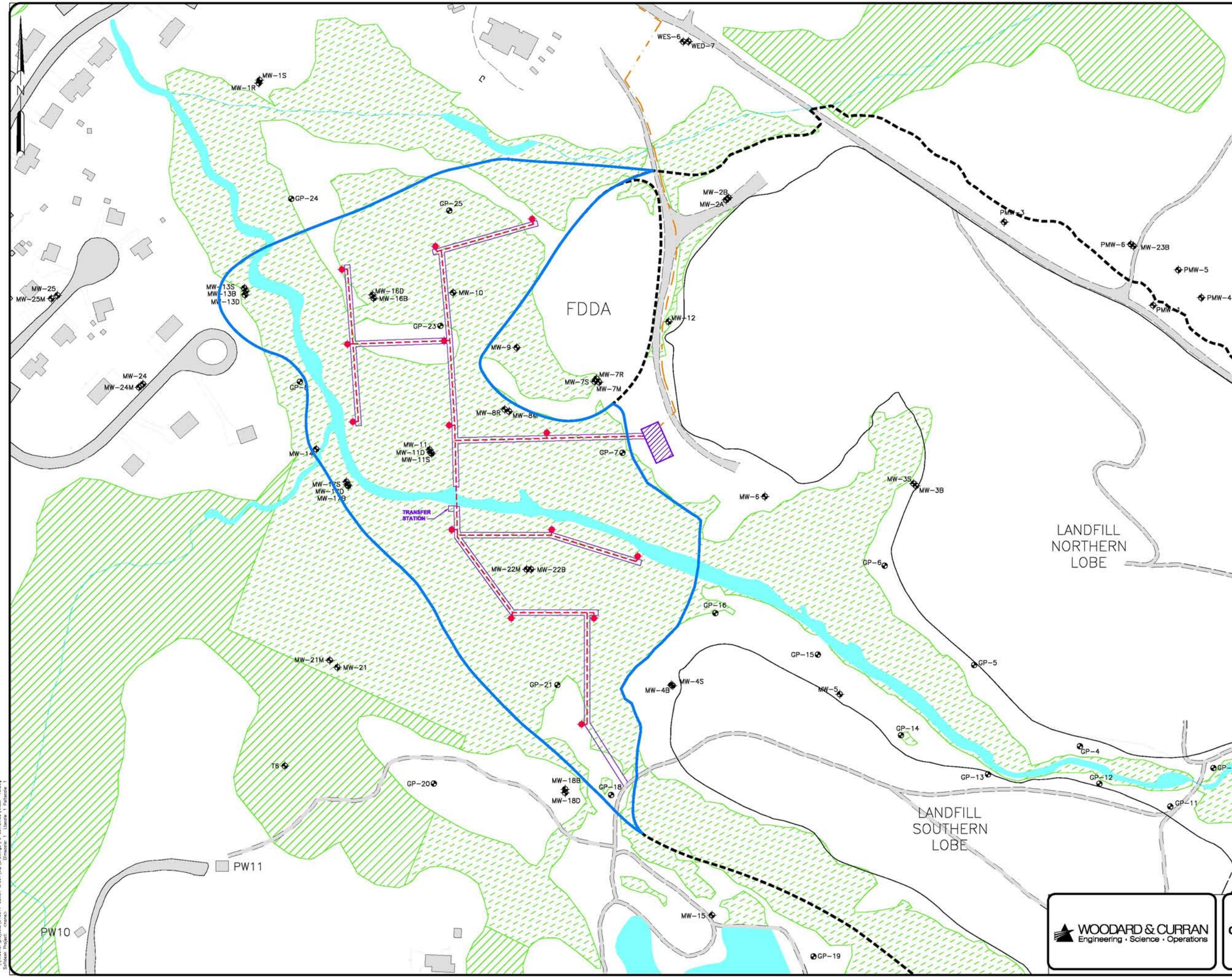
FIGURE 8-10
CONCEPTUAL PLAN FOR ALTERNATIVE DGGW-3
SUTTON BROOK DISPOSAL AREA



LEGEND

- MW-6 — MONITORING WELL LOCATION AND IDENTIFIER
- GP-1 — TEMPORARY WELL LOCATION AND IDENTIFIER
- INTERPRETIVE LIMITS OF SOLID WASTE
- LANDFILL AND FDDA SOURCE AREA GROUNDWATER FDDA = FORMER DRUM DISPOSAL AREA
- HYDRAULICALLY DOWNGRADIENT GROUNDWATER WITH ORGANIC CONSTITUENTS DETECTED IN EXCESS OF PRGs
- PROPOSED GROUNDWATER EXTRACTION WELLS (14 WELLS AT 10 GPM EACH FOR 140 GPM TOTAL)
- WETLAND BOUNDARY DELINEATED IN ACCORDANCE WITH US ACOE 1987 METHODS
- WETLAND AREA DELINEATED BY AERIAL PHOTOGRAPH INTERPRETATION
- PROPOSED GROUNDWATER EXTRACTION PIPING AND WELL HEAD ELECTRICAL CONDUIT
- PROPOSED ELECTRICAL POWER LINES (OVERHEAD)
- PROPOSED ACCESS ROAD TO EXTRACTION WELLS (EXTRACTION AND ELECTRICAL LINES TO BE BURIED WITHIN)
- ANTICIPATED EXTENT OF WETLAND IMPACTS 35,740 FT^2
- REMEDIAL TREATMENT BUILDING
- PAVED ROAD
- UNPAVED ROAD
- WATER
- DRIVEWAY
- FENCE
- BUILDING

NOTES:

1. THE TOPOGRAPHIC AND PLANIMETRIC FEATURES AS SHOWN PROVIDED BY THE TOWN OF TEWKSBURY, MASSACHUSETTS, DEPARTMENT OF PUBLIC WORKS, AND ARE BASED UPON AERIAL PHOTOGRAMETRIC MAPPING COMPLETED BY JAMES W. SEWALL COMPANY OF OLD TOWN, MAINE FROM AERIAL PHOTOGRAPHS DATED MARCH 29, 1985. THE MAP IS REPORTED TO MEET NATIONAL MAP ACCURACY STANDARDS FOR 1"=100' MAPS WITH 2 FOOT CONTOURS. WOODARD & CURRAN HAS NOT FIELD VERIFIED AND IS NOT RESPONSIBLE FOR ACCURACY OF SAME.

2. THE GROUND SURFACE TOPOGRAPHIC VERTICAL DATUM REFERENCED IS EXPRESSED IN FEET AND BASED UPON THE USGS NORTH AMERICAN VERTICAL DATUM OF 1929 (NAVD29), AS ESTABLISHED BY OTHERS.

3. THE SURVEY DATA AS PRESENTED ON THIS PLAN WAS CORRECT AT THE TIME THIS PLAN WAS PRODUCED. ANY AND ALL DATA IS SUBJECT TO CHANGE WITH TIME AND WE ASSUME NO RESPONSIBILITY FOR THE USE OF INCORRECT OR OUTDATED INFORMATION. FOR VERIFICATION OR UPDATE OF SURVEY DATA FOR THIS SITE CONTACT WOODARD & CURRAN. WOODARD & CURRAN HAS NOT CONDUCTED PROPERTY BOUNDARY OR EASEMENT SURVEYS.

4. IF THIS ALTERNATIVE IS SELECTED WITH LF-2, THEN THE GROUNDWATER EXTRACTION SYSTEM FOR THE SOUTHERN LOBE WOULD LIKELY BE CONNECTED TO THE SOUTHERN PORTION OF THE DGGW-3 WELL NETWORK.

0 100 200
SCALE IN FEET

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FIGURE 8-11

CONCEPTUAL PLAN FOR ALTERNATIVE DGGW-4

SUTTON BROOK DISPOSAL AREA

9. COMPARATIVE ANALYSIS OF ALTERNATIVES

The comparative analysis presented in this section compares the remedial action alternatives evaluated in Section 8 relative to the NCP evaluation criteria. The purpose of the comparative analysis is to identify the advantages and disadvantages of the alternatives relative to one another and to aid in the selection of a remedial alternative. As discussed previously, the detailed analysis of remedial alternatives provides sufficient information to compare the alternatives and facilitate selection of the preferred remedy that best meets the following CERCLA requirements:

- is protective of public health and the environment;
- attains ARARs (or provides grounds for invoking a waiver);
- is cost-effective;
- is a permanent solution using alternative treatment technologies or resource recovery technologies to the maximum extent practicable; and
- provides preference for treatment that reduces toxicity, mobility, or volume.

As discussed in the detailed analysis section, an alternative must be protective of human health and the environment and comply with ARARs (unless a specific ARAR is waived) to be selected as the remedy in the ROD. Tables 9-1 through 9-4 provide the comparative analysis for the four areas of evaluation (Landfill Lobes, Former Drum Disposal Area, Garage and Storage Area, and Downgradient Groundwater), highlighting the results of the detailed analysis. The following sections summarize the results of the comparative analysis based on each of the evaluation criteria.

9.1 LANDFILL LOBES

A summary table of the seven criteria evaluated during the detailed analysis comparing the four landfill source area alternatives is provided as Table 9-1. Further discussion is provided below.

Overall Protection of Human Health and the Environment

The baseline risk assessment presumed that the Northern and Southern landfill lobes will be capped; thereby eliminating exposure to the waste in these areas. The results of the HHRA indicated that potential risks exist if groundwater beneath the landfill lobes was used as a drinking water supply. The presence of VOCs and metals in sediment and surface water in Sutton Brook (between the two landfill lobes) may pose potential risk to ecological receptors. All of the alternatives evaluated, with the exception of LF-1 (the No Action Alternative), will be protective of human health and the environment by eliminating, reducing, and controlling current and future risks through treatment, containment and/or institutional controls.

Alternative LF-1 is the least protective of the four options as no action would be taken to control exposure to or reduce concentrations in landfill waste, brook sediment, groundwater or surface water. The three remaining alternatives, LF-2 through LF-3 all address current and potential future exposure risks through institutional controls, containment and treatment (LF-2a through a phased approach), restricting exposure to the landfill waste (through containment and institutional controls), and preventing the use of groundwater in this area until RAOs are attained.

Groundwater RAOs will be attained and exposure risks will be controlled with alternative LF-2 and LF-4 using containment (vertical barrier) and either in-situ natural attenuation processes (LF-2a with a phased approach to an active treatment technology, if needed) or focused active treatment (LF-2b and LF-4); or with alternative LF-3 through groundwater extraction and ex-situ treatment.

For the sediment portion of the alternative, LF-1 provides the least amount of protection to human health and the environment since the material remains in place and no action is taken to treat or restrict exposure to the contaminated material. Alternatives LF-2 and LF-3 offer the highest level of protection as the contaminated material is removed from the brook, eliminating the potential exposure to human and ecological receptors. LF-4 includes re-routing the brook and thus provides a moderate to high level of protection as exposure is prevented through excavation (of hot spots) and filling in of the existing brook, essentially containing the material to prevent exposure.

Compliance with ARARs

Alternative LF-1 will not meet chemical specific ARARs as no remedial actions will be performed to reduce concentrations in sediment, surface water and groundwater. Location and action specific ARARs are not applicable for the no action alternative. Both LF-2 and LF-3 can be designed to comply with chemical, location and action specific ARARs (summarized in Appendix E). Attainment of chemical specific ARARs with regard to groundwater will not occur immediately, but rather, over a period of time once source control measures are implemented and in-situ or ex-situ remedial processes break down contaminants. The estimated timeframe to achieve the chemical specific ARARs for these alternatives (LF-2 and LF-4) are within the same order of magnitude, estimated to be in the 65 to 200 year range. Alternative LF-3, which incorporates groundwater extraction and ex-situ treatment, was estimated to meet cleanup goals in a slightly quicker timeframe (50 to 165 years).

Alternative LF-4 can be designed and implemented to comply with applicable chemical and action specific ARARs; however the brook re-routing component of this alternative will most likely not meet location specific ARARs. Under the Massachusetts Wetlands Protection Act, in addition to replicating the resource areas that will be destroyed on-site with the brook re-routing, the project must demonstrate that there is no practicable alternative to the response action being proposed that would be less damaging, in terms of magnitude, to the resource areas. Both alternatives, LF-2 and LF-3, present viable options that are less damaging to the existing on-site resource areas.

As a result, alternatives LF-2 and LF-3 are the only two alternatives that appear to be able to be designed and implemented to comply with applicable ARARs.

Long-Term Effectiveness and Permanence

Overall, alternative LF-1 is the least effective in regards to long-term effectiveness and permanence since no actions are taken to control or limit exposure to the landfill waste, brook sediment and surface water and groundwater. The remaining alternatives all provide a comparable level of long term effectiveness and permanence in regards to the landfill waste. Alternatives LF-2 and LF-3 which incorporate sediment excavation provide the highest level of long-term effectiveness for the brook sediment since the material is removed from the area, preventing current and potential future exposure. Alternative LF-4 is effective in reducing risks associated with the impacted sediment; however, since some of the contaminated sediments remain in place (and covered), the long-term effectiveness is reduced compared to LF-2 and LF-3.

For the groundwater component of these alternatives, although minimal risks for groundwater exposure is present under existing site conditions, since there is no use of site groundwater, alternative LF-1 will provide the least long-term effectiveness because no actions would be taken to control future exposure risk or to reduce residual contaminant mass in groundwater. The remaining three alternatives (LF-2 through LF-4) each prevent future potential risks via institutional controls and groundwater remediation.

Alternative LF-3 is the most aggressive option as it extracts groundwater from the downgradient edges of the landfill source area (Northern and Southern lobes) potentially resulting in a reduced time to achieve RAOs compared to the other LF alternatives. The extraction rate (estimated at 245 gpm) will result in a large treatment facility requiring significant upkeep and maintenance over time. The reliability of the system will be dependent on the ability to sustain the routine O&M activities and design parameters (i.e., flow rates, drawdowns, etc.).

Alternatives LF-2 and LF-4 use a combination of a permanent vertical barrier for containment and a focused groundwater remedial action at the downgradient end of the barrier. Alternative LF-2a incorporates a phased approach to the groundwater remedy, initiating with a monitoring natural attenuation program with a contingency for an active treatment component based on the monitoring results. Alternatives LF-2b and LF-4 incorporate an active treatment component to groundwater (either in situ technologies or extraction and ex situ treatment).

Overall, LF-2 and LF-4 may provide a higher level of reliability in groundwater containment over LF-3 since the vertical barrier is a permanent physical barrier and the alternatives may include in situ methods to address groundwater impacts; whereas, under alternative LF-3, the potential exists for design parameters not to be met on a continuous basis (due to a variety of operational reasons) which may reduce the alternatives overall reliability and effectiveness.

In addition, long-term effectiveness of the groundwater remedial actions must be evaluated over time (even following achievement of clean-up goals) to assess the ability to sustain the cleanup goals once the remedial action is complete to ensure that contaminant levels do not rebound above cleanup goals. Groundwater extraction systems and some in situ remedial actions (e.g., in situ chemical oxidation) have a much higher tendency to develop preferential pathways within the subsurface, creating the potential of not extracting or treating all impacted areas and thus resulting in rebound occurrences. MNA processes, on the other hand, are at work via the wide assortment of in-situ processes within all of the heterogeneous formations, which may result in a reduced potential for rebound.

Reduction of Toxicity, Mobility, or Volume Through Treatment

Treatment of the landfill waste or excavated brook sediment is not proposed or anticipated for any of the LF alternatives; however, the potential exists that treatment of the sediment may be required prior to re-use and/or disposal beneath the on-site landfill final cover system if waste characterization results demonstrate the need for such treatment. Regardless, through disposal of the material beneath the landfill final cover system as part of alternatives LF-2, LF-3, and LF-4, the toxicity, mobility and volume of impacted sediment in the brook will be significantly reduced with these alternatives. Since alternatives LF-2 and LF-3 will excavate portions of the brook between the two landfill lobes, the overall reduction in contaminated sediment mass within the brook will be higher than for LF-4 (only hot spot removal). Although some impacted sediment may remain with Alternative LF-4, the mobility of the sediment will be reduced with containment. A reduction of toxicity, mobility or volume of impacted sediment will not be attained with Alternative LF-1.

Natural attenuation processes with or without enhancements will reduce the toxicity, mobility and volume of contaminants in groundwater for alternatives LF-2a. Active treatment (either in situ or ex situ) under alternatives LF-2b and LF-4 will also reduce the toxicity, mobility and volume of contaminants in groundwater. The processes will be permanent, with no treatment residuals to handle or dispose of following treatment with the exception of ex situ treatment of groundwater which would result in treatment residuals. The toxicity and volume of contaminants will be reduced in groundwater for alternative LF-3 through ex-situ treatment technologies and the migration of contaminants will be reduced via groundwater extraction and treatment. Significant residuals may be generated from the treatment system requiring off-site disposal for LF-3. The mass destroyed in groundwater will be comparable for alternatives LF-2, LF-3, and LF-4, depending on the specific remedial approach implemented under LF-2 and LF-4.

Short-Term Effectiveness

No short-term impacts to the local community, on-site remedial workers or the environment will occur under alternative LF-1. Depending on the final landfill cover system design (LF-2 - LF-4), the impacts to the local community and environment will range from moderate to high due to the increased truck traffic during construction activities and the wetland resource area destruction. Concerns about the potentially significant additional truck traffic on South Street have been vocalized by the community.

For the groundwater component of the alternative, the short-term impacts to the local community, on-site remedial workers and the environment are anticipated to be slightly higher for LF-3 due to the lengthier construction time and the larger impacts to the wetlands (during extraction well and piping installation). Alternatives LF-2b and LF-4 are comparable for the groundwater component of the remedy with LF-2a being lower assuming less construction/installation components.

For the sediment/ brook component of the alternative, however, alternative LF-4 will provide the highest short term impacts to the local community, on-site remedial works and the environment compared to LF-2 and LF-3 due to the increased construction time and the increased amount of resource area impacted during the brook filling and re-routing.

In summary, with the exception of the no action alternative (LF-1), alternative LF-2 provides the least amount of short-term term impacts to the local community, on-site remedial works and the environment.

Implementability

For the landfill final cover system, all of the alternatives are readily implementable as they require no construction (LF-1) or common construction activities (landfill final cover system) that are straight forward to implement (LF-2 through LF-4). The presence of the wetland resource areas and Sutton Brook surrounding the landfill lobes will present some challenges with the design and construction; however, they are comparable for LF-2 through LF-4.

The groundwater component for alternative LF-1 is easily implementable since no construction activities are required to implement. Installation of the vertical barrier for LF-2 and LF-4 is a common construction activity, readily implementable; however, there may be some design and construction challenges that will require coordination in conjunction with the final landfill cover system design and construction due to the proximity of the brook and the edge of waste (Southern lobe). Installation of the groundwater extraction and treatment system for LF-3 is straight forward; however, with similar design and construction issues as LF-2 and LF-4 due to the proximity of the edge of waste to the wetlands and brook. Detailed pre-design,

pilot, and/or bench scale studies will be required for LF-2b, LF-3, and LF-4 (and potentially LF-2a) to allow effective design and implementation of the remedial action.

The brook sediment component of the landfill alternatives are straight forward and readily implementable for LF-2 and LF-3; sediment removal and brook restoration with LF-2 and LF-3 will present less challenges to implement than re-routing the brook with LF-4, both in design and construction. As no actions will be taken in the brook with LF-1, it is easily implementable.

All materials and services required for implementation are readily available either commercially or via specialized vendors for all alternatives. With the presumption that the landfills will be capped, none of the remaining aspects of the proposed alternatives should significantly limit potential further remedial actions, if required. The operational requirements of each of the alternatives vary from none (LF-1) to intensive (LF-3). LF-2 through LF-4 all require routine groundwater monitoring. Given the anticipated flow rates, alternative LF-3 will require more O&M of the groundwater extraction and treatment system compared to the remedial actions implemented under alternatives LF-2 and LF-4.

Cost

Alternative LF-1 requires the least cost to implement, followed by LF-2a, LF-2b, and LF-4, with alternative LF-3 significantly more expensive to implement. The range in costs relates to the differences in the groundwater components of the alternatives given the landfill cover costs are consistent between alternatives. In addition, alternative LF-4 includes costs associated with re-routing the brook. Cost backup for alternatives LF-1 through LF-4 are provided as Attachments D-1 through D-4 in Appendix D, respectively.

Summary

Of the alternatives evaluated for the landfill source area, LF-2 and LF-3 are the only alternatives that meet the main threshold criteria by eliminating current and potential future risks, complying with ARARs and achieving RAOs over time. Alternative LF-4 has been assumed not be able to meet the location specific ARARs related to the re-routing of the brook. The amount of mass reduction on-site will also be highest with LF-2 and LF-3; however, the timeframe to meet RAOs may be expedited for LF-3. With the exception of the no action alternative (LF-1), alternative LF-2 provides the least amount of short-term term impacts to the local community, on-site remedial works and the environment and is the least expensive to implement (LF-2a). LF-2 is also slightly easier to implement and provides the potential for higher reliability than LF-3.

9.2 FORMER DRUM DISPOSAL AREA

A summary table of the seven criteria evaluated during the detailed analysis comparing the five FDDA alternatives is provided as Table 9-2. Further discussion is provided below.

Overall Protection of Human Health and the Environment

The results of the baseline risk assessment indicate that human health risks exist for the potential potable use and volatilization of FDDA groundwater into a future building. In addition, potential risks to human and ecological receptors exist due to contaminants in FDDA soil. All of the alternatives, with the

exception of FDDA-1, will be protective of human health and the environment by eliminating, reducing, or controlling current and future risks through treatment, containment and/or institutional controls.

Alternative FDDA-1 is the least protective of the five options as no action will be taken to reduce contaminant concentrations in soil or groundwater or to control exposure risks. The four remaining alternatives, FDDA-2 through FDDA-4 all address current exposure risks through institutional controls, restricting potable use of groundwater, soil removal, and groundwater remediation, until RAOs are attained. Groundwater RAOs will be attained with alternative FDDA-4 using in-situ natural attenuation processes with phased enhancements and with alternatives FDDA-2, FDDA-3 and FDDA-5 through groundwater extraction and ex-situ treatment.

For the impacted soil, alternative FDDA-2 utilizes a containment barrier (e.g. low permeability cap) and institutional controls to control exposure. Alternatives FDDA-3 through FDDA-5 all incorporate soil excavation to eliminate exposure risks associated with the impacted soil.

Compliance with ARARs

Alternative FDDA-1 will not meet chemical specific ARARs as no remedial actions will be performed to reduce concentrations in soil and groundwater. Location and action specific ARARs are not applicable for this alternative. The remaining alternatives can be designed to comply with chemical, location and action specific ARARs (summarized in Appendix E). Attainment of chemical specific ARARs with regard to groundwater will not occur in the immediate short-term, but rather, over a period of time once source control measures are implemented and in-situ or ex-situ treatment processes break down contaminants.

The estimated timeframe to achieve groundwater chemical specific ARARs for alternatives FDDA-3, FDDA-4, and FDDA-5 are within the same order of magnitude (since the source material is removed) with a differential of approximately 10 to 15 years between the slowest and quickest alternatives. Alternative FDDA-2 has a wider range in timeframe (30 to 134 years) to meet groundwater ARARs due to the uncertainty of timeframes for source material to leach into groundwater. The alternatives that incorporate groundwater extraction and ex-situ treatment with soil excavation (FDDA-3 and FDDA-5) were estimated to meet cleanup goals in a slightly quicker timeframe of approximately 25 to 100 years.

Long-Term Effectiveness and Permanence

The three alternatives that incorporate soil excavation (FDDA-3, FDDA-4, and FDDA-5) provide the highest level of long-term effectiveness and permanence since the material is removed from the area, preventing future leaching of contaminants in soil to groundwater. Alternative FDDA-2 is effective in reducing risks associated with the impacted soil; however, since the material remains in place, the long-term effectiveness is reduced compared to FDDA-3, FDDA-4, and FDDA-5. Even with an impermeable barrier, the potential exists for future leaching into groundwater since residuals remain. Overall, however, Alternative FDDA-1 is the least effective in regards to long-term effectiveness and permanence related to the impacted soil since the material remains with no controls to limit infiltration and potential leaching and migration.

Although minimal risks for groundwater exposure is present under existing site conditions, since there is no current potable use of site groundwater nor are there any current receptors for volatilization from the FDDA groundwater, Alternative FDDA-1 will provide the least long-term effectiveness because no actions would be taken to control exposure risk or to reduce residual contaminant mass in groundwater.

The remaining four alternatives (FDDA-2 through FDDA-5) each prevent future potential risks via institutional controls and various forms of remedial actions.

Alternative FDDA-5 is the most aggressive option as it extracts groundwater over the entire FDDA plume potentially resulting in a reduced timeframe to achieve RAOs compared to the other FDDA alternatives. Alternatives FDDA-2 and FDDA-3 are similar to FDDA-5 in that they involve groundwater extraction and treatment; however, the goal is hydraulic containment/contaminant reduction. Alternative FDDA-4 capitalizes on existing natural attenuation processes occurring in this area and/or enhanced in situ remedial methods (through a phased approach) to provide long-term effectiveness and permanence.

Groundwater extraction systems and some in situ remedial actions (e.g., in situ chemical oxidation) have a much higher tendency to develop preferential pathways within the subsurface, creating the potential of not extracting or treating all impacted areas and thus resulting in rebound occurrences. MNA processes, on the other hand, are at work via the wide assortment of in-situ processes within all of the heterogeneous formations, which may result in a reduced potential for rebound.

Reduction of Toxicity, Mobility, or Volume Through Treatment

Treatment of the impacted soil is not proposed or anticipated for any of the FDDA alternatives; however, the potential exists that treatment may be required prior to re-use and/or disposal beneath the landfill final cover system if waste characterization results demonstrate the need for treatment. Regardless, through disposal of the material beneath a landfill final cover system as part of alternatives FDDA-3, FDDA-4, and FDDA-5, the toxicity, mobility and volume of impacted soil in the FDDA will be significantly reduced. The reduction in mass in soil will be the same for FDDA-3, FDDA-4, and FDDA-5. A reduction of toxicity, mobility or volume of impacted soil will not be attained with Alternative FDDA-1. Although the toxicity and volume of impacted material will not be reduced with Alternative FDDA-2, the mobility of the impacted soil will be reduced with containment.

Natural attenuation processes with or without enhancements will actively reduce the toxicity, mobility and volume of contaminants in groundwater for alternative FDDA-4. The processes will be permanent, with no treatment residuals. The toxicity and volume of contaminants in groundwater will be reduced for alternatives FDDA-2, FDDA-3 and FDDA-5 through ex-situ treatment technologies and the migration of contaminants will be reduced via the groundwater extraction component of the treatment system. The mass destroyed in groundwater will be comparable for alternatives FDDA-3, FDDA-4, and FDDA-5, however, the timeframe to destroy the mass may be slightly expedited with FDDA-3 and FDDA-5. Since a larger contaminant mass will be present within the FDDA with alternative FDDA-2 (since no soil excavation), the groundwater component will likely treat a higher amount of mass during its operation. It is anticipated that alternatives FDDA-2, FDDA-3, and FDDA-5 will produce residuals requiring off-site disposal (e.g. sludge from metals treatment) or off-site treatment (e.g. carbon).

Short-Term Effectiveness

No short-term impacts to the local community, on-site remedial workers, and the environment are anticipated under alternative FDDA-1. The three alternatives that incorporate soil excavation (FDDA-3, FDDA-4, and FDDA-5) provide the highest level of short-term effectiveness since the material is removed from the area, preventing future leaching of contaminants in soil to groundwater. Alternative FDDA-2 is effective in reducing exposure risks associated with the impacted soil; however, since the material remains in place, the effectiveness is reduced compared to FDDA-3, FDDA-4, and FDDA-5.

Impacts under FDDA-4 are anticipated to be minimal during installation of additional monitoring wells and during monitoring activities. Access to wells during long-term groundwater monitoring can be on foot, not requiring access roads through the wetlands.

The short-term impacts to the local community, on-site remedial workers, and the environment are anticipated to be slightly higher for FDDA-2, FDDA-3 and FDDA-5. Due to the location of extraction wells and the need for access roads (i.e. vehicular accessible roads) to each well (access for O&M and for installation of extraction piping and electrical conduit), slightly higher impacts to the adjacent wetland resource area are anticipated. FDDA-5 will require the most disruption/destruction, with FDDA-2 and FDDA-3 reduced, yet comparable to one another.

The estimated timeframe to achieve RAOs for alternatives FDDA-3, FDDA-4, and FDDA-5 are within the same order of magnitude since the source material is removed, with the quickest timeframe estimated for FDDA-5, followed by FDDA-3. Alternative FDDA-2 has the potential to be the lengthiest timeframe since infiltration is reduced (and not eliminated) through the cap, reducing the potential for leaching of contaminants from soil to groundwater; however since the potential exists for the material to leach over time, concentrations in groundwater may continue to remain over RAOs for an extended period. RAOs will not be achieved with Alternative FDDA-1 as current and potential future risks are not controlled.

Implementability

For the soil component, all of the alternatives are easily implementable as they require no construction (FDDA-1) or common construction activities (cap or excavation) that are straight forward to implement (FDDA-2, FDDA-3, FDDA-4, and FDDA-5).

The groundwater components for alternatives FDDA-1 and FDDA-4 are easily implementable since limited (FDDA-4) to no (FDDA-1) construction activities are required to implement. Installation of the groundwater extraction and treatment systems for FDDA-2, FDDA-3 and FDDA-5 is straight forward, with potential construction issues involving disruption or destruction of adjacent wetlands. Detailed pre-design, pilot, and/or bench scale studies will be required for these alternatives to allow effective design and implementation.

All materials and services required for implementation are readily available either commercially or via specialized vendors for all alternatives. With the exception of FDDA-2, none of the proposed alternatives should significantly limit potential further remedial actions, if required. With the likely use of the area as a storm water detention basin for the landfill final cover system, there will not be access to the impacted material beneath the cap (and basin) with Alternative FDDA-2.

The operational requirements of each of the alternatives vary from none (FDDA-1) to significant (FDDA-2, FDDA-3 and FDDA-5). FDDA-2, FDDA-3, FDDA-4, and FDDA-5 all require routine groundwater monitoring. Alternatives FDDA-2, FDDA-3 and FDDA-5 all require active O&M of the treatment system.

Cost

Alternative FDDA-1 requires the least cost to implement, followed by FDDA-4 (assuming natural attenuation mechanisms continue degrading/reducing groundwater concentrations following source control implementation). The three groundwater extraction and ex-situ treatment system alternatives

(FDDA-2, FDDA-3, and FDDA-5) are comparable in cost, with FDDA-5 the highest. Cost backup for alternatives FDDA-1 through FDDA-5 are provided as Attachments D-5 through D-9 in Appendix D, respectively.

Summary

Of the alternatives evaluated for the FDDA, FDDA-2 through FDDA-5 are reliable alternatives that meet the main threshold criteria by eliminating current and potential future risks, complying with ARARs and achieving RAOs over time. FDDA-3 through FDDA-5 provides a higher level of mass reduction with the excavation of impacted soil, in conjunction with groundwater remedial actions. Timeframes to meet RAOs are also similar for these alternatives (FDDA-3, FDDA-4 and FDDA-5), and expedited as a result of the mass removal. FDDA-4 provides the added benefit of using the existing in-situ natural attenuation processes to address residual impacts in groundwater, creating limited impacts to wetland resource areas and no treatment residuals. In addition, FDDA-4 requires the least amount of O&M and is the least expensive alternative to implement to achieve the RAOs.

9.3 GARAGE AND STORAGE AREA

A summary table of the seven criteria evaluated during the detailed analysis comparing the two garage and storage area alternatives is provided as Table 9-3. Further discussion is provided below.

Overall Protection of Human Health and the Environment

The results of the human health and ecological risk assessments indicated that select compounds in soils in the GSA may pose a current and/or potential future risk to future site residents, facility workers, construction workers and/or ecological receptors. Alternative GSA-1 (No Action) is the least protective of the two options as no action would be taken to eliminate or control exposure risks. Potential future risks would remain and RAOs will not be achieved. Alternative GSA-2 will effectively eliminate current and/or potential future exposure risks as the material will be excavated and removed from the GSA.

Compliance with ARARs

Alternative GSA-1 will not meet chemical specific ARARs as no remedial actions will be performed to reduce concentrations in soil; location and action specific ARARs are not applicable for this alternative. Alternative GSA-2 can be designed to comply with pertinent chemical, location and action specific ARARs (summarized in Appendix E).

Long-Term Effectiveness and Permanence

Through excavation and disposal beneath the landfill final cover system, alternative GSA-2 will provide long term effectiveness and permanence as residual risks will be eliminated within the GSA area. With Alternative GSA-1, however, the current and potential future exposure risks to contaminants in soil will continue to pose a potential residual risk, thereby not providing short-term or long-term effectiveness or permanence.

Reduction of Toxicity, Mobility, or Volume Through Treatment

Treatment of the impacted soil is not proposed or anticipated for either of the GSA alternatives; however, the potential exists that treatment may be required prior to re-use and/or disposal beneath the landfill final

cover system (GSA-2). Regardless, through disposal of the material beneath a landfill final cover system as part of alternative GSA-2, the toxicity, mobility and volume of impacted material in the GSA will be significantly reduced.

Short-Term Effectiveness

The short-term impacts to the local community, on-site remedial workers and the environment under Alternative GSA-2 are anticipated to be minimal and controllable due to the relatively small volume of soil requiring removal, the short duration of construction activity and the proximity to on-site disposal areas. RAOs will be met for GSA-2 upon removal of the impacted soil, anticipated after 1 to 2 years (includes timing for design, implementation, and confirmatory analysis). RAOs will not be achieved with Alternative GSA-1.

Implementability

Both alternatives are easily implementable and would not limit or interfere with the ability to perform future remedial actions. Shallow soil excavation with GSA-2 is a common technique, straight forward and reliable to implement.

Cost

The estimated costs for the two GSA alternatives are comparable over the 30 year projected timeframe. GSA-2 includes upfront capital costs to excavate and dispose of the impacted soil and no O&M costs where as GSA-1 requires no capital costs, but includes annual O&M (site inspections) and periodic costs over the estimated 30 year time period. Cost backup for alternatives GSA-1 and GSA-2 are provided as Attachments D-10 and D-11 in Appendix D, respectively.

GSA Summary

Of the alternatives evaluated for the GSA, alternative GSA-2 is the only one that provides a reliable and implementable approach to eliminate current and potential future risk in accordance with applicable ARARs providing short and long-term effectiveness.

9.4 DOWNGRADIENT GROUNDWATER

A summary table of the seven criteria evaluated during the detailed analysis comparing the four downgradient groundwater alternatives is provided as Table 9-4. Further discussion is provided below.

Overall Protection of Human Health and the Environment

The results of the baseline risk assessment indicated that a potential risk exists if downgradient groundwater (on-site) is used as a potable supply in the future. Currently no one is using on-site groundwater as a drinking water supply. All of the alternatives, with the exception of DGGW-1, will be protective of human health and the environment under this scenario by eliminating, reducing, or controlling current and future risks through remedial actions and/or institutional controls.

Alternative DGGW-1 is the least protective of the four options as no action would be taken to reduce concentrations in groundwater or to control exposure risks. Under this alternative, there would be no

restrictions on groundwater use. The three remaining alternatives, DGGW-2, DGGW-3, and DGGW-4 all address current exposure risks through institutional controls, restricting potable use of groundwater in this area until RAOs are attained. Groundwater RAOs will be attained with alternative DGGW-2 using in-situ natural attenuation processes with or without enhancements and with alternatives DGGW-3 and DGGW-4 through groundwater extraction and ex-situ treatment.

Compliance with ARARs

Alternative DGGW-1 will not meet chemical specific ARARs as no remedial actions will be performed to reduce COCs in groundwater. Location and action specific ARARs are not applicable for this alternative. The remaining alternatives can be designed to comply with pertinent chemical, location, and action specific ARARs (summarized in Appendix E). Attainment of chemical specific ARARs will not occur in the immediate short-term, but rather, over a period of time once source control measures are implemented and in-situ or ex-situ treatment processes break down contaminants.

The estimated timeframe to achieve chemical specific ARARs for alternatives DGGW-2, DGGW-3, and DGGW-4 are within the same order of magnitude, with a differential of approximately 25 to 30 years between the slowest and quickest alternatives. It should be noted that given the cleanup time model assumptions, groundwater extraction alternatives typically estimate meeting cleanup goals in a quicker timeframe.

Long-Term Effectiveness and Permanence

Although minimal risk is present under existing site conditions since there is no potable use of on-site groundwater, alternative DGGW-1 will provide the least long-term effectiveness because no actions would be taken to control risk or to reduce residual contaminant mass in groundwater. The remaining three alternatives (DGGW-2, DGGW-3, and DGGW-4) prevent future potential risks via institutional controls and various forms of remedial actions.

Alternative DGGW-4 is the most aggressive option as it extracts groundwater over the entire DGGW plume potentially resulting in a reduced time to achieve RAOs compared to the other DGGW alternatives. Alternative DGGW-3 is similar to DGGW-4 in that it involves groundwater extraction and treatment. Alternative DGGW-2 capitalizes on existing natural attenuation processes occurring in this area and with or without enhancements provides long-term effectiveness and permanence.

In addition, long-term effectiveness of the groundwater remedial actions must be evaluated over time (even following achievement of clean-up goals) to assess the ability to sustain the cleanup goals once the remedial action is complete to ensure that contaminant levels do not rebound above cleanup goals. Groundwater extraction systems and some in situ remedial actions (e.g., in situ chemical oxidation) have a much higher tendency to develop preferential pathways within the subsurface, creating the potential of not extracting or treating all impacted areas and thus resulting in rebound occurrences. MNA processes, on the other hand, are at work via the wide assortment of in-situ processes within all of the heterogeneous formations, which may result in a reduced potential for rebound.

Reduction of Toxicity, Mobility, or Volume Through Treatment

Natural attenuation processes with or without enhancements will reduce the toxicity, mobility, and volume of contaminants in downgradient groundwater for alternative DGGW-2. The processes will be permanent, with no treatment residuals to handle. The toxicity and volume of contaminants in

groundwater will be reduced for alternatives DGGW-3 and DGGW-4 through ex-situ treatment technologies; the migration of contaminants will be reduced via the groundwater extraction component of the treatment system. The mass destroyed will be comparable for alternatives DGGW-2 through DGGW-4, however, the timeframe to destroy the mass has been assumed to be expedited with DGGW-4. It is anticipated that alternatives DGGW-3 and DGGW-4 will produce residuals requiring off-site disposal (e.g. sludge from metals treatment) or treatment (e.g. carbon).

Short-Term Effectiveness

The short-term impacts to the local community and on-site remedial workers are anticipated to be minimal for DGGW-3 and DGGW-4; however, the impacts to the environment, specifically the wetland resource area, are anticipated to be high. With the installation of groundwater extraction wells throughout the DGGW area, destruction of wetlands will be required to access, install, and maintain the groundwater extraction wells. In addition, a gravel roadway (accessible by vehicle) will be required to each extraction point to access the well and for installation of the extraction piping and utility conduits. With fewer extraction wells, DGGW-3 will require significantly less destruction of the wetland resource area (anticipated 5,050 sq ft) compared to DGGW-4 (anticipated 35,740 sq ft).

No short-term impacts to the local community, on-site remedial workers and the environment are anticipated under Alternative DGGW-1 and impacts under DGGW-2 are anticipated to be minimal during installation of additional monitoring wells and during monitoring activities. Access to wells during long-term monitoring events can be on foot, not requiring access roads through the wetlands.

As discussed above, the estimated timeframe to achieve RAOs for alternatives DGGW-2 through DGGW-4 are within the same order of magnitude, with a differential of approximately 25 to 30 years between the slowest and quickest alternatives. Through modeling, alternative DGGW-4 is anticipated to achieve RAOs quickest, followed by DGGW-3 and then DGGW-2; RAOs will not be achieved with alternative DGGW-1 as current and potential future risks are not controlled.

Implementability

Alternatives DGGW-1 and DGGW-2 are easily implementable since limited (DGGW-2) to no (DGGW-1) construction activities are required to implement. As discussed above, installation of the groundwater extraction and treatment systems for DGGW-3 and DGGW-4 present potential construction issues, with access concerns, destruction of wetlands, etc. Detailed pre-design, pilot, and/or bench scale studies will be required for DGGW-3 and DGGW-4 to allow effective design and implementation of the groundwater extraction and treatment systems. Potential issues with discharging the treated groundwater may arise if one of these alternatives (DGGW-3 or DGGW-4) is coupled with other high volume extraction rates alternatives (e.g. LF-3). Individually, the POTW or surface water can handle the discharge; however an evaluation will be required to determine if one discharge method can be implemented or if a combination of discharge methods will be required if the alternatives are combined.

All materials and services required for implementation are readily available either commercially or via specialized vendors for all alternatives. None of the proposed alternatives should significantly limit potential further remedial actions, if required.

The operational requirements of each of the alternatives vary from none (DGGW-1) to intensive (DGGW-4). DGGW-2 through DGGW-4 all require routine groundwater monitoring. Alternatives DGGW-3 and DGGW-4 both require active O&M of the groundwater treatment system, including monitoring of the

system's effectiveness in capturing the desired groundwater and in treating the groundwater to the required discharge limits.

Cost

The estimated costs for the DGGW alternatives vary significantly. Alternative DGGW-1 requires the least cost to implement, followed by DGGW-2. The majority of costs with DGGW-2 are associated with the MNA program. Alternatives DGGW-3 and DGGW-4 result in significantly higher costs (up to an order of magnitude) to implement, with elevated capital and O&M costs. Cost backup for alternatives DGGW-1 through DGGW-4 are provided as Attachments D-12 through D-15 in Appendix D, respectively.

DGGW Summary

Of the alternatives evaluated for the DGGW, DGGW-2 through DGGW-4 are reliable alternatives that meet the main threshold criteria by eliminating current and potential future risks, complying with ARARs and achieving RAOs over time. DGGW-2 provides the added benefit of utilizing the existing wetlands and in-situ natural attenuation processes (with or without enhancements) to address residual impacts in groundwater, creating limited impacts to wetland resource areas and no treatment residuals. DGGW-3 and DGGW-4 may meet RAOs in a slightly quicker timeframe; however they present significant disruption/ destruction to the wetland resource area and will cost up to 10 times the amount of DGGW-2.

TABLE 9-1
COMPARATIVE ANALYSIS FOR THE LANDFILL LOBE REMEDIAL ALTERNATIVES
Remedial Investigation and Feasibility Study
Sutton Brook Disposal Area Superfund Site - Tewksbury, MA

EVALUATION CRITERIA	LF-1	LF-2a and LF-2b	LF-3	LF-4
OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT				
Human Health Protection	The potential human health risks **will remain** and RAOs will **not** be achieved.	The potential human health risks **will be eliminated** and RAOs will be achieved.	The potential human health risks **will be eliminated** and RAOs will be achieved.	The potential human health risks **will be eliminated** and RAOs will be achieved.
Ecological Protection	The potential future risk to ecological receptors **will remain** and RAOs will **not** be achieved.	The potential future risk to ecological receptors **will be eliminated** and RAOs will be achieved.	The potential future risk to ecological receptors **will be eliminated** and RAOs will be achieved.	The potential future risk to ecological receptors **will be eliminated** and RAOs will be achieved.
COMPLIANCE WITH ARARs				
Chemical Specific	Chemical specific ARARs will not be met for this alternative in a timely manner.	This alternative will meet the RAOs and therefore comply with the chemical specific ARARs.	This alternative will meet the RAOs and therefore comply with the chemical specific ARARs.	This alternative will meet the RAOs and therefore comply with the chemical specific ARARs.
Location Specific	Location specific ARARs do not apply for this alternative.	This alternative will be designed and implemented to comply with applicable location-specific ARARs.	This alternative will be designed and implemented to comply with applicable location-specific ARARs.	This alternative **may not** meet applicable location-specific ARARs, specific to the amount of work in the wetland resource areas.
Action Specific	Action specific ARARs do not apply for this alternative.	This alternative will be designed and implemented to comply with applicable action-specific ARARs.	This alternative will be designed and implemented to comply with applicable action-specific ARARs.	This alternative will be designed and implemented to comply with applicable action-specific ARARs.
LONG-TERM EFFECTIVENESS AND PERMANENCE				
Magnitude of Residual Risk	Potential future exposure to contaminants in waste, sediment, surface water and groundwater will continue to pose a potential residual risk.	Residual risk is low; comparable to LF-3 and LF-4.	Residual risk is low; comparable to LF-2 and LF-4.	Residual risk is low; comparable to LF-2 and LF-3.
Adequacy and Reliability of Controls	No controls proposed.	LF-2 prevents exposure to the waste, reduces infiltration through the waste into groundwater, prevents or reduces the potential for re-contamination of the brook, and limits human exposure to impacted groundwater until groundwater RAOs are achieved. Containment of groundwater utilizing a vertical barrier (in conjunction with monitored natural attenuation (LF-2a) or active groundwater treatment (LF-2b)) is anticipated to effectively and reliably limit human exposure to impacted groundwater until RAOs are met.	LF-3 prevents exposure to the waste, reduces infiltration through the waste into groundwater, prevents or reduces the potential for re-contamination of the brook, and limits human exposure to impacted groundwater until groundwater RAOs are achieved. Collection of groundwater with ex-situ treatment is anticipated to effectively and reliably limit human exposure to impacted groundwater until RAOs are met.	LF-4 prevents exposure to the waste, reduces infiltration through the waste into groundwater, prevents or reduces the potential for re-contamination of the brook, and limits human exposure to impacted groundwater until groundwater RAOs are achieved. Containment of groundwater utilizing a vertical barrier (in conjunction with active groundwater treatment) is anticipated to effectively and reliably limit human exposure to impacted groundwater until RAOs are met.
REDUCTION OF TOXICITY, MOBILITY AND VOLUME THROUGH TREATMENT				
Treatment Process Used and Materials Treated	No active treatment is proposed.	Materials addressed in groundwater include VOCs, SVOCs & metals. Alternative LF-2a does not actively treat groundwater. MNA processes will address COCs in-situ following a phased approach to the groundwater remedy. Alternative LF-2b will treat these COCs in-situ (e.g., chemical oxidation) or if extraction and ex-situ treatment is implemented, a combination of technologies such as air stripping, advanced oxidation processes and/or metals treatment, in addition to one or more pretreatment steps (to be determined during the design phase) will be used.	Materials treated in groundwater include VOCs, SVOCs & metals; a combination of technologies such as air stripping, advanced oxidation processes and/or metals treatment, in addition to one or more pretreatment steps (to be determined during the design phase) will be utilized to treat the COCs extracted.	Same as LF-2b.
Amount Destroyed or Treated	None	Current dissolved concentrations indicate an estimated 2,700 to 4,500 lbs of VOCs in Northern and Southern lobe groundwater.	Same as LF-2 and LF-4.	Same as LF-2b and LF-3.

TABLE 9-1
COMPARATIVE ANALYSIS FOR THE LANDFILL LOBE REMEDIAL ALTERNATIVES
Remedial Investigation and Feasibility Study
Sutton Brook Disposal Area Superfund Site - Tewksbury, MA

EVALUATION CRITERIA	LF-1	LF-2a and LF-2b	LF-3	LF-4
Degree of Expected Reductions in Toxicity, Mobility or Volume through Treatment	No reduction in toxicity, mobility or volume through treatment will be achieved.	Compared to other alternatives evaluated for the landfill lobes, this alternative provides a **low** (LF-2a) to **moderate** (LF-2b) level of reduction in toxicity, mobility and volume of contaminants through treatment.	Compared to other alternatives evaluated for the landfill lobes, this alternative provides, through groundwater treatment, a **moderate** level of reduction in toxicity and volume and a high level of reduction with regard to mobility of contaminants.	Same as LF-2b.
Degree to which Treatment is Irreversible	No treatment is proposed.	Alternative LF-2a does not include treatment technologies. Under Alternative LF-2b, the groundwater treatment will be permanent.	Same as LF-2b and LF-4.	Same as LF-2b and LF-3.
Type and Quantity of Residuals Remaining after Treatment	Existing conditions will remain since no treatment is proposed.	MNA process will address COCs in-situ. **Low** volume of residuals anticipated following groundwater treatment (LF-2b).	**Moderate to high** volume of residuals anticipated following groundwater treatment.	Same as LF-2b.
Degree to Which Treatment Reduces Principal Threats	No treatment is proposed.	Overall, this alternative presents a high degree of reducing principal threats since in-situ natural attenuation process with or without enhancements (LF-2a) or active treatment (LF-2b) will address groundwater impacts and in conjunction with the physical barrier, will prevent re-contamination of the brook.	Overall, this alternative presents a high degree of reducing principal threats through treatment since it extracts and treats a large volume of impacted groundwater.	Same as LF-2b.
SHORT-TERM EFFECTIVENESS				
Protection of Community During Remedial Action	Not applicable.	**Limited** short-term effects anticipated.	**Moderate** short-term effects anticipated; slight increase over LF-2 due to longer construction timeframe (for groundwater components).	**Higher** short-term effects anticipated due to the lengthier construction timeframe (re-routing brook and wetlands replication).
Protection of Workers During Remedial Action	Not applicable.	Work will be performed in accordance with applicable OSHA standards. Site-specific health and safety plan(s) will be developed to protect site workers.	Same as LF-2 and LF-4.	Same as LF-2 and LF-3.
Environmental Impacts	Not applicable.	Impacts to the wetland resource areas are anticipated to be **moderate** during construction activities due to the location of the wetland resource areas surrounding the landfill lobes and during the brook excavation, temporary re-directing/routing of the brook may be required to effectively remove the impacted sediment, potentially causing disruption to the existing ecological habitat.	Similar to LF-2, with a slightly higher area of impact due to the groundwater component.	Impacts to the wetland resource areas are anticipated to be **high** during construction activities due to the destruction of the existing wetland/marsh area to the south of the southern lobe during the brook re-creation (disrupting ecological habitat) and due to the location of the wetland resource areas surrounding the landfill lobes (erosion controls and stormwater management will be required to reduce impacts).
Time Until Remedial Action Objectives are Achieved	RAO's **will not be achieved** through this alternative.	65 to 210 years	52 to 164 years	65 to 210 years
IMPLEMENTABILITY				
Ability to Construct and Operate the Technology	Not applicable.	This alternative involves common construction techniques; however the presence of wetland resource areas and the adjacent 100-year flood plain may present potential design challenges. This alternative provides a **reduced** level of operation, maintenance and monitoring than LF-3.	This alternative involves common construction techniques; however the presence of wetland resource areas and the adjacent 100-year flood plain may present potential design challenges. This alternative provides a **higher** level of operation, maintenance and monitoring than other alternatives evaluated (e.g. LF-2 and LF-4).	In general, this alternative involves common construction techniques; however the presence of wetland resource areas and the 100-year flood plain **will present potential design challenges**. In addition, implementation/construction of re-routing the brook **will present access and habitat disruption** issues.

TABLE 9-1
COMPARATIVE ANALYSIS FOR THE LANDFILL LOBE REMEDIAL ALTERNATIVES
Remedial Investigation and Feasibility Study
Sutton Brook Disposal Area Superfund Site - Tewksbury, MA

EVALUATION CRITERIA	LF-1	LF-2a and LF-2b	LF-3	LF-4
Reliability of the Technology	Not applicable.	The combination of technologies that this alternative incorporates presents a reliable approach to comply with ARARs and achieve RAOs.	Same as LF-2.	The combination of technologies that this alternative incorporates presents a reliable approach to achieve RAOs; however due to the issues associated with re-routing the brook (i.e. recreating function and value of resource areas on-site and finding available space on-site), this alternative is not as reliable as the other alternatives to meet RAOs.
Ease of Undertaking Additional Remedial Actions, if necessary	This alternative will not limit or interfere with the ability to implement or perform future remedial actions.	This alternative should not limit or interfere with the ability to implement or perform future remedial actions.	Similar to LF-2 and LF-4.	Similar to LF-2 and LF-3.
Ability to Monitor Effectiveness of Remedy	Not applicable.	Confirmatory sediment sampling and analysis is easily implementable to measure the effectiveness of the brook sediment excavation. Groundwater monitoring to demonstrate contaminant containment and mass reduction is easily implementable.	Same as LF-2 and LF-4.	Same as LF-2 and LF-3.
Ability to Obtain Approvals and Coordinate with Other Agencies	Not applicable since no remedial actions are included in this alternative; therefore, no approvals or coordination required.	The remedial action will be designed and implemented under coordination with appropriate Federal and State agencies.	Same as LF-2.	With the potential ARAR issues in regards to the Massachusetts Wetlands Act, this alternative may have difficulty obtaining approval (i.e., substantial compliance).
Availability of off-site Treatment, Storage and Disposal Services and Capacity	Not applicable for this alternative.	Facilities are available to treat or dispose of the excavated material within Massachusetts. However, there is also availability to re-use this material on-site at one of the landfill lobes beneath the final cover system. If groundwater extraction and ex-situ treatment are implemented, the treated groundwater can be discharged to surface water or to the local POTW.	Similar to LF-2 and LF-4.	Similar to LF-2 and LF-3.
Availability of Necessary Equipment and Specialists	No equipment or specialists required for this alternative.	Equipment, materials and services for this alternative are readily available.	Same as LF-2 and LF-4.	Similar to LF-2 and LF-3.
Availability of Technology	Not applicable since no remedial technologies will be used.	Qualified engineers and contractors are available to design and implement this alternative.	Same as LF-2 and LF-4.	Similar to LF-2 and LF-3.
COSTS - *net present value (7%) - 30 years*				
Capital Costs	$0	$17,500,000 LF-2a to $19,700,000 LF-2b	$24,900,000	$25,900,000
Annual Operation, Maintenance and Monitoring	$68,000	$2,900,000 LF-2a to $5,400,000 LF-2b	$15,900,000 to $26,100,000	$5,400,000
Periodic Costs	$43,000	$120,000	$130,000	$120,000
TOTAL	$111,000	$20,520,000 LF-2a to $25,220,000 LF-2b	$40,930,000 to $51,130,000	$31,420,000

TABLE 9-2
COMPARATIVE ANALYSIS FOR THE FORMER DRUM DISPOSAL AREA REMEDIAL ALTERNATIVES
Remedial Investigation and Feasibility Study
Sutton Brook Disposal Area Superfund Site - Tewksbury, MA

EVALUATION CRITERIA	FDDA-1	FDDA-2	FDDA-3	FDDA-4	FDDA-5
OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT					
Human Health Protection	The potential future risks will remain.	This alternative **controls** the potential future risks through containment.	This alternative **eliminates** the potential future risks.	This alternative **eliminates** the potential future risks.	This alternative **eliminates** the potential future risks.
Ecological Protection	The potential future risks will remain.	The potential future risks will be **controlled** through containment.	The potential future risks will be **eliminated.**	The potential future risks will be **eliminated.**	The potential future risks will be **eliminated.**
COMPLIANCE WITH ARARs					
Chemical Specific	Chemical specific ARARs will not be met for this alternative.	This alternative will prevent exposure to the impacted material, but may not meet the RAOs in soil and therefore **may not** comply with the chemical specific ARARs in the foreseeable future.	This alternative will meet the RAOs over time and therefore comply with the chemical specific ARARs.	This alternative will meet the RAOs over time and therefore comply with the chemical specific ARARs.	This alternative will meet the RAOs over time and therefore comply with the chemical specific ARARs.
Location Specific	Location specific ARARs do not apply for this alternative.	This alternative will be designed and implemented to comply with applicable location-specific ARARs.	This alternative will be designed and implemented to comply with applicable location-specific ARARs.	This alternative will be designed and implemented to comply with applicable location-specific ARARs.	This alternative will be designed and implemented to comply with applicable location-specific ARARs.
Action Specific	Action specific ARARs do not apply for this alternative.	This alternative will be designed and implemented to comply with applicable action-specific ARARs.	This alternative will be designed and implemented to comply with applicable action-specific ARARs.	This alternative will be designed and implemented to comply with applicable action-specific ARARs.	This alternative will be designed and implemented to comply with applicable action-specific ARARs.
LONG-TERM EFFECTIVENESS AND PERMANENCE					
Magnitude of Residual Risk	Potential future exposure to contaminants in soil will continue to pose a potential residual risk.	Hydraulic containment of impacted groundwater will significantly reduce residual risk; however, the impacted soil will remain (beneath the containment barrier), providing the potential for future leaching into groundwater over time. Therefore, residual risk is **relatively high,** compared to FDDA-3 through FDDA-5.	Hydraulic containment of impacted groundwater will significantly reduce residual risk. In addition, removal of the impacted soil through excavation will significantly reduce any residual risk associated with the impacted soil. Therefore, residual risk is **low** compared to FDDA-1 and FDDA-2 and comparable to FDDA-5.	Removal of the impacted soil through excavation will significantly reduce any residual risk associated with the impacted soil. A phased groundwater remedial action will further reduce residual risk over time. Therefore, residual risk is low to moderate compared to the other alternatives.	Similar to FDDA-3.
Adequacy and Reliability of Controls	No controls proposed.	Institutional controls should effectively limit human exposure to impacted soil and groundwater. Monitoring of the extraction system's effectiveness in hydraulically containing the plume will be required to determine the reliability of the groundwater component of this alternative and routine monitoring that the containment barrier is intact will be required to determine the reliability of the soil component of this alternative.	Excavation of impacted soil will provide long-term effectiveness and permanence since the material will be removed. Institutional controls should effectively limit human exposure to impacted groundwater until groundwater RAOs are achieved. Monitoring of the extraction system's effectiveness in hydraulically containing the plume will be required to determine the reliability of the groundwater component of this alternative.	Excavation of impacted soil will provide long-term effectiveness and permanence since the material will be removed. Institutional controls should effectively limit human exposure to impacted groundwater until groundwater RAOs are achieved through natural attenuation with or without enhancements. Monitoring will be required to determine the reliability of the groundwater component of this alternative.	Similar to FDDA-3.
REDUCTION OF TOXICITY, MOBILITY AND VOLUME THROUGH TREATMENT					
Treatment Process Used and Materials Treated	No active treatment is proposed for this alternative.	Materials treated within groundwater include VOCs, SVOCs and metals via a combination of technologies such as air stripping, advanced oxidation processes and/or metals treatment, in addition to one or more pretreatment steps (to be determined during remedial design phase).	Treatment of the excavated soil may or may not be required prior to disposal; depending on the waste characterization sampling results. Materials treated within groundwater include VOCs, SVOCs and metals via a combination of technologies such as air stripping, advanced oxidation processes and/or metals treatment, in addition to one or more pretreatment steps (to be determined during remedial design phase).	Treatment of the excavated soil may or may not be required prior to disposal; depending on the waste characterization sampling results. Natural attenuation processes, including biodegradation, dispersion, dilution, adsorption, volatilization and/or chemical and biological stabilization or destruction of contaminants, will address impacted groundwater (VOCs, SVOCs and metals). Following the phased approach, this alternative may also include MNA enhancements, other in-situ treatment components, or groundwater extraction and treatment. If implemented, the in-situ or ex-situ treatment system will treat groundwater via a combination of technologies such as air stripping, advanced oxidation processes and/or metals treatment, in addition to one or more pretreatment steps (to be determined during design phase).	Same as FDDA-3.

TABLE 9-2
COMPARATIVE ANALYSIS FOR THE FORMER DRUM DISPOSAL AREA REMEDIAL ALTERNATIVES
Remedial Investigation and Feasibility Study
Sutton Brook Disposal Area Superfund Site - Tewksbury, MA

EVALUATION CRITERIA	FDDA-1	FDDA-2	FDDA-3	FDDA-4	FDDA-5
Amount Destroyed or Treated	None	No soil will be treated, but an estimated total extraction rate of 20 gpm of groundwater will be treated through the groundwater extraction and ex-situ treatment system. Current dissolved concentrations indicate an estimated 1,600 to 2,000 lbs of VOCs in FDDA groundwater available for treatment. With the soil remaining in-situ, the potential exists for future leaching of additional contaminants from soil to groundwater.	Treatment of a portion of the excavated soil may be required prior to disposal; however, the volume or concentrations will be dependent on waste characterization analysis. An estimated total extraction rate of 24 gpm of groundwater will be treated through the groundwater extraction and ex-situ treatment system. Current dissolved concentrations indicate an estimated 1,600 to 2,000 lbs of VOCs in FDDA groundwater available for treatment.	Treatment of a portion of the excavated soil may be required prior to disposal; however, the volume or concentrations will be dependent on waste characterization analysis. Current dissolved concentrations indicate an estimated 1,600 to 2,000 lbs of VOCs in FDDA groundwater. Natural attenuation processes with or without enhancements will address the dissolved plume. Following the phased groundwater approach, and in-situ treatment system or a groundwater extraction and ex-situ treatment system may be implemented (estimated total extraction rate of 15 gpm of groundwater).	Similar to FDDA-3, but with an anticipated extraction rate of 50 gpm.
Degree of Expected Reductions in Toxicity, Mobility or Volume through Treatment	No active treatment is proposed for this alternative, therefore, no reduction in toxicity, mobility or volume through treatment will be achieved with this alternative.	Compared to other alternatives evaluated for the FDDA, this alternative provides a **low** level of reduction in toxicity and volume of contaminants and a high level of reduction in mobility of contaminants.	Compared to other alternatives evaluated for the FDDA, this alternative provides a **moderate** level of reduction in toxicity, mobility and volume of contaminants through groundwater (and potentially soil) treatment.	Compared to other alternatives evaluated for the FDDA, this alternative provides a **lower** level of reduction in toxicity, mobility and volume of contaminants through groundwater (and potentially soil) treatment.	Compared to other alternatives evaluated for the FDDA, this alternative provides a **moderate to high** level of reduction in toxicity, mobility and volume of contaminants through groundwater (and potentially soil) treatment.
Degree to which Treatment is Irreversible	No treatment is proposed.	No soil will be actively treated. The groundwater treatment will be permanent.	The groundwater and, if required, soil treatment will be permanent.	If required, the groundwater and soil treatment will be permanent.	Same as FDDA-3.
Type and Quantity of Residuals Remaining after Treatment	Existing conditions will remain since no treatment is proposed.	Treatment of the groundwater plume and any resulting VOC vapors will result in a low to moderate volume of treatment residuals that will require off-site treatment/disposal at a licensed facility.	Similar to FDDA-2.	Limited to no residuals remaining after treatment.	Slightly higher residuals than other alternatives evaluated.
Degree to Which Treatment Reduces Principal Threats	No treatment is proposed.	Principal threats of soil exposure and potential leaching from soil to groundwater are not addressed via treatment for this alternative; however, in conjunction with institutional controls and construction of the containment barrier, the treatment of contaminants in groundwater will control the principal threats/ exposure risks over time.	Principal threats of soil exposure and potential leaching from soil to groundwater are not addressed via treatment for this alternative; however, through excavation, institutional controls, groundwater extraction and treatment, the principal threats/ exposure risks will be controlled over time.	Through excavation, institutional controls, and natural attenuation process, the principal threats/exposure risks will be controlled over time.	Similar to FDDA-3.
SHORT-TERM EFFECTIVENESS					
Protection of Community During Remedial Action	Not applicable.	Construction activities are not anticipated to have significant short-term impacts on the local community; however, there may be a slight increase in vehicular traffic to the site during construction activities.	This alternative will not have significant short-term effects on the local community. Re-use/disposal of the material on-site is anticipated beneath the landfill final cover system; however, should off-site treatment be required, local truck/vehicular traffic may be increased during implementation.	Similar to FDDA-3 and FDDA-5.	Similar to FDDA-3 and FDDA-4.
Protection of Workers During Remedial Action	Not applicable.	Comparable to other alternatives; slightly reduced exposure risk during implementation since soil remains in-place.	Comparable to alternatives FDDA-4 and FDDA-5.	Comparable to alternatives FDDA-3 and FDDA-5.	Comparable to alternatives FDDA-3 and FDDA-4.
Environmental Impacts	Not applicable.	Impacts to the wetland resource areas are anticipated to be **moderate,** compared to other alternatives evaluated.	Impacts to the wetland resource areas are anticipated to be **moderate,** compared to other alternatives evaluated.	Impacts to the wetland resource areas are anticipated to be **low to moderate,** compared to other alternatives evaluated.	Impacts to the wetland resource areas are anticipated to be **moderate to high,** compared to other alternatives evaluated.
Time Until Remedial Action Objectives are Achieved	RAO's **will not be achieved** through this alternative.	30 to 134 years	24 to 89 years	36 to 103 years	23 to 85 years

TABLE 9-2
COMPARATIVE ANALYSIS FOR THE FORMER DRUM DISPOSAL AREA REMEDIAL ALTERNATIVES
Remedial Investigation and Feasibility Study
Sutton Brook Disposal Area Superfund Site - Tewksbury, MA

EVALUATION CRITERIA	FDDA-1	FDDA-2	FDDA-3	FDDA-4	FDDA-5
IMPLEMENTABILITY					
Ability to Construct and Operate the Technology	Not applicable.	Comparable to other alternatives; slightly higher difficulty in construction of the soil barrier due to the proximity of the resource area and in designing the barrier due to the potential future use of the FDDA as a Northern lobe stormwater management basin.	Comparable to other alternatives; slightly higher level of disruption and difficulty constructing the groundwater extraction system components within or immediately adjacent to the wetland resource areas.	Comparable to other alternatives; less disruption and difficulty constructing within or immediately adjacent to the wetland resource areas.	Comparable to alternative FDDA-3, with a slightly higher level of disruption due to the wetland resource areas.
Reliability of the Technology	Not applicable.	Reduced reliability than FDDA-3 through FDDA-5 since source material remains in place.	Comparable to FDDA-4 and FDDA-5; higher reliability than FDDA-1 and FDDA-2.	Comparable to FDDA-3 and FDDA-5; higher reliability than FDDA-1 and FDDA-2.	Comparable to FDDA-3 and FDDA-4; higher reliability than FDDA-1 and FDDA-2.
Ease of Undertaking Additional Remedial Actions, if necessary	This alternative will not limit or interfere with the ability to implement or perform future remedial actions	Utilizing the area as a stormwater management basin for the Northern lobe final cover system and leaving the soil in place will present difficulty in undertaking additional remedial actions due to access restrictions.	This alternative would not limit or interfere with the ability to implement or perform future remedial actions same as FDDA-4 and FDDA-5.	Same as FDDA- 3 and FDDA-5.	Same as FDDA-3 and FDDA-4.
Ability to Monitor Effectiveness of Remedy	Not applicable.	Groundwater monitoring to demonstrate contaminant reduction is easily implementable. Treatment system effluent will be monitored on a routine basis to evaluate the effectiveness of the treatment system and document that discharge requirements are being met. Routine inspection of the containment barrier is easily implementable as well.	Confirmatory soil sampling and analysis is easily implementable to measure the effectiveness of the soil component of this alternative. Groundwater monitoring to demonstrate contaminant reduction is easily implementable. Treatment system effluent will be monitored on a routine basis to evaluate the effectiveness of the treatment system and document that discharge requirements are being met.	Confirmatory soil sampling and analysis is easily implementable to measure the effectiveness of the soil component of this alternative. Groundwater monitoring to demonstrate contaminant reduction is easily implementable.	Same as FDDA-3.
Ability to Obtain Approvals and Coordinate with Other Agencies	Not applicable.	The remedial action will be designed and implemented under coordination with appropriate Federal and State agencies.	Same as FDDA-2, FDDA-4 and FDDA-5.	Same as FDDA-2, FDDA-3 and FDDA-5.	Same as FDDA-2 through FDDA-4.
Availability of off-site Treatment, Storage and Disposal Services and Capacity	Not applicable.	No off-site treatment, storage or disposal services required for the soil component of the alternative. Discharge of the treated groundwater will be to surface water or the local POTW.	Facilities are available to treat or dispose of the excavated material within the northeast. However, it is assumed that excavated soil will be reused on-site at one of the landfill lobes beneath the final cover system. Discharge of the treated groundwater will be to surface water or the local POTW.	Facilities are available to treat or dispose of the excavated material within the northeast. However, it is assumed that excavated soil will be reused on-site at one of the landfill lobes beneath the final cover system. If groundwater extraction and ex-situ treatment is implemented (through phased approach), discharge of the treated groundwater will be to surface water or the local POTW.	Same as FDDA-3.
Availability of Necessary Equipment and Specialists	No equipment or specialists required for this alternative.	Equipment, materials and services for this alternative are readily available.	Same as FDDA-2, FDDA-4 and FDDA-5.	Same as FDDA-2, FDDA-3 and FDDA-5.	Same as FDDA-2 through FDDA-4.
Availability of Technology	Not applicable since no remedial technologies will be used.	Qualified engineers and contractors are available to design and implement this alternative.	Same as FDDA-2, FDDA-4 and FDDA-5.	Same as FDDA-2, FDDA-3 and FDDA-5.	Same as FDDA-2 through FDDA-4.
COSTS - *net present value (7%) - 30 years*					
Capital Costs	$0	$3,100,000	$3,400,000	$1,000,000	$4,500,000
Annual Operation, Maintenance and Monitoring	$41,000	$4,300,000 to $5,100,000	$4,100,000 to $5,700,000	$1,700,000	$5,300,000 to $7,700,000
Periodic Costs	$43,000	$130,000	$120,000	$110,000	$130,000
TOTAL	$84,000	$7,530,000 to $8,330,000	$7,620,000 to $9,220,000	$2,810,000	$9,930,000 to $12,330,000

TABLE 9-3
COMPARATIVE ANALYSIS FOR THE GARAGE AND STORAGE AREA REMEDIAL ALTERNATIVES
Remedial Investigation and Feasibility Study
Sutton Brook Disposal Area Superfund Site - Tewksbury, MA

EVALUATION CRITERIA	GSA-1	GSA-2
OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT		
Human Health Protection	The potential future risks will remain and RAOs will not be achieved.	The potential future risks will be eliminated and RAOs will be achieved.
Ecological Protection	The current and potential future risks will remain and RAOs will **not** be achieved.	The current and potential future risks will be eliminated and RAOs will be achieved.
COMPLIANCE WITH ARARs		
Chemical Specific	Chemical specific ARARs will **not** be met for this alternative.	This alternative will be designed and implemented to comply with the chemical specific ARARs.
Location Specific	Location specific ARARs do not apply for this alternative.	This alternative will be designed and implemented to comply with applicable location-specific ARARs.
Action Specific	Action specific ARARs do not apply for this alternative.	This alternative will be designed and implemented to comply with applicable action-specific ARARs.
LONG-TERM EFFECTIVENESS AND PERMANENCE		
Magnitude of Residual Risk	Current and potential future exposure to contaminants in soil will continue to pose a potential residual risk.	Residual risks will be significantly reduced.
Adequacy and Reliability of Controls	No controls are proposed for this alternative.	Alternative will provide long-term effectiveness and permanence.
REDUCTION OF TOXICITY, MOBILITY AND VOLUME THROUGH TREATMENT		
Treatment Process Used and Materials Treated	No active treatment is proposed for this alternative.	Treatment of impacted soil is not anticipated; however, if required, ex-situ treatment of the material will be implemented.
Amount Destroyed or Treated	None	No treatment is anticipated with this alternative; however, if required, concentrations will be reduced to allow for reuse and disposal on-site beneath the landfill final cover system.
Degree of Expected Reductions in Toxicity, Mobility or Volume through Treatment	No reduction in toxicity, mobility or volume through treatment will be achieved with this alternative.	No active treatment of the excavated material is anticipated for this alternative; however, through re-use/disposal of the material beneath the landfill final cover system, the toxicity, mobility and volume of impacted material in the GSA is significantly reduced.
Degree to which Treatment is Irreversible	No treatment is proposed.	No treatment is anticipated.

TABLE 9-3
COMPARATIVE ANALYSIS FOR THE GARAGE AND STORAGE AREA REMEDIAL ALTERNATIVES
Remedial Investigation and Feasibility Study
Sutton Brook Disposal Area Superfund Site - Tewksbury, MA

EVALUATION CRITERIA	GSA-1	GSA-2
Type and Quantity of Residuals Remaining after Treatment	Existing conditions will remain since no treatment or removal is proposed.	No active treatment of the excavated material is anticipated for this alternative; however, through excavation of the impacted material, no residuals presenting exposure risks will remain.
Degree to Which Treatment Reduces Principal Threats	No treatment is proposed.	No active treatment of the excavated material is anticipated for this alternative; however, through excavation of the impacted material, the principal threats will be eliminated.
SHORT-TERM EFFECTIVENESS		
Protection of Community During Remedial Action	Not applicable	This alternative will not have significant short-term effects on the local community.
Protection of Workers During Remedial Action	Not applicable	Use of appropriate engineering controls, PPE, and training will be incorporated into the alternative design to protect workers.
Environmental Impacts	Not applicable	Limited environmental impacts are anticipated.
Time Until Remedial Action Objectives are Achieved	RAO's will **not** be achieved through this alternative.	1 to 2 years
IMPLEMENTABILITY		
Ability to Construct and Operate the Technology	Not applicable	Common technique, straight forward to implement.
Reliability of the Technology	Not applicable	Reliable technology to quickly and effectively eliminate exposure risks.
Ease of Undertaking Additional Remedial Actions, if necessary	This alternative will not limit or interfere with the ability to implement or perform future remedial actions.	This alternative will not limit or interfere with the ability to implement or perform future remedial actions.
Ability to Monitor Effectiveness of Remedy	Not applicable	Confirmatory soil sampling and analysis is easily implementable to measure the effectiveness of the remedy.
Ability to Obtain Approvals and Coordinate with Other Agencies	Not applicable	The remedial action will be designed and implemented under coordination with appropriate Federal and State agencies.

TABLE 9-3
COMPARATIVE ANALYSIS FOR THE GARAGE AND STORAGE AREA REMEDIAL ALTERNATIVES
Remedial Investigation and Feasibility Study
Sutton Brook Disposal Area Superfund Site - Tewksbury, MA

EVALUATION CRITERIA	GSA-1	GSA-2
Availability of off-site Treatment, Storage and Disposal Services and Capacity	Not applicable	Excavated soil can be reused/disposed of on-site at one of the landfill lobes beneath the final cover system.
Availability of Necessary Equipment and Specialists	No equipment or specialists required for this alternative.	Equipment, materials and services for this alternative are readily available.
Availability of Technology	Not applicable	Qualified engineers and contractors are readily available to design and implement this alternative.
COSTS - *net present value (7%) - 30 years*		
Capital Costs	$0	$184,000
Annual Operation, Maintenance and Monitoring	$40,000	$0
Periodic Costs	$10,000	$16,000
TOTAL	**$50,000**	**$200,000**

TABLE 9-4
COMPARATIVE ANALYSIS FOR DOWNGRADIENT GROUNDWATER REMEDIAL ALTERNATIVES
Remedial Investigation and Feasibility Study
Sutton Brook Disposal Area Superfund Site - Tewksbury, MA

EVALUATION CRITERIA	DGGW-1	DGGW-2	DGGW-3	DGGW-4
OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT				
Human Health Protection	The potential future risk of potable groundwater use **will remain** and RAOs will not be achieved.	Until the RAOs are achieved, institutional controls will be in place to prevent groundwater use/exposure, controlling human risks.	Until the RAOs are achieved, institutional controls will be in place to prevent groundwater use/exposure, controlling human risks.	Until the RAOs are achieved, institutional controls will be in place to prevent groundwater use/exposure, controlling human risks.
Ecological Protection	Not applicable	Not applicable	Not applicable	Not applicable
COMPLIANCE WITH ARARs				
Chemical Specific	Chemical specific ARARs **will not** be met.	This alternative will meet the RAOs and therefore comply with the chemical specific ARARs.	This alternative will meet the RAOs and therefore comply with the chemical specific ARARs.	This alternative will meet the RAOs and therefore comply with the chemical specific ARARs.
Location Specific	Location specific ARARs do not apply for this alternative.	This alternative can be designed and implemented to comply with applicable location specific ARARs; this alternative requires the **least** amount of **disruption** to the resource areas and ecological receptors during implementation.	This alternative can be designed and implemented to comply with applicable location specific ARARs; this alternative requires a **moderate to high** level of **disruption** to the resource areas and ecological receptors during construction.	This alternative can be designed and implemented to comply with applicable location specific ARARs; this alternative requires the **highest** level of **disruption** to the resource areas and ecological receptors during construction.
Action Specific	Action specific ARARs do not apply for this alternative.	This alternative can be implemented to comply with applicable action-specific ARARs.	This alternative can be implemented to comply with applicable action-specific ARARs.	This alternative can be implemented to comply with applicable action-specific ARARs.
LONG-TERM EFFECTIVENESS AND PERMANENCE				
Magnitude of Residual Risk	Potential future exposure to contaminants in groundwater **will continue** to pose a residual risk.	Until the achievement of site RAOs, implementation of institutional controls will reduce potential use and exposure to impacted groundwater; therefore residual risk is low.	Comparable to DGGW-2 and DGGW-4.	Comparable to DGGW-2 and DGGW-3.
Adequacy and Reliability of Controls	No controls are proposed.	Institutional controls should effectively limit human exposure to impacted groundwater until RAOs are achieved. Monitoring of groundwater will be required to measure the reliability of the alternative.	Institutional controls should effectively limit human exposure to impacted groundwater until RAOs are achieved. Monitoring of the extraction system's effectiveness will be required to measure the reliability of the alternative. Extraction and treatment system components will require maintenance, upkeep and potentially replacement overtime to ensure reliability over time.	Same as DGGW-3.
REDUCTION OF TOXICITY, MOBILITY AND VOLUME THROUGH TREATMENT				
Treatment Process Used and Materials Treated	No active treatment is proposed for this alternative.	Natural attenuation processes with or without enhancements, including biodegradation, dispersion, dilution, adsorption, volatilization and/or chemical and biological stabilization or destruction of contaminants, will address impacted groundwater.	A combination of ex-situ technologies such as air stripping, advanced oxidation processes and/or metals treatment, in addition to one or more pretreatment steps will treat impacted groundwater (to be determined during remedial design phase).	Same as DGGW-3.
Amount Destroyed or Treated	No active treatment is proposed for this alternative.	Natural attenuation processes are anticipated to reduce contaminants over time.	An estimated 75 gpm of groundwater will be treated through the treatment system.	Comparable to DGGW-3 (except at estimated 140 gpm).
Degree of Expected Reductions in Toxicity, Mobility or Volume through Treatment	No reduction in toxicity, mobility or volume through treatment will be achieved with this alternative.	The degree that this alternative will reduce the toxicity, mobility, and volume of COCs through natural attenuation is moderate compared to other alternatives.	Provides a high degree of reduction in toxicity and mobility and moderate degree in volume reduction.	Provides a high level of reduction in toxicity, mobility or volume through treatment.
Degree to which Treatment is Irreversible	No active treatment is proposed.	Natural degradation processes with or without enhancements will be permanent.	Ex-situ groundwater treatment will be permanent.	Ex-situ groundwater treatment will be permanent.

TABLE 9-4
COMPARATIVE ANALYSIS FOR DOWNGRADIENT GROUNDWATER REMEDIAL ALTERNATIVES
Remedial Investigation and Feasibility Study
Sutton Brook Disposal Area Superfund Site - Tewksbury, MA

EVALUATION CRITERIA	DGGW-1	DGGW-2	DGGW-3	DGGW-4
Type and Quantity of Residuals Remaining after Treatment	No active treatment is proposed.	No ex-situ residuals.	Low to moderate volume of treatment residuals (e.g., sludge from metals treatment) anticipated to be generated, requiring off-site disposal.	Moderate to high volume of treatment residuals (e.g., sludge from metals treatment) anticipated to be generated, requiring off-site disposal.
Degree to Which Treatment Reduces Principal Threats	No active treatment is proposed.	Upon achieving RAOs, the potential human risks to downgradient groundwater will be eliminated.	Upon treatment of contaminants in groundwater, the potential human risks to downgradient groundwater will be eliminated.	Upon treatment of contaminants in groundwater, the potential human risks to downgradient groundwater will be eliminated.
SHORT-TERM EFFECTIVENESS				
Protection of Community During Remedial Action	Not applicable since no remedial actions are included in this alternative.	No impacts to the community are anticipated for this alternative.	No significant short-term impacts to the local community are anticipated for this alternative; however, there may be a slight increase in vehicular traffic to the site during construction activities.	Similar to DGGW-3.
Protection of Workers During Remedial Action	Not applicable.	Work will be performed in accordance with applicable OSHA standards. Site-specific health and safety plan(s) will be developed to protect site workers.	Similar to DGGW-2 and DGGW-4	Similar to DGGW-2 and DGGW-3.
Environmental Impacts	Not applicable.	Impacts to the wetland resource areas are anticipated to be **limited** during activities.	Impacts to the wetland resource areas are anticipated to be **moderate to high** during construction activities due to the location of the extraction wells within the resource area.	Impacts to the wetland resource areas is anticipated to be **high** during construction activities due to the location of the extraction wells within the resource area.
Time Until Remedial Action Objectives are Achieved	RAOs will not be achieved through this alternative.	With Source Control - 67 to 79 years Without Source Control - 81 to 98 years	With Source Control - 57 to 68 years Without Source Control - 70 to 86 years	With Source Control - 40 to 49 years Without Source Control - 53 to 66 years
IMPLEMENTABILITY				
Ability to Construct and Operate the Technology	Not applicable.	No construction activities are planned for this alternative other than installation of additional monitoring wells; monitoring activities are easily implementable. If enhancements are deemed necessary, they will also be moderately implementable.	Construction in wetland resource areas will have moderate implementability.	Extensive construction in wetland resource areas may be difficult to implement.
Reliability of the Technology	Not applicable.	Site characterization data indicate that natural attenuation processes are effectively and reliably degrading contaminants.	Groundwater extraction is a demonstrated and reliable method for capturing and collecting impacted groundwater. In addition, the ex-situ treatment components are effective in treating groundwater to the remedial goals.	Similar to DGGW-3.
Ease of Undertaking Additional Remedial Actions, if necessary	This alternative will not limit or interfere with the ability to implement or perform future remedial actions.	Similar to other DGGW alternatives evaluated.	Similar to other DGGW alternatives evaluated.	Similar to other DGGW alternatives evaluated.
Ability to Monitor Effectiveness of Remedy	Not applicable.	Groundwater sampling and analysis to evaluate contaminant levels is easily implementable.	Groundwater monitoring to demonstrate hydraulic containment and to determine contaminant levels is easily implementable. Treatment system effluent will be monitored on a routine basis to evaluate the effectiveness of the treatment system and document that discharge requirements are being met.	Same as DGGW-3.

TABLE 9-4
COMPARATIVE ANALYSIS FOR DOWNGRADIENT GROUNDWATER REMEDIAL ALTERNATIVES
Remedial Investigation and Feasibility Study
Sutton Brook Disposal Area Superfund Site - Tewksbury, MA

EVALUATION CRITERIA	DGGW-1	DGGW-2	DGGW-3	DGGW-4
Ability to Obtain Approvals and Coordinate with Other Agencies	Not applicable since no remedial actions are included in this alternative; therefore, no approvals or coordination required.	The remedial action will be designed and implemented under coordination with appropriate Federal and State agencies.	Similar to DGGW-2 and DGGW-4.	Similar to DGGW-2 and DGGW-3.
Availability of off-site Treatment, Storage and Disposal Services and Capacity	Not applicable.	Not applicable.	Discharge of the treated groundwater will be to surface water or the local POTW.	Discharge of the treated groundwater will be to surface water or the local POTW.
Availability of Necessary Equipment and Specialists	No equipment or specialists required for this alternative.	Equipment, materials and services for this alternative are readily available.	Similar to DGGW-2 and DGGW-4.	Similar to DGGW-2 and DGGW-3.
Availability of Technology	Not applicable since no remedial technologies will be used.	Qualified engineers and contractors are available to design and implement this alternative.	Similar to DGGW-2 and DGGW-4.	Similar to DGGW-2 and DGGW-3.
COSTS - *net present value (7%) - 30 years*				
Capital Costs	$0	$230,000	$2,900,000	$4,500,000
Annual Operation, Maintenance and Monitoring	$41,000	$1,400,000	$6,800,000 to $9,800,000	$6,500,000 to $12,200,000
Periodic Costs	$43,000	$120,000	$130,000	$130,000
TOTAL	$84,000	$1,750,000	$9,830,000 to $12,830,000	$11,130,000 to $16,830,000

DGGW-3 and DGGW-4 O&M cost range incorporates: 30 years of system operation with 30 years of groundwater monitoring - low: discharge to surface water, high: discharge to POTW

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APPENDIX A: RISK BASED CLEAN-UP GOALS SUPPORTING INFORMATION

Appendix A

Risk Based Clean-up Goals Supporting Information

As presented in Section 3 of this document, risk based clean-up goals (RBCGs) (non-cancer and cancer [10^{-5} and 10^{-6}]) for each media and for each receptor group were calculated as part of the Preliminary Remediation Goal development process.

The back-up calculations/derivations (toxicity values, exposure factors for each relevant receptor, exposure route and chemical, etc.) for the human health RBCGs for each receptor group are provided in the following tables. For ease of presentation, the 10^{-5} based RBCGs are not presented on these RBCG "back-up" tables.

TABLE A-1
Derivation of Risk-Based Cleanup Goals for Upland Soil Exposures
Reasonable Maximum Exposures (RME)

$RBCG_{nc}$ = HI / [(ExFo/RfDo) + (ExFd * ABSd/RfDd)]

$RBCG_{c}$ = ILCR / [ExFo*CSFo) + (ExFd * ABSd * CSFd)]

Where:

Parameter	Definition	Units
RBCG =	Risk-based cleanup goal	mg/kg
HI =	Target Hazard Index	Unitless
ILCR =	Target Incremental Lifetime Cancer Risk	Unitless
ExFo =	Exposure Factor-incidental ingestion of upland soil (see Appendix A-5)	1/d
ExFd =	Exposure Factor-dermal contact with upland soil (see Appendix A-5)	1/d
ABSd =	Dermal Absorption Adjustment Fraction (see Appendix A-12)	Unitless
RfDo =	Oral Reference Dose (Appendix A-13)	mg/kg-d
RfDd =	Dermal Reference Dose (Appendix A-13)	mg/kg-d
CSFo =	Oral Cancer Slope Factor (Appendix A-13)	$(mg/kg\text{-}d)^{-1}$
CSFd =	Dermal Cancer Slope Factor (Appendix A-13)	$(mg/kg\text{-}d)^{-1}$

RESIDENTIAL RBCGs

	Noncancer Effects							Cancer Effects							
Chemical of Potential Concern	HI	ExFo	ExFd	ABSd	RfDo	RfDd	RBCGnc	ILCR	ExFo	ExFd	ABSd	CSFo	CSFd	RBCGc	**Final RBCG**
Arsenic	1	5.48E-06	1.53E-05	3.00E-02	3.00E-04	3.00E-04	5.05E+01	1.00E-06	6.71E-07	2.12E-06	3.00E-02	1.50E+00	1.50E+00	9.08E-01	**9.08E-01**
Benzo(a)pyrene	1	5.48E-06	1.53E-05	1.30E-01	--	--	--	1.00E-06			*			4.37E-02	**4.37E-02**
Benzo(a)anthracene	1	5.48E-06	1.53E-05	1.30E-01	--	--	--	1.00E-06			*			4.37E-01	**4.37E-01**
Benzo(b)fluoranthene	1	5.48E-06	1.53E-05	1.30E-01	--	--	--	1.00E-06			*			4.37E-01	**4.37E-01**
Benzo(k)fluoranthene	1	5.48E-06	1.53E-05	1.30E-01	--	--	--	1.00E-06			*			4.37E+00	**4.37E+00**
Bis(2-ethylhexyl)phthalate	1	5.48E-06	1.53E-05	1.00E-01	2.00E-02	2.00E-02	2.85E+03	1.00E-06	6.71E-07	2.12E-06	1.00E-01	1.40E-02	1.40E-02	8.09E+01	**8.09E+01**
Dibenzo(a,h)anthracene	1	5.48E-06	1.53E-05	1.30E-01	--	--	--	1.00E-06			*			4.37E-02	**4.37E-02**
Indeno(1,2,3-cd)pyrene	1	5.48E-06	1.53E-05	1.30E-01	--	--	--	1.00E-06			*			4.37E-01	**4.37E-01**
Tetrachloroethene	1	5.48E-06	1.53E-05	0.00E+00	1.00E-02	1.00E-02	1.83E+03	1.00E-06	6.71E-07	2.12E-06	0.00E+00	5.40E-01	5.40E-01	2.76E+00	**2.76E+00**

Notes:
-- = No toxicity information available; thus, no RBCG derived for this effect.
*Risk-based cleanup goals for the carcinogenic PAHs, which include age-dependent adjustment factors, are derived in Appendix A-11 for the residential and recreational receptors.

TABLE A-2
Derivation of Risk-Based Cleanup Goals for Groundwater Exposures
Reasonable Maximum Exposures (RME)

$RBCG_{nc}$ = HI / [(ExFo/RfDo) + (ExFd * DA_{ev}/RfDd) + (ExFi/RfC)]

$RBCG_{c}$ = ILCR / [ExFo*CSFo) + (ExFd * DA_{ev} * CSFd) + (ExFi * IUR)]

Where:

Parameter	Definition	Units
RBCG =	Risk-based cleanup goal	mg/L
HI =	Target Hazard Index	Unitless
ILCR =	Target Incremental Lifetime Cancer Risk	Unitless
ExFo =	Exposure Factor- ingestion of potable groundwater (see Table A-8)	L/kg-d
ExFd =	Exposure Factor-dermal contact with potable groundwater (see Appendix A-8)	ev-cm^2/kg-d
ExFi =	Exposure Factor-inhalation of volatiles in shower air (see Appendix A-9)	(mg/m3)/(mg/l)
DA_{ev}	Aqueous Dermal Absorption Fraction (per event) (see Appendix A-10)	L/cm^2-ev
RfDo =	Oral Reference Dose (Appendix A-13)	mg/kg-d
RfDd =	Dermal Reference Dose (Appendix A-13)	mg/kg-d
RfC =	Inhalation Reference Concentration (Appendix A-13)	mg/m^3
CSFo =	Oral Cancer Slope Factor (Appendix A-13)	(mg/kg-d)$^{-1}$
CSFd =	Dermal Cancer Slope Factor (Appendix A-13)	(mg/kg-d)$^{-1}$
IUR =	Inhalation Unit Risk (Appendix A-13)	(mg/m3)$^{-1}$

RESIDENTIAL SCENARIO					Noncancer Effects									Cancer Effects					
Chemical of Potential Concern	HI	ExFo	ExFd	ExFi	DA_{ev}	RfDo	RfDd	RfC	RBCGnc	ILCR	ExFo	ExFd	ExFi	DA_{ev}	CSFo	CSFd	IUR	RBCGc
Inorganics									(mg/L)									(mg/L)
Antimony	1	8.31E-02	4.22E+02	--	1.00E-06	4.00E-04	6.00E-05	--	**4.66E-03**	1.00E-06	1.64E-02	1.21E+02	--	5.80E-07	--	--	--	--
Arsenic	1	8.31E-02	4.22E+02	--	1.00E-06	3.00E-04	3.00E-04	3.00E-05	**3.59E-03**	1.00E-06	1.64E-02	1.21E+02	--	5.80E-07	1.50E+00	1.50E+00	4.30E+00	**4.05E-05**
Beryllium	1	8.31E-02	4.22E+02	--	1.00E-06	2.00E-03	1.40E-05	2.00E-05	**1.39E-02**	1.00E-06	1.64E-02	1.21E+02	--	5.80E-07	--	--	2.40E+00	--
Cadmium	1	8.31E-02	4.22E+02	--	1.00E-06	5.00E-04	2.50E-05	--	**5.46E-03**	1.00E-06	1.64E-02	1.21E+02	--	5.80E-07	--	--	1.80E+00	--
Chromium	1	8.31E-02	4.22E+02	--	2.00E-06	3.00E-03	7.50E-05	1.00E-04	**2.57E-02**	1.00E-06	1.64E-02	1.21E+02	--	1.16E-06	--	--	1.20E+01	--
Manganese	1	8.31E-02	4.22E+02	--	1.00E-06	4.67E-02	1.87E-03	5.00E-05	**4.99E-01**	1.00E-06	1.64E-02	1.21E+02	--	5.80E-07	--	--	--	--
Silver	1	8.31E-02	4.22E+02	--	6.00E-07	5.00E-03	2.00E-04	--	**5.59E-02**	1.00E-06	1.64E-02	1.21E+02	--	3.48E-07	--	--	--	--
Thallium	1	8.31E-02	4.22E+02	--	1.00E-06	8.00E-05	8.00E-05	--	**9.58E-04**	1.00E-06	1.64E-02	1.21E+02	--	5.80E-07	--	--	--	--
Zinc	1	8.31E-02	4.22E+02	--	6.00E-07	3.00E-01	3.00E-01	--	**3.60E+00**	1.00E-06	1.64E-02	1.21E+02	--	3.48E-07	--	--	--	--
Organics																		
1,4-Dichlorobenzene	1	8.31E-02	4.22E+02	9.64E-01	9.78E-05	9.00E-02	9.00E-02	8.00E-01	**3.87E-01**	1.00E-06	1.64E-02	1.21E+02	2.68E-01	7.45E-05	2.40E-02	2.40E-02	--	**1.64E-03**
1,1,2-Trichloroethane	1	8.31E-02	4.22E+02	8.94E-01	1.37E-05	4.00E-03	4.00E-03	1.40E-02	**1.16E-02**	1.00E-06	1.64E-02	1.21E+02	2.48E-01	1.04E-05	5.70E-02	5.70E-02	1.60E-02	**2.01E-04**
1,1-Dichloroethane	1	8.31E-02	4.22E+02	1.17E+00	1.14E-05	2.00E-01	2.00E-01	5.00E-01	**3.60E-01**	1.00E-06	1.64E-02	1.21E+02	3.25E-01	8.70E-06	--	--	--	--
1,2-Dichloroethane	1	8.31E-02	4.22E+02	1.02E+00	7.16E-06	2.00E-01	2.00E-01	2.43E+00	**1.18E+00**	1.00E-06	1.64E-02	1.21E+02	2.83E-01	5.45E-06	9.10E-02	9.10E-02	2.60E-02	**1.12E-04**
1,2-Dichloroethene	1	8.31E-02	4.22E+02	1.19E+00	1.29E-05	9.00E-03	9.00E-03	6.00E-02	**3.36E-02**	1.00E-06	1.64E-02	1.21E+02	3.32E-01	9.86E-06	--	--	--	--
1,2-Dichloropropane	1	8.31E-02	4.22E+02	1.08E+00	1.46E-05	--	--	4.00E-03	**3.71E-03**	1.00E-06	1.64E-02	1.21E+02	3.00E-01	1.11E-05	6.80E-02	6.80E-02	--	**8.29E-04**
1,4-Dioxane	1	8.31E-02	4.22E+02	3.25E-02	5.24E-07	1.00E-01	1.00E-01	3.00E+00	**1.18E+00**	1.00E-06	1.64E-02	1.21E+02	9.05E-03	3.99E-07	1.10E-02	1.10E-02	7.70E-03	**3.99E-03**
2-Butanone	1	8.31E-02	4.22E+02	1.79E-01	1.59E-06	6.00E-01	6.00E-01	5.00E+00	**5.70E+00**	1.00E-06	1.64E-02	1.21E+02	4.99E-02	1.21E-06	--	--	--	--
2-Methylphenol	1	8.31E-02	4.22E+02	7.32E-03	1.83E-05	5.00E-02	5.00E-02	1.75E-01	**5.38E-01**	1.00E-06	1.64E-02	1.21E+02	2.03E-03	1.39E-05	--	--	--	--
3-Methylphenol/4-Methylphenol	1	8.31E-02	4.22E+02	6.11E-03	1.45E-05	5.00E-02	5.00E-02	1.75E-02	**4.69E-01**	1.00E-06	1.64E-02	1.21E+02	1.70E-03	1.10E-05	--	--	--	--
4-Methyl-2-pentanone	1	8.31E-02	4.22E+02	5.12E-01	6.85E-06	8.00E-02	8.00E-02	3.00E+00	**8.03E-01**	1.00E-06	1.64E-02	1.21E+02	1.42E-01	5.22E-06	--	--	--	--
Acetone	1	8.31E-02	4.22E+02	2.67E-01	1.44E-06	9.00E-01	9.00E-01	3.15E+00	**5.62E+00**	1.00E-06	1.64E-02	1.21E+02	7.43E-02	1.09E-06	--	--	--	--
Alpha-BHC	1	8.31E-02	4.22E+02	--	4.42E-05	--	--	1.75E-03	--	1.00E-06	1.64E-02	1.21E+02	--	3.37E-05	6.30E+00	6.30E+00	1.80E+00	**7.76E-06**
Aroclor 1254	1	8.31E-02	4.22E+02	6.80E-01	0.00E+00	2.00E-05	2.00E-05	7.00E-05	**7.21E-05**	1.00E-06	1.64E-02	1.21E+02	1.89E-01	0.00E+00	4.00E-01	4.00E-01	1.00E-01	**3.93E-05**
Benzene	1	8.31E-02	4.22E+02	1.27E+00	2.23E-05	4.00E-03	4.00E-03	3.00E-02	**1.52E-02**	1.00E-06	1.64E-02	1.21E+02	3.54E-01	1.70E-05	5.50E-02	5.50E-02	7.80E-03	**2.65E-04**
Bis(2-ethylhexyl)phthalate	1	8.31E-02	4.22E+02	3.29E-04	2.17E-04	2.00E-02	2.00E-02	7.00E-02	**1.15E-01**	1.00E-06	1.64E-02	1.21E+02	9.15E-05	1.65E-04	1.40E-02	1.40E-02	2.40E-03	**1.97E-03**
Carbon tetrachloride	1	8.31E-02	4.22E+02	1.02E+00	3.91E-05	7.00E-04	7.00E-04	2.45E-03	**1.80E-03**	1.00E-06	1.64E-02	1.21E+02	2.82E-01	2.98E-05	1.30E-01	1.30E-01	1.50E-02	**1.46E-04**
Chloroform	1	8.31E-02	4.22E+02	1.07E+00	1.33E-05	1.00E-02	1.00E-02	3.00E-01	**8.03E-02**	1.00E-06	1.64E-02	1.21E+02	2.98E-01	1.01E-05	3.10E-02	3.10E-02	2.30E-02	**1.35E-04**
cis-1,2-Dichloroethene	1	8.31E-02	4.22E+02	1.16E+00	1.29E-05	1.00E-02	1.00E-02	6.00E-02	**3.54E-02**	1.00E-06	1.64E-02	1.21E+02	3.24E-01	9.86E-06	--	--	--	--
Ethylbenzene	1	8.31E-02	4.22E+02	1.15E+00	8.78E-05	1.00E-01	1.00E-01	1.00E+00	**4.25E-01**	1.00E-06	1.64E-02	1.21E+02	3.20E-01	6.69E-05	--	--	--	--
Methylene chloride	1	8.31E-02	4.22E+02	1.18E+00	5.47E-06	6.00E-02	6.00E-02	3.00E+00	**5.50E-01**	1.00E-06	1.64E-02	1.21E+02	3.28E-01	4.17E-06	7.50E-03	7.50E-03	4.70E-04	**3.56E-03**
Naphthalene	1	8.31E-02	4.22E+02	7.86E-01	9.72E-05	2.00E-02	2.00E-02	3.00E-03	**3.73E-03**	1.00E-06	1.64E-02	1.21E+02	2.18E-01	7.41E-05	--	--	--	--
N-Nitrosodi-n-butylamine	1	8.31E-02	4.22E+02	6.23E-01	9.51E-06	--	--	--	--	1.00E-06	1.64E-02	1.21E+02	1.73E-01	7.25E-06	5.40E+00	5.40E+00	1.60E+00	**2.70E-06**
N-Nitrosopyrrolidine	1	8.31E-02	4.22E+02	3.12E-04	9.46E-07	--	--	--	--	1.00E-06	1.64E-02	1.21E+02	8.67E-05	7.20E-07	2.10E+00	2.10E+00	6.10E-01	**2.88E-05**
n-Propylbenzene	1	8.31E-02	4.22E+02	2.68E+00	2.54E-04	--	--	1.40E-01	**5.23E-02**	1.00E-06	1.64E-02	1.21E+02	7.44E-01	1.94E-04	--	--	--	--
o-Toluidine	1	8.31E-02	4.22E+02	1.21E-02	5.38E-06	--	--	--	--	1.00E-06	1.64E-02	1.21E+02	3.36E-03	4.09E-06	2.40E-01	2.40E-01	--	**2.47E-04**
Phenol	1	8.31E-02	4.22E+02	2.61E-03	1.34E-05	3.00E-01	3.00E-01	2.00E-01	**3.24E+00**	1.00E-06	1.64E-02	1.21E+02	7.25E-04	1.02E-05	--	--	--	--
Pyridine	1	8.31E-02	4.22E+02	7.45E-02	5.03E-06	1.00E-03	1.00E-03	3.50E-03	**9.39E-03**	1.00E-06	1.64E-02	1.21E+02	2.07E-02	3.83E-06	--	--	--	--
Tetrachloroethene	1	8.31E-02	4.22E+02	9.82E-01	8.70E-05	1.00E-02	1.00E-02	3.50E-02	**2.50E-02**	1.00E-06	1.64E-02	1.21E+02	2.73E-01	6.63E-05	5.40E-01	5.40E-01	5.90E-03	**6.76E-05**
Tetrahydrofuran	1	8.31E-02	4.22E+02	1.33E+00	3.59E-06	--	--	3.01E-01	**2.27E-01**	1.00E-06	1.64E-02	1.21E+02	3.69E-01	2.74E-06	--	--	--	--
Toluene	1	8.31E-02	4.22E+02	1.21E+00	5.07E-05	8.00E-02	8.00E-02	5.00E+00	**6.46E-01**	1.00E-06	1.64E-02	1.21E+02	3.36E-01	3.86E-05	--	--	--	--
Trichloroethene	1	8.31E-02	4.22E+02	1.07E+00	2.53E-05	--	--	6.00E-01	**5.62E-01**	1.00E-06	1.64E-02	1.21E+02	2.97E-01	1.92E-05	4.00E-01	4.00E-01	2.00E-03	**1.24E-04**
Vinyl chloride	1	8.31E-02	4.22E+02	1.41E+00	7.58E-06	3.00E-03	3.00E-03	1.00E-01	**2.33E-02**	1.00E-06	1.64E-02	1.21E+02	3.91E-01	5.78E-06	1.50E+00	1.50E+00	8.80E-03	**3.44E-05**
Xylenes (total)	1	8.31E-02	4.22E+02	1.15E+00	1.26E-04	2.00E-01	2.00E-01	1.00E-01	**8.23E-02**	1.00E-06	1.64E-02	1.21E+02	3.19E-01	9.61E-05	--	--	--	--
Acrylonitrile	1	8.31E-02	4.22E+02	5.16E-01	1.52E-06	1.00E-03	1.00E-03	3.50E-03	**4.33E-03**	1.00E-06	1.64E-02	1.21E+02	1.43E-01	1.16E-06	5.40E-01	5.40E-01	6.80E-02	**5.35E-05**
Ethyl methacrylate	1	8.31E-02	4.22E+02	8.62E-01	2.53E-05	9.00E-02	9.00E-02	3.15E-01	**2.65E-01**	1.00E-06	1.64E-02	1.21E+02	2.40E-01	1.92E-05	--	--	--	--

TABLE A-2
Derivation of Risk-Based Cleanup Goals for Groundwater Exposures
Reasonable Maximum Exposures (RME)

$RBCG_{nc}$ = HI / [(ExFo/RfDo) + (ExFd * DA_{ev}/RfDd) + (ExFi/RfC)]

$RBCG_{c}$ = ILCR / [ExFo*CSFo) + (ExFd * DA_{ev} * CSFd) + (ExFi * IUR)]

Where:

Parameter	Definition	Units
RBCG =	Risk-based cleanup goal	mg/L
HI =	Target Hazard Index	Unitless
ILCR =	Target Incremental Lifetime Cancer Risk	Unitless
ExFo =	Exposure Factor- ingestion of potable groundwater (see Table A-8)	L/kg-d
ExFd =	Exposure Factor-dermal contact with potable groundwater (see Appendix A-8)	ev-cm^2/kg-d
ExFi =	Exposure Factor-inhalation of volatiles in shower air (see Appendix A-9)	(mg/m3)/(mg/l)
DA_{ev}	Aqueous Dermal Absorption Fraction (per event) (see Appendix A-10)	L/cm^2-ev
RfDo =	Oral Reference Dose (Appendix A-13)	mg/kg-d
RfDd =	Dermal Reference Dose (Appendix A-13)	mg/kg-d
RfC =	Inhalation Reference Concentration (Appendix A-13)	mg/m^3
CSFo =	Oral Cancer Slope Factor (Appendix A-13)	$(mg/kg\text{-}d)^{-1}$
CSFd =	Dermal Cancer Slope Factor (Appendix A-13)	$(mg/kg\text{-}d)^{-1}$
IUR =	Inhalation Unit Risk (Appendix A-13)	$(mg/m3)^{-1}$

FACILITY WORKER SCENARIO

	Noncancer Effects									Cancer Effects								
Chemical of Potential Concern	HI	ExFo	ExFd	ExFi	DA_{ev}	RfDo	RfDd	RfC	RBCGnc	ILCR	ExFo	ExFd	ExFi	DA_{ev}	CSFo	CSFd	IUR	RBCGc
Inorganics									(mg/L)									(mg/L)
Antimony	1	1.13E-02	3.25E+02	--	5.56E-09	4.00E-04	6.00E-05	--	**3.55E-02**	1.00E-06	4.02E-03	1.16E+02	--	5.80E-07	--	--	--	--
Arsenic	1	1.13E-02	3.25E+02	--	5.56E-09	3.00E-04	3.00E-04	3.00E-05	**2.67E-02**	1.00E-06	4.02E-03	1.16E+02	--	5.80E-07	1.50E+00	1.50E+00	4.30E+00	**1.63E-04**
Beryllium	1	1.13E-02	3.25E+02	--	5.56E-09	2.00E-03	1.40E-05	2.00E-05	**1.74E-01**	1.00E-06	4.02E-03	1.16E+02	--	5.80E-07	--	--	2.40E+00	--
Cadmium	1	1.13E-02	3.25E+02	--	5.56E-09	5.00E-04	2.50E-05	--	**4.43E-02**	1.00E-06	4.02E-03	1.16E+02	--	5.80E-07	--	--	1.80E+00	--
Chromium	1	1.13E-02	3.25E+02	--	1.11E-08	3.00E-03	7.50E-05	1.00E-04	**2.63E-01**	1.00E-06	4.02E-03	1.16E+02	--	1.16E-06	--	--	1.20E+01	--
Manganese	1	1.13E-02	3.25E+02	--	5.56E-09	4.67E-02	1.87E-03	5.00E-05	**4.13E+00**	1.00E-06	4.02E-03	1.16E+02	--	5.80E-07	--	--	--	--
Silver	1	1.13E-02	3.25E+02	--	3.33E-09	5.00E-03	2.00E-04	--	**4.43E-01**	1.00E-06	4.02E-03	1.16E+02	--	3.48E-07	--	--	--	--
Thallium	1	1.13E-02	3.25E+02	--	5.56E-09	8.00E-05	8.00E-05	--	**7.11E-03**	1.00E-06	4.02E-03	1.16E+02	--	5.80E-07	--	--	--	--
Zinc	1	1.13E-02	3.25E+02	--	3.33E-09	3.00E-01	3.00E-01	--	**2.67E+01**	1.00E-06	4.02E-03	1.16E+02	--	3.48E-07	--	--	--	--
Organics																		
1,4-Dichlorobenzene	1	1.13E-02	3.25E+02	--	7.29E-06	9.00E-02	9.00E-02	8.00E-01	**6.61E+00**	1.00E-06	4.02E-03	1.16E+02	--	7.45E-05	2.40E-02	2.40E-02	--	**3.29E-03**
1,1,2-Trichloroethane	1	1.13E-02	3.25E+02	--	1.02E-06	4.00E-03	4.00E-03	1.40E-02	**3.45E-01**	1.00E-06	4.02E-03	1.16E+02	--	1.04E-05	5.70E-02	5.70E-02	1.60E-02	**3.35E-03**
1,1-Dichloroethane	1	1.13E-02	3.25E+02	--	8.51E-07	2.00E-01	2.00E-01	5.00E-01	**1.73E+01**	1.00E-06	4.02E-03	1.16E+02	--	8.70E-06	--	--	--	--
1,2-Dichloroethane	1	1.13E-02	3.25E+02	--	5.34E-07	2.00E-01	2.00E-01	2.43E+00	**1.75E+01**	1.00E-06	4.02E-03	1.16E+02	--	5.45E-06	9.10E-02	9.10E-02	2.60E-02	**2.36E-03**
1,2-Dichloroethene	1	1.13E-02	3.25E+02	--	9.65E-07	9.00E-03	9.00E-03	6.00E-02	**7.78E-01**	1.00E-06	4.02E-03	1.16E+02	--	9.86E-06	--	--	--	--
1,2-Dichloropropane	1	1.13E-02	3.25E+02	--	1.09E-06	--	--	4.00E-03	--	1.00E-06	4.02E-03	1.16E+02	--	1.11E-05	6.80E-02	6.80E-02	--	**2.77E-03**
1,4-Dioxane	1	1.13E-02	3.25E+02	--	3.91E-08	1.00E-01	1.00E-01	3.00E+00	**8.88E+00**	1.00E-06	4.02E-03	1.16E+02	--	3.99E-07	1.10E-02	1.10E-02	7.70E-03	**2.24E-02**
2-Butanone	1	1.13E-02	3.25E+02	--	1.19E-07	6.00E-01	6.00E-01	5.00E+00	**5.31E+01**	1.00E-06	4.02E-03	1.16E+02	--	1.21E-06	--	--	--	--
2-Methylphenol	1	1.13E-02	3.25E+02	--	1.36E-06	5.00E-02	5.00E-02	1.75E-01	**4.27E+00**	1.00E-06	4.02E-03	1.16E+02	--	1.39E-05	--	--	--	--
3-Methylphenol/4-Methylphenol	1	1.13E-02	3.25E+02	--	1.08E-06	5.00E-02	5.00E-02	1.75E-02	**4.31E+00**	1.00E-06	4.02E-03	1.16E+02	--	1.10E-05	--	--	--	--
4-Methyl-2-pentanone	1	1.13E-02	3.25E+02	--	5.11E-07	8.00E-02	8.00E-02	3.00E+00	**7.01E+00**	1.00E-06	4.02E-03	1.16E+02	--	5.22E-06	--	--	--	--
Acetone	1	1.13E-02	3.25E+02	--	1.07E-07	9.00E-01	9.00E-01	3.15E+00	**7.97E+01**	1.00E-06	4.02E-03	1.16E+02	--	1.09E-06	--	--	--	--
Alpha-BHC	1	1.13E-02	3.25E+02	--	3.30E-06	--	--	1.75E-03	--	1.00E-06	4.02E-03	1.16E+02	--	3.37E-05	6.30E+00	6.30E+00	1.80E+00	**2.00E-05**
Aroclor 1254	1	1.13E-02	3.25E+02	--	0.00E+00	2.00E-05	2.00E-05	7.00E-05	**1.78E-03**	1.00E-06	4.02E-03	1.16E+02	--	0.00E+00	4.00E-01	4.00E-01	1.00E-01	**6.22E-04**
Benzene	1	1.13E-02	3.25E+02	--	1.66E-06	4.00E-03	4.00E-03	3.00E-02	**3.39E-01**	1.00E-06	4.02E-03	1.16E+02	--	1.70E-05	5.50E-02	5.50E-02	7.80E-03	**3.03E-03**
Bis(2-ethylhexyl)phthalate	1	1.13E-02	3.25E+02	--	1.61E-05	2.00E-02	2.00E-02	7.00E-02	**1.21E+00**	1.00E-06	4.02E-03	1.16E+02	--	1.65E-04	1.40E-02	1.40E-02	2.40E-03	**3.08E-03**
Carbon tetrachloride	1	1.13E-02	3.25E+02	--	2.91E-06	7.00E-04	7.00E-04	2.45E-03	**5.74E-02**	1.00E-06	4.02E-03	1.16E+02	--	2.98E-05	1.30E-01	1.30E-01	1.50E-02	**1.03E-03**
Chloroform	1	1.13E-02	3.25E+02	--	9.91E-07	1.00E-02	1.00E-02	3.00E-01	**8.64E-01**	1.00E-06	4.02E-03	1.16E+02	--	1.01E-05	3.10E-02	3.10E-02	2.30E-02	**6.21E-03**
cis-1,2-Dichloroethene	1	1.13E-02	3.25E+02	--	9.65E-07	1.00E-02	1.00E-02	6.00E-02	**8.65E-01**	1.00E-06	4.02E-03	1.16E+02	--	9.86E-06	--	--	--	--
Ethylbenzene	1	1.13E-02	3.25E+02	--	6.54E-06	1.00E-01	1.00E-01	1.00E+00	**7.47E+00**	1.00E-06	4.02E-03	1.16E+02	--	6.69E-05	--	--	--	--
Methylene chloride	1	1.13E-02	3.25E+02	--	4.08E-07	6.00E-02	6.00E-02	3.00E+00	**5.27E+00**	1.00E-06	4.02E-03	1.16E+02	--	4.17E-06	7.50E-03	7.50E-03	4.70E-04	**2.96E-02**
Naphthalene	1	1.13E-02	3.25E+02	--	7.25E-06	2.00E-02	2.00E-02	3.00E-03	**1.47E+00**	1.00E-06	4.02E-03	1.16E+02	--	7.41E-05	--	--	--	--
N-Nitrosodi-n-butylamine	1	1.13E-02	3.25E+02	--	7.09E-07	--	--	--	--	1.00E-06	4.02E-03	1.16E+02	--	7.25E-06	5.40E+00	5.40E+00	1.60E+00	**3.81E-05**
N-Nitrosopyrrolidine	1	1.13E-02	3.25E+02	--	7.05E-08	--	--	--	--	1.00E-06	4.02E-03	1.16E+02	--	7.20E-07	2.10E+00	2.10E+00	6.10E-01	**1.16E-04**
n-Propylbenzene	1	1.13E-02	3.25E+02	--	1.90E-05	--	--	1.40E-01	--	1.00E-06	4.02E-03	1.16E+02	--	1.94E-04	--	--	--	--
o-Toluidine	1	1.13E-02	3.25E+02	--	4.01E-07	--	--	--	--	1.00E-06	4.02E-03	1.16E+02	--	4.09E-06	2.40E-01	2.40E-01	--	**9.27E-04**
Phenol	1	1.13E-02	3.25E+02	--	1.00E-06	3.00E-01	3.00E-01	2.00E-01	**2.59E+01**	1.00E-06	4.02E-03	1.16E+02	--	1.02E-05	--	--	--	--
Pyridine	1	1.13E-02	3.25E+02	--	3.75E-07	1.00E-03	1.00E-03	3.50E-03	**8.79E-02**	1.00E-06	4.02E-03	1.16E+02	--	3.83E-06	--	--	--	--
Tetrachloroethene	1	1.13E-02	3.25E+02	--	6.49E-06	1.00E-02	1.00E-02	3.50E-02	**7.48E-01**	1.00E-06	4.02E-03	1.16E+02	--	6.63E-05	5.40E-01	5.40E-01	5.90E-03	**1.58E-04**
Tetrahydrofuran	1	1.13E-02	3.25E+02	--	2.68E-07	--	--	3.01E-01	--	1.00E-06	4.02E-03	1.16E+02	--	2.74E-06	--	--	--	--
Toluene	1	1.13E-02	3.25E+02	--	3.78E-06	8.00E-02	8.00E-02	5.00E+00	**6.41E+00**	1.00E-06	4.02E-03	1.16E+02	--	3.86E-05	--	--	--	--
Trichloroethene	1	1.13E-02	3.25E+02	--	1.88E-06	--	--	6.00E-01	--	1.00E-06	4.02E-03	1.16E+02	--	1.92E-05	4.00E-01	4.00E-01	2.00E-03	**4.00E-04**
Vinyl chloride	1	1.13E-02	3.25E+02	--	5.65E-07	3.00E-03	3.00E-03	1.00E-01	**2.62E-01**	1.00E-06	4.02E-03	1.16E+02	--	5.78E-06	7.20E-01	7.20E-01	4.40E-03	**2.96E-04**
Xylenes (total)	1	1.13E-02	3.25E+02	--	9.40E-06	2.00E-01	2.00E-01	1.00E-01	**1.40E+01**	1.00E-06	4.02E-03	1.16E+02	--	9.61E-05	--	--	--	--
Acrylonitrile	1	1.13E-02	3.25E+02	--	1.13E-07	1.00E-03	1.00E-03	3.50E-03	**8.86E-02**	1.00E-06	4.02E-03	1.16E+02	--	1.16E-06	5.40E-01	5.40E-01	6.80E-02	**4.46E-04**
Ethyl methacrylate	1	1.13E-02	3.25E+02	--	1.88E-06	9.00E-02	9.00E-02	3.15E-01	**7.59E+00**	1.00E-06	4.02E-03	1.16E+02	--	1.92E-05	--	--	--	--

-- = No toxicity information available; thus, no RBCG derived for this effect.

APPENDIX A-3

VALUES USED FOR DAILY INTAKE CALCULATIONS
REASONABLE MAXIMUM EXPOSURE
Remedial Investigation and Feasibility Study
Sutton Brook Disposal Area Superfund Site - Tewksbury, Massachusetts

Scenario Timeframe:	Current/Future
Medium:	Upland Soil
Exposure Medium:	Upland Soil*

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Reference	
Incidental ingestion and dermal contact	Facility Worker	Adult	Soil:	EPC	Exposure Point Concentration	Chemical-specific	mg/kg	Chemical-specific	1
			Group 3	IR_s	Ingestion rate of soil	100	mg/event	USEPA, 2002a	2
			Group 4	AF	Skin-soil adherence factor	0.2	mg/cm^2 - event	USEPA, 2004	3
				SA	Skin surface area	3300	cm^2	USEPA, 2004	4
				EF	Exposure Frequency	150	events/year	USEPA, 1994	5
				ED	Exposure Duration	25	years	USEPA, 2004	6
				BW	Body weight	70	kg	USEPA, 1994	7
				AT_c	Averaging Time-cancer	70	years	USEPA, 1999	8
				AT_{nc}	Averaging Time-noncancer	25	years	USEPA, 1989	9
				ABS_d	Dermal Absorption Fraction	Chemical-specific	unitless	USEPA, 2004	10
				C1	Units Conversion Factor	365	days/year	Constant	
				C2	Units Conversion Factor	1,000,000	mg/kg	Constant	
Incidental ingestion and dermal contact	Construction Worker	Adult	Soil:	EPC	Exposure Point Concentration	Chemical-specific	mg/kg	Chemical-specific	1
			Group 3	IR_s	Ingestion rate of soil	330	mg/event	USEPA, 2002a	11
			Group 4	AF	Skin-soil adherence factor	0.3	mg/cm^2 - event	USEPA, 2004	12
				SA	Skin surface area	2479	cm^2	USEPA, 2004	4
				EF	Exposure Frequency	130	events/year	Professional judgement	13
				ED	Exposure Duration	1	year	Professional judgement	13
				BW	Body weight	70	kg	USEPA, 1994	7
				AT_c	Averaging Time-cancer	70	years	USEPA, 1999	8
				AT_{nc}	Averaging Time-noncancer	1	years	USEPA, 1989	9
				ABS_d	Dermal Absorption Fraction	Chemical-specific	unitless	USEPA, 2004	10
				C1	Units Conversion Factor	365	days/year	Constant	
				C2	Units Conversion Factor	1,000,000	mg/kg	Constant	
Incidental ingestion and dermal contact	Resident	Child (1-6 years) (noncancer effects)	Soil:	EPC	Exposure Point Concentration	Chemical-specific	mg/kg	Chemical-specific	1
			Group 3	IR_s	Ingestion rate of soil-child, 1-6 yrs	200	mg/event	USEPA, 1994	14
			Group 4	IR_s	Ingestion rate of soil-adult	100	mg/event	USEPA, 1999	2
		Child/Adult (1-31 years) (cancer effects)		AF	Skin-soil adherence factor-child	0.2	mg/cm^2 - event	USEPA, 2004	15
				AF	Skin-soil adherence factor-adult	0.07	mg/cm^2 - event	USEPA, 2004	15
				SA	Skin surface area-child	2800	cm^2	USEPA, 2004	15
				SA	Skin surface area-adult	5700	cm^2	USEPA, 2004	15
				EF	Exposure Frequency	150	events/year	USEPA, 1994	5
				ED_{nc}	Exposure Duration-child	6	years	USEPA, 2004	15
				ED_c	Exposure Duration-adult	24	years	USEPA, 2004	15
				BW	Body weight, child	15	kg	USEPA, 1994	16
				BW	Body weight, adult	70	kg	USEPA, 1994	16
				AT_c	Averaging Time-cancer	70	years	USEPA, 1999	8
				AT_{nc}	Averaging Time-noncancer	6	years	USEPA, 1989	9
				ABS_d	Dermal Absorption Fraction	Chemical-specific	unitless	USEPA 2004	10
				C1	Units Conversion Factor	365	days/year	Constant	
				C2	Units Conversion Factor	1,000,000	mg/kg	Constant	
Incidental ingestion and dermal contact	Trespasser / Recreational User	Youth (8-18 years)	Soil:	EPC	Exposure Point Concentration	Chemical-specific	mg/kg	Chemical-specific	1
			Group 3	IR_s	Ingestion rate of soil	100	mg/event	USEPA, 1999	17.
			Group 4	AF	Skin-soil adherence factor	0.09	mg/cm^2 - event	USEPA, 2004	18.
				SA	Skin surface area	3220	cm^2	USEPA, 2004	19.
				EF	Exposure Frequency	90	events/year	Professional judgement	20.
				ED	Exposure Duration	11	years	Professional judgement	21.
				BW	Body weight	45	kg	USEPA, 1999	22.
				AT_c	Averaging Time-cancer	70	years	USEPA, 1999	8
				AT_{nc}	Averaging Time-noncancer	11	years	USEPA, 1989	9
				ABS_d	Dermal Absorption Fraction	Chemical-specific	unitless	USEPA 2004	10
				C1	Units Conversion Factor	365	days/year	Constant	
				C2	Units Conversion Factor	1,000,000	mg/kg	Constant	

RME

EXP FACTOR FW-SOIL	
DC-C	1.38E-06
DC-NC	3.87E-06
II-C	2.10E-07
II-NC	5.87E-07

RME

EXP FACTOR CW-SOIL	
DC-C	5.41E-08
DC-NC	3.78E-06
II-C	2.40E-08
II-NC	1.68E-06

RME

EX FACTOR RES	Child	Child/ Adult
DC-C	--	2.12E-06
DC-NC	1.53E-05	--
II-C	--	6.71E-07
II-NC	5.48E-06	--

RME

EX FACTOR Trespasser = TP	
DC-C	2.52E-07
DC-NC	1.61E-06
II-C	8.61E-08
II-NC	5.48E-07

APPENDIX A-3

VALUES USED FOR DAILY INTAKE CALCULATIONS
REASONABLE MAXIMUM EXPOSURE
Remedial Investigation and Feasibility Study
Sutton Brook Disposal Area Superfund Site - Tewksbury, Massachusetts

Average Daily Intake (ADI) Equations:

$ADI_{ingestion}$ (mg/kg-d) = EPC * IR * EF * ED * 1/BW * 1/AT * 1/C1 * 1/C2

ADL_{dermal} (mg/kg-d) = EPC * SA * AF * EF * ED * 1/BW * 1/AT * 1/C1 * 1/C2 * ABS_d

Note: Derivation of area-weighted soil-skin adherence factors is presented on Table 3-16A.

Notes:

1. EPCs for soil are based on the 95% upper confidence limit of the mean concentration or maximum detected concentration in soil samples collected from the site.
2. Daily soil ingestion rate (IR_s) is the default IR_s from USEPA, 1994.
3. Skin-soil adherence factor (AF) is the recommended reasonable maximum exposure (RME) AF for industrial workers, from Exhibit 3-5 of USEPA, 2004. Parts of the body include the face (1/3 of head), hands and forearms.
4. Skin surface area (SA) for the facility worker is based on the default value for industrial scenarios, from Exhibit 3-5 of USEPA, 2004. Parts of the body include the head, hands and forearms. SA for the construction worker is based on the mean SA for industrial scenarios (both males and females), from Exhibit C-1 of USEPA, 2004. Parts of the body include the face (402 cm^2), hands (904 cm^2) and forearms (1,173 cm^2).
5. Exposure frequency (EF) describes how often the exposure event occurs over a given period of time. We assumed that facility workers and residents would be exposed to soil 150 days per year, in accordance with EPA Region 1 guidance (USEPA, 1994).
6. The exposure duration (ED) for facility workers was assumed to be 25 years, which is the RME value in Exhibit 3-5, USEPA, 2004.
7. Body weight (BW) is the recommended adult body weight presented in USEPA 1994.
8. The averaging time (AT_c) is set equal to a lifetime (i.e., 70 years) when estimating cancer risk. This is the recommended lifetime in USEPA, 1999.
9. The averaging time for noncancer effects (AT_{nc}) is set equal to the exposure duration.
10. Dermal ABS values were obtained from Exhibit 3-4 of USEPA, 2004.
11. This is the default soil IR_s recommended in USEPA, 2002a for construction worker scenarios.
12. The 95th percentile AF is based on the "construction workers" study, presented in Exhibit C-2 of USEPA, 2004. The AF for body parts assumed exposed hands (0.518), forearms (0.215), and head (0.071).
13. Assumed a construction worker would be present at the site 5 days per week for six months of a one-year construction period.
14. Recommended soil ingestion rate for children, RME scenarios, presented in Table 5-19 of USEPA, 2002b.
15. Default dermal exposure values for RME residential scenarios. Exhibit 3-5, USEPA, 2004.
16. Body weight (BW) is the default value provided in USEPA, 1994.
17. Daily soil ingestion rate is the recommended ingestion rate for children, from Table 4-23 of USEPA, 1999.
18. The 95th percentile AF is based on the "soccer players" study, presented in Exhibit C-2 of USEPA, 2004. The AF for body parts assumed exposed hands (0.166), forearms (0.014), and lower legs (0.097).
19. Skin surface area (SA) is based on the body part-specific surface area calculations for males and females. From Exhibit C-1 of USEPA , 2004. Parts of the body assumed to be exposed include hands, forearms, and lower legs.
20. It was assumed that a trespasser would be exposed to contaminants in soil for 3 days per week during the 7 non-winter months of the year, or 90 days per year, when the ground is not frozen.
21. The trespasser was assumed to be 8 through 18 years old, so an exposure period of 11 years was selected.
22. Body weight (BW) is based on the mean body weights for boys and girls (8 through 18 years). From Table 7-3, USEPA, 1999. The mean body weight for each age category was averaged to calculate the body weight for this age range.

* Please refer to Tables 32 M & N and Tables 33 M & N for additional exposure parameters necessary to calculate risks associated with carcinogenic PAHs.

References:

USEPA, 2004. US EPA Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment) EPA/540/R/99/005, July 2004.

USEPA, 2002a. US EPA Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites OSWER 9355.4-24, December 2002.

USEPA, 2002b. US EPA Child-Specific Exposure Factors Handbook. EPA/600/P00/002B, September 2002.

USEPA, 1999. US EPA Exposure Factors Handbook EPA/600/C-99/001, February 1999.

USEPA, 1994. Risk Updates: No 2. USEPA Region 1, Waste Management Division, August 1994.

USEPA, 1989. US EPA Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual. (EPA/540/1-89/002).

APPENDIX A-4

VALUES USED FOR DAILY INTAKE CALCULATIONS
REASONABLE MAXIMUM EXPOSURE
Remedial Investigation and Feasibility Study
Sutton Brook Disposal Area Superfund Site - Tewksbury, Massachusetts

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

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Reference	
Ingestion of potable water	Facility Worker	Adult	Group 3 Group 4	EPC	Exposure Point Concentration	Chemical-specific	mg/L	Chemical-specific	1
				IR_x	Ingestion rate of drinking water	1.15	L/day	Professional judgment	2
				EF	Exposure Frequency	250	days/year	USEPA, 2004	3
				ED	Exposure Duration	25	years	USEPA, 2004	4
				BW	Body weight	70	kg	USEPA, 1994	5
				AT_c	Averaging Time-cancer	70	years	USEPA, 1999	6
				AT_{nc}	Averaging Time-noncancer	25	years	USEPA, 1989	7
				C1	Units Conversion Factor	365	days/year	Constant	
Dermal contact with Potable Water	Facility Worker	Adult	Group 3 Group 4	EPC	Exposure Point Concentration	Chemical-specific	mg/L	Chemical-specific	1
				DA_e	Absorbed dose per event	Chemical-specific	mg/cm^2-event	Calculated	
				Kp	Permeability coefficient	Chemical-specific	cm/h	USEPA, 2004	8
				FA	Fraction Absorbed	Chemical-specific	Dimensionless	USEPA, 2004	8
				BW	Body weight	70	kg	USEPA, 1994	5
				SA	Skin surface area	2077	cm^2	USEPA, 2004	9
				EV	Event Frequency	16	events/day	Professional judgment	10
				EF	Exposure Frequency	250	days/year	USEPA, 1999	3
				ED	Exposure Duration	25	years	USEPA, 1999	4
				tau_{event}	Lag time per event	Chemical-specific	hours/event	USEPA, 2004	8
				t_e	Event duration	0.01	hours/event	Professional judgment	10
				C1	Units Conversion Factor	365.00	days/year	Constant	
				C2	Units Conversion Factor	0.001	L/cm^3	Constant	
				AT_c	Averaging Time-cancer	70	years	USEPA, 1999	6
				AT_{nc}	Averaging Time-noncancer	25	years	USEPA, 1989	7
Dermal contact with Groundwater	Construction Worker	Adult	Group 3 Group 4	EPC	Exposure Point Concentration	Chemical-specific	mg/L	Chemical-specific	1
				DA_e	Absorbed dose per event	Chemical-specific	mg/cm^2-event	Calculated	
				Kp	Permeability coefficient	Chemical-specific	cm/h	USEPA, 2004	8
				FA	Fraction Absorbed	Chemical-specific	Dimensionless	USEPA, 2004	8
				BW	Body weight	70	kg	USEPA, 1994	5
				SA	Skin surface area	2077	cm^2	USEPA, 2004	9
				EV	Event Frequency	1	events/day	Professional judgment	11
				EF	Exposure Frequency	130	days/year	Professional judgment	11
				ED	Exposure Duration	1	years	Professional judgment	11
				tau_{event}	Lag time per event	Chemical-specific	hours/event	USEPA, 2004	8
				t_e	Event duration	0.5	hours/event	Professional judgment	11
				C1	Units Conversion Factor	365	days/year	Constant	
				C2	Units Conversion Factor	0.001	L/cm^3	Constant	
				AT_c	Averaging Time-cancer	70	years	USEPA, 1999	6
				AT_{nc}	Averaging Time-noncancer	1	years	USEPA, 1989	7
Ingestion of potable water	Resident	Child (1-6 years) (noncancer effects)	Groups 1-2 Groups 3-6	EPC	Exposure Point Concentration	Chemical-specific	mg/L	Chemical-specific	1
				IR_x	Ingestion rate of drinking water, 1-6 years	1.3	L/day	USEPA, 1999	12
				IR_x	Ingestion rate of drinking water, 7-31 years	1.98	L/day	USEPA, 1994	13
		Child/adult (1-31 years) (cancer effects)		EF	Exposure Frequency	350	days/year	USEPA, 2004	14
				ED_{nc}	Exposure Duration-child	6	years	USEPA, 1999	15
				ED_c	Exposure Duration-adult	24	years	USEPA, 1999	15
				BW	Body weight, child	15	kg	USEPA, 1994	16
				BW	Body weight, adult	70	kg	USEPA, 1994	16
				AT_c	Averaging Time-cancer	70	years	USEPA, 1999	6
				AT_{nc}	Averaging Time-noncancer	6	years	USEPA, 1989	7
				C1	Units Conversion Factor	365	days/year	Constant	

RME

EXP FACTOR	
FW-ING	
DWI-C	**4.02E-03**
DWI-NC	**1.13E-02**

note dermal units!!! Need to calc DA separately!!!

RME	
EXP FACTOR	
FW-DCW	
DC-C	**1.16E+02** ev-cm2 /d-kg
DC-NC	**3.25E+02**

note dermal units!!! Need to calc DA separately!!!

RME	
EXP FACTOR	
CW-DCW	
DC-C	**1.51E-01** ev-cm2 /d-kg
DC-NC	**1.06E+01**

RME	
EXP FACTOR	
RES-DWI	
DWI NC	**0.083105023 child**
DWI C	**0.016399217 child/adult**

APPENDIX A-4 Continued

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

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Reference	
Dermal contact with potable water (i.e., showering)	Resident	Child (1-6 years) (noncancer effects)	Groups 1-2 Groups 3-6	EPC	Exposure Point Concentration	Chemical-specific	mg/L	Chemical-specific	1
				DA_e	Absorbed dose per event	Chemical-specific	mg/cm^2-event	Calculated	
				Kp	Permeability coefficient	Chemical-specific	cm/h	USEPA, 2004	8
		Child/adult (cancer effects)		FA	Fraction Absorbed	Chemical-specific	Dimensionless	USEPA, 2004	8
				BW	Body weight, child	15	kg	USEPA, 1999	16
				BW	Body weight, adult	70	kg	USEPA, 1994	16
				SA	Skin surface area, 1-6 years	6600	cm^2	USEPA, 2004	17
				SA	Skin surface area, 7-31 years	18000	cm^2	USEPA, 2004	17
				EV	Event Frequency	1	events/day	USEPA, 2004	14
				EF	Exposure Frequency	350	days/year	USEPA, 2004	14
				ED_{nc}	Exposure Duration-child	6	years	USEPA, 1999	15
				ED_c	Exposure Duration-adult	24	years	USEPA, 1999	15
				tau_{event}	Lag time per event	Chemical-specific	hours/event	USEPA, 2004	8
				t_e	Event duration, 1-6 years	1	hours/event	USEPA, 2004	14
				t_e	Event duration, 7-31 years	0.58	hours/event	USEPA, 2004	14
				B	Ratio of permeability coefficients, stratum corneum to viable epidermis	Chemical-specific	Dimensionless	USEPA, 2004	8
				C1	Units Conversion Factor	365	days/year	Constant	
				C2	Units Conversion Factor	0.001	L/cm^3	Constant	
				AT_c	Averaging Time-cancer	70	years	USEPA, 1999	6
				AT_{nc}	Averaging Time-noncancer	6	years	USEPA, 1989	7
Dermal contact (surface water)	Trespasser/ Future Site Recreational User	Youth (Ages 8-18 years)	Groups 5 & 6	EPC	Exposure Point Concentration	Chemical-specific	mg/L	Chemical-specific	18
				DA_e	Absorbed dose per event	Chemical-specific	mg/cm^2-event	Calculated	
				Kp	Permeability coefficient	Chemical-specific	cm/h	USEPA, 2004	8
				FA	Fraction Absorbed	Chemical-specific	Dimensionless	USEPA, 2004	8
				BW	Body weight	45	kg	USEPA, 1999	19
				SA	Skin surface area	4194	cm^2	USEPA, 2004	20
				EV	Event Frequency	1	events/day	Professional judgment	21
				EF	Exposure Frequency	90	days/year	Professional judgment	21
				ED	Exposure Duration	11	years	Professional judgment	22
				tau_{event}	Lag time per event	Chemical-specific	hours/event	USEPA, 2004	8
				t_e	Event duration	1	hours/event	Professional judgment	23
				C1	Units Conversion Factor	365	days/year	Constant	
				C2	Units Conversion Factor	0.001	L/cm^3	Constant	
				AT_c	Averaging Time-cancer	70	years	USEPA, 1999	6
				AT_{nc}	Averaging Time-noncancer	11	years	USEPA, 1989	7
Dermal contact (surface water)	Future Site Resident	Child (1-6 years) (noncancer effects)	Groups 5 & 6	EPC	Exposure Point Concentration	Chemical-specific	mg/L	Chemical-specific	18
				DA_e	Absorbed dose per event	Chemical-specific	mg/cm^2-event	Calculated	
				Kp	Permeability coefficient	Chemical-specific	cm/h	USEPA, 2004	8
		Child/adult (cancer effects)		FA	Fraction Absorbed	Chemical-specific	Dimensionless	USEPA, 2004	8
				BW	Body weight, child	15	kg	USEPA, 1994	16
				BW	Body weight, adult	70	kg	USEPA, 1994	16
				SA	Skin surface area, child	2218	cm^2	USEPA, 2004	20
				SA	Skin surface area, adult	4927	cm^2	USEPA, 2004	20
				EV	Event Frequency	1	events/day	Professional judgment	21
				EF	Exposure Frequency	90	days/year	Professional judgment	21
				ED	Exposure Duration-child	6	years	USEPA, 1999	15
				ED	Exposure Duration-adult	24	years	USEPA, 1999	15
				tau_{event}	Lag time per event	Chemical-specific	hours/event	USEPA, 2004	8
				t_e	Event duration	1	hours/event	Professional judgment	23
				C1	Units Conversion Factor	365	days/year	Constant	
				C2	Units Conversion Factor	0.001	L/cm^3	Constant	
				AT_c	Averaging Time-cancer	70	years	USEPA, 1999	6
				AT_{nc}	Averaging Time-noncancer	6	years	USEPA, 1989	7

note dermal units!!! Need to calc DA separately!!!
RME
EXP FACTOR
RES-DCW
DC-C **120.704501**
DC-NC **421.9178082**

note dermal units!!! Need to calc DA separately!!!
RME
EXP FACTOR
TRES-DC_SW
DC-C **3.61E+00** ev-cm2 /d-kg
DC-NC **2.30E+01**

note dermal units!!! Need to calc DA separately!!!
RME
EXP FACTOR
RES-DC_SW
DC-C **9.075582891**
DC-NC **36.46027397**

Average Daily Intake (ADI) Equations:

$ADI_{ingestion}$ (mg/kg-d) = EPC * IR * EF * ED * 1/BW * 1/AT * 1/C1

ADI_{dermal} (mg/kg-d) = DA_{event} * EV * EF * ED * SA * 1/BW * 1/AT * 1/C1

where for inorganics: DA_{event} (mg/cm^2-event)= EPC * Kp * t_e * C2

where for organics: DA_{event} = EPC * 2 FA * Kp * C2 * SQRT{(6 * tau-event * t-e)/pi}

(short-duration exposures)

and DA_{event} = EPC * FA * Kp * C2 * [(t-event/1 + B) + 2 tau-event {(1 + 3 B + 3 B^2)/(1 + B)^2}]

(long-duration exposures)

Note: The DA "exposure factor" (DA_{event} not including the EPC) is presented on Table A-12.

Notes:

1. EPCs are the maximum groundwater concentration in each exposure point.
2. Since the facility worker represents a non-residential, adult exposure, we used one-half of the RME drinking water ingestion rate (2.3 L/day), which is the 90th percentile ingestion rate for adults (Table 3-30; USEPA, 1999), for this exposure scenario, assuming that a facility worker spends only a portion of the day at the site and, accordingly, would not ingest the full daily allotment for adults.
3. Exposure Frequency (EF) describes how often the exposure event occurs over a given period of time. The exposure frequency is the default EF for industrial RME scenarios, in USEPA, 2004.
4. The exposure duration (ED) for facility workers was assumed to be 25 years, which is the RME value in Exhibit 3-5, USEPA, 2004.
5. Body weight (BW) is the adult body weight presented in USEPA, 1994.
6. The averaging time (AT_c) is set equal to a lifetime (i.e., 70 years) when estimating cancer risk. This is the recommended lifetime in USEPA, 1999.
7. The averaging time for noncancer effects (AT_{nc}) is set equal to the exposure duration.
8. Chemical-specific dermal absorption coefficients/factors were obtained from USEPA, 2004.
9. Skin surface area (SA) for both the facility and construction worker scenarios was based on the mean SA for hands and forearms, from USEPA, 2004.
10. Handwashing frequency and event duration values were based on information provided by the Centers for Disease Control (CDC) and Prevention (CDC, 2002) and USEPA, 1999. USEPA (1999) also provides statistics on handwashing frequency in the United States. We assumed that a facility would wash his hands twice per hour (or 16 times per day) under the RME scenario. Information provided by the CDC indicates an average observed handwashing time of 7-10 seconds among hospital workers, which we assumed would also reflect average handwashing habits among United States residents. The CDC recommends washing hands a minimum of 15 seconds (CDC, 2002). For the RME scenario, we assumed that a facility worker spent 20 seconds per hand washing event.
11. It was assumed that construction workers would be present at the site during a one-year period of site redevelopment work. Because OSHA mandates dewatering in excavation pits or trenches, construction workers were assumed to contact groundwater only while setting up or dismantling dewatering equipment at the beginning and ending of a work week (or 52 events per year, for six months of one year), for one-half hour per exposure event.
12. Drinking water ingestion rate is based on the 90th percentile ingestion rate for children ages 1-10 yrs (Ershow and Cantor, 1989, as cited in Table 3-30, USEPA, 1999).
13. Daily drinking water ingestion rate is based on the 90th percential tapwater intake rate for males and females within age categories 11-19 (conservatively used for the 7-19 age range) and 20 through 30 years. From Ershow and Cantor, 1989, as cited in Table 3-30, EPA 1999.
14. These are the recommended exposure values for RME residential scenarios, as indicated in Exhibit 3-2, USEPA 2004.
15. We evaluated a thirty year exposure duration, which is the EPA-recommended ED for RME residential scenarios (USEPA, 1999). The ED is divided into two age groups: child, ages 1-6, which we use to evaluate noncancer effects; and child/adult, ages 7-31. Both age groups are considered collectively to evaluate cancer effects over the entire ED.
16. Body weight (BW) is the default value provided in USEPA, 1994.
17. Skin surface areas are the recommended SAs for RME residential scenarios, as indicated in Exhibit 3-2 of USEPA, 2004.
18. Surface water exposure point concentration is either the maximum detected concentration or 95% UCL concentration.
19. Body weight (BW) is based on the mean body weights for boys and girls (8 through 18 years) from US EPA Exposure Factors Handbook EPA/600/C-99/001, February 1999, Table 7-3. The mean body weight for each age category was averaged to calculate the body weight.
20. Skin surface areas for the resident and trespasser are based on the body part-specific surface area calculations for males and females within each age range, from US EPA, 2004. Parts of the body assumed to be exposed include hands, forearms, feet and lower legs.
21. We assumed that a trespasser or area resident would be exposed to contaminants in surface water for 3 days per week during the 7 non-winter months.
22. The trespasser was assumed to be 8 through 18 years old, so an exposure period of 11 years was selected.
23. We assumed that a trespasser or resident would be present at the site for only one hour per exposure event.

References:

USEPA, 1999. US EPA Exposure Factors Handbook EPA/600/C-99/001, February 1999.
USEPA, 2004. US EPA Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment) EPA/540/R/99/005, July 2004.
USEPA, 1989. US EPA Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual. (EPA/540/1-89/002).
USEPA, 2002. US EPA Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites OSWER 9355.4-24, December 2002.
Center for Disease Control (CDC). 2002. *Guideline for Hand Hygiene in Health-Care Settings: Recommendations of the Healthcare Infection Control Practices Advisory Committee* and the ICPAC/SHEA/APIC/IDSA Hand Hygiene Task Force. Morbidity and Mortality Weekly Report. October 25, 2002 / Vol. 51 / No. RR-16.

Appendix A-5
SHOWER INHALATION CALCULATIONS, REASONABLE MAXIMUM EXPOSURES
Remedial Investigation and Feasibility Study,
Sutton Brook Disposal Area Superfund Site - Tewksbury, Massachusetts

INHALATION EXPOSURES FROM SHOWERING	HENRY'S LAW CONSTANT HLC	Molecular Weight MW	INTERIM CALCULATIONS gas-film mass transfer coefficient kg	liquid-film mass transfer coefficient kl	Overall Mass Transfer Coefficient KL	Adjusted Mass Transfer Coefficient KaL	Concentration Leaving Water Droplet Cwd	Indoor Air Generation Rate S	Exposure Factor Noncancer EXPinh	Exposure Factor Cancer Risk EXPinh
OIL OR HAZARDOUS MATERIAL	atm-m3/mol	g/mole	cm/hr	cm/hr	cm/hr	cm/hr	µg/l	µg/(m3-min)	(µg/m3)/(µg/l)	(µg/m3)/(µg/l)
ACETONE	3.9E-05	5.8E+01	1.7E+03	1.7E+01	2.3E+00	3.2E+00	1.0E-01	1.7E-01	2.7E-01	7.4E-02
BENZENE	5.6E-03	7.8E+01	1.4E+03	1.5E+01	1.4E+01	1.9E+01	4.8E-01	7.9E-01	1.3E+00	3.5E-01
BIS(2-ETHYLHEXYL)PHTHALATE	1.0E-07	3.9E+02	6.4E+02	6.7E+00	2.7E-03	3.7E-03	1.2E-04	2.0E-04	3.3E-04	9.1E-05
CARBON TETRACHLORIDE	3.0E-02	1.5E+02	1.0E+03	1.1E+01	1.1E+01	1.4E+01	3.8E-01	6.3E-01	1.0E+00	2.8E-01
CHLOROBENZENE	3.7E-03	1.1E+02	1.2E+03	1.2E+01	1.2E+01	1.6E+01	4.1E-01	6.8E-01	1.1E+00	3.0E-01
CHLOROFORM	3.7E-03	1.2E+02	1.2E+03	1.2E+01	1.1E+01	1.5E+01	4.0E-01	6.7E-01	1.1E+00	3.0E-01
DICHLOROBENZENE, 1,2- (o-DCB)	1.9E-03	1.5E+02	1.0E+03	1.1E+01	9.7E+00	1.3E+01	3.5E-01	5.9E-01	9.4E-01	2.6E-01
DICHLOROBENZENE, 1,3- (m-DCB)	2.6E-03	1.5E+02	1.0E+03	1.1E+01	1.0E+01	1.3E+01	3.6E-01	6.0E-01	9.7E-01	2.7E-01
DICHLOROBENZENE, 1,4- (p-DCB)	2.4E-03	1.5E+02	1.0E+03	1.1E+01	9.9E+00	1.3E+01	3.6E-01	6.0E-01	9.6E-01	2.7E-01
DICHLOROETHANE, 1,1-	5.6E-03	9.9E+01	1.3E+03	1.3E+01	1.3E+01	1.7E+01	4.4E-01	7.3E-01	1.2E+00	3.3E-01
DICHLOROETHANE, 1,2-	9.8E-04	9.9E+01	1.3E+03	1.3E+01	1.1E+01	1.4E+01	3.8E-01	6.3E-01	1.0E+00	2.8E-01
DICHLOROETHYLENE, 1,1-	2.6E-02	9.7E+01	1.3E+03	1.3E+01	1.3E+01	1.8E+01	4.5E-01	7.5E-01	1.2E+00	3.4E-01
DICHLOROETHYLENE, CIS-1,2-	4.1E-03	9.7E+01	1.3E+03	1.3E+01	1.3E+01	1.7E+01	4.4E-01	7.3E-01	1.2E+00	3.2E-01
DICHLOROMETHANE	2.2E-03	8.5E+01	1.4E+03	1.4E+01	1.3E+01	1.7E+01	4.4E-01	7.3E-01	1.2E+00	3.3E-01
DIOXANE, 1,4-	4.9E-06	8.8E+01	1.4E+03	1.4E+01	2.7E-01	3.7E-01	1.2E-02	2.0E-02	3.3E-02	9.0E-03
ETHYLBENZENE	7.9E-03	1.1E+02	1.2E+03	1.3E+01	1.2E+01	1.7E+01	4.3E-01	7.2E-01	1.2E+00	3.2E-01
METHYL ETHYL KETONE	2.7E-05	7.2E+01	1.5E+03	1.6E+01	1.5E+00	2.1E+00	6.7E-02	1.1E-01	1.8E-01	5.0E-02
METHYL ISOBUTYL KETONE	1.4E-04	1.0E+02	1.3E+03	1.3E+01	4.7E+00	6.4E+00	1.9E-01	3.2E-01	5.1E-01	1.4E-01
METHYLNAPHTHALENE, 2-	5.0E-04	1.4E+02	1.1E+03	1.1E+01	7.4E+00	1.0E+01	2.8E-01	4.7E-01	7.6E-01	2.1E-01
NAPHTHALENE	4.8E-04	1.3E+02	1.1E+03	1.2E+01	7.7E+00	1.0E+01	2.9E-01	4.9E-01	7.9E-01	2.2E-01
PHENOL	4.0E-07	9.4E+01	1.3E+03	1.4E+01	2.2E-02	2.9E-02	9.7E-04	1.6E-03	2.6E-03	7.2E-04
STYRENE	2.8E-03	1.0E+02	1.2E+03	1.3E+01	1.2E+01	1.6E+01	4.2E-01	6.9E-01	1.1E+00	3.1E-01
TETRACHLOROETHYLENE	1.8E-02	1.7E+02	9.9E+02	1.0E+01	1.0E+01	1.4E+01	3.7E-01	6.1E-01	9.8E-01	2.7E-01
TOLUENE	6.6E-03	9.2E+01	1.3E+03	1.4E+01	1.3E+01	1.8E+01	4.5E-01	7.5E-01	1.2E+00	3.4E-01
1,2,4-Trichlorobenzene	1.4E-03	1.8E+02	9.5E+02	9.9E+00	8.4E+00	1.1E+01	3.1E-01	5.2E-01	8.4E-01	2.3E-01
TRICHLOROETHANE, 1,1,1-	1.7E-02	1.3E+02	1.1E+03	1.2E+01	1.1E+01	1.5E+01	4.0E-01	6.7E-01	1.1E+00	3.0E-01
TRICHLOROETHANE, 1,1,2-	9.1E-04	1.3E+02	1.1E+03	1.2E+01	9.0E+00	1.2E+01	3.3E-01	5.6E-01	8.9E-01	2.5E-01
TRICHLOROETHYLENE	1.0E-02	1.3E+02	1.1E+03	1.2E+01	1.1E+01	1.5E+01	4.0E-01	6.7E-01	1.1E+00	3.0E-01
VINYL CHLORIDE	2.7E-02	6.3E+01	1.6E+03	1.7E+01	1.7E+01	2.2E+01	5.3E-01	8.8E-01	1.4E+00	3.9E-01
XYLENES (Mixed Isomers)	6.7E-03	1.1E+02	1.2E+03	1.3E+01	1.2E+01	1.7E+01	4.3E-01	7.1E-01	1.1E+00	3.2E-01
Tetrahydrofuran	9.6E-03	7.2E+01	1.5E+03	1.6E+01	1.5E+01	2.1E+01	5.0E-01	8.3E-01	1.3E+00	3.7E-01
2-Methylphenol	1.2E-06	1.1E+02	1.2E+03	1.3E+01	6.1E-02	8.2E-02	2.7E-03	4.6E-03	7.3E-03	2.0E-03
3-Methylphenol/4-Methylphenol	1.0E-06	1.1E+02	1.2E+03	1.3E+01	5.1E-02	6.9E-02	2.3E-03	3.8E-03	6.1E-03	1.7E-03
4-Methylphenol	1.0E-06	1.1E+02	1.2E+03	1.3E+01	5.1E-02	6.9E-02	2.3E-03	3.8E-03	6.1E-03	1.7E-03
1,2,4-Trimethylbenzene	5.7E-03	1.2E+02	1.2E+03	1.2E+01	1.2E+01	1.6E+01	4.1E-01	6.8E-01	1.1E+00	3.0E-01
1,3,5-Trimethylbenzene	7.7E-03	1.2E+02	1.2E+03	1.2E+01	1.2E+01	1.6E+01	4.1E-01	6.8E-01	1.1E+00	3.0E-01
Chloroethane	2.4E-02	5.1E+01	1.8E+03	1.9E+01	1.8E+01	2.5E+01	5.6E-01	9.4E-01	1.5E+00	4.2E-01
Isopropylbenzene	1.2E+00	1.2E+02	1.2E+03	1.2E+01	1.2E+01	1.6E+01	4.2E-01	7.0E-01	1.1E+00	3.1E-01

Appendix A-5
SHOWER INHALATION CALCULATIONS, REASONABLE MAXIMUM EXPOSURES
Remedial Investigation and Feasibility Study,
Sutton Brook Disposal Area Superfund Site - Tewksbury, Massachusetts

INHALATION EXPOSURES FROM SHOWERING	HENRY'S LAW CONSTANT HLC	Molecular Weight MW	INTERIM CALCULATIONS gas-film mass transfer coefficient kg	liquid-film mass transfer coefficient kl	Overall Mass Transfer Coefficient KL	Adjusted Mass Transfer Coefficient KaL	Concentration Leaving Water Droplet Cwd	Indoor Air Generation Rate S	Exposure Factor Noncancer EXPinh	Exposure Factor Cancer Risk EXPinh
OIL OR HAZARDOUS MATERIAL	atm-m3/mol	g/mole	cm/hr	cm/hr	cm/hr	cm/hr	µg/l	µg/(m3-min)	(µg/m3)/(µg/l)	(µg/m3)/(µg/l)
n-Propylbenzene	2.0E+02	1.3E-02	1.1E+05	1.2E+03	1.2E+03	1.6E+03	1.0E+00	1.7E+00	2.7E+00	7.4E-01
n-Butylbenzene	1.3E-02	1.3E+02	1.1E+03	1.1E+01	1.1E+01	1.5E+01	4.0E-01	6.6E-01	1.1E+00	3.0E-01
tert-Butylbenzene	1.3E-02	1.3E+02	1.1E+03	1.1E+01	1.1E+01	1.5E+01	4.0E-01	6.6E-01	1.1E+00	3.0E-01
2-Nitrophenol	1.3E-05	1.4E+02	1.1E+03	1.1E+01	5.5E-01	7.4E-01	2.4E-02	4.1E-02	6.5E-02	1.8E-02
Acetophenone	1.1E-05	1.2E+02	1.2E+03	1.2E+01	5.1E-01	6.9E-01	2.3E-02	3.8E-02	6.1E-02	1.7E-02
Benzyl Alcohol	3.4E-07	1.1E+02	1.2E+03	1.3E+01	1.7E-02	2.3E-02	7.7E-04	1.3E-03	2.1E-03	5.7E-04
N-Nitrosodi-n-butylamine	3.2E-04	1.6E+02	1.0E+03	1.0E+01	5.9E+00	7.9E+00	2.3E-01	3.9E-01	6.2E-01	1.7E-01
N-Nitrosopyrrolidine	4.9E-08	1.0E+02	1.3E+03	1.3E+01	2.6E-03	3.5E-03	1.2E-04	1.9E-04	3.1E-04	8.7E-05
o-Toluidine	2.0E-06	1.1E+02	1.2E+03	1.3E+01	1.0E-01	1.4E-01	4.5E-03	7.5E-03	1.2E-02	3.4E-03
Pyridine	1.1E-05	7.9E+01	1.4E+03	1.5E+01	6.3E-01	8.5E-01	2.8E-02	4.6E-02	7.5E-02	2.1E-02
2-Hexanone	9.3E-05	1.0E+02	1.3E+03	1.3E+01	3.6E+00	4.9E+00	1.5E-01	2.5E-01	4.0E-01	1.1E-01
Chloromethane	2.4E-02	5.1E+01	1.8E+03	1.9E+01	1.8E+01	2.5E+01	5.6E-01	9.4E-01	1.5E+00	4.2E-01
Dichlorodifluoromethane	1.0E-01	1.2E+02	1.2E+03	1.2E+01	1.2E+01	1.6E+01	4.2E-01	7.0E-01	1.1E+00	3.1E-01
Ethyl Ether	1.3E-05	7.4E+01	1.5E+03	1.5E+01	7.6E-01	1.0E+00	3.4E-02	5.6E-02	9.0E-02	2.5E-02
Trichlorofluoromethane	9.7E-02	1.4E+02	1.1E+03	1.1E+01	1.1E+01	1.5E+01	4.0E-01	6.6E-01	1.1E+00	3.0E-01
o-Chlorotoluene	3.5E-03	1.3E+02	1.1E+03	1.2E+01	1.1E+01	1.5E+01	3.9E-01	6.5E-01	1.0E+00	2.9E-01
Acrylonitrile	8.8E-05	5.3E+01	1.7E+03	1.8E+01	4.8E+00	6.4E+00	1.9E-01	3.2E-01	5.2E-01	1.4E-01
ETHYL METHACRYLATE	5.7E-04	1.1E+02	1.2E+03	1.2E+01	8.6E+00	1.2E+01	3.2E-01	5.4E-01	8.6E-01	2.4E-01
P-ISOPROPYLTOLUENE	1.1E-02	1.3E+02	1.1E+03	1.1E+01	1.1E+01	1.5E+01	4.0E-01	6.6E-01	1.1E+00	2.9E-01

TABLE A-6
CALCULATION OF THE AQUEOUS DERMAL ABSORBED (DA) FACTOR
Remedial Investigation and Feasibility Study
Sutton Brook Disposal Area Superfund Site - Tewksbury, Massachusetts

Chemical of Potential Concern	Permeability Coefficient (Kp) (cm/hour)	Tau (hour/event)	Fraction Absorbed (FA) (unitless)	Constants C2 L/cm3	2FA	Group 3-4, Facility Worker, RME te (hr/event)	pi	SQRT(6tau*t/pi)	DAfactor grp 3-4 FW	Group 3-4 Construction Worker, RME te (hr/event)	SQRT(6tau*t/pi)	DAfactor grp 3-4 CW
Antimony	1.0E-03	1.0E+00	1.0E+00	1.0E-03	2.0E+00	5.6E-03	3.1E+00		**5.6E-09**	5.0E-01		**5.0E-07**
Arsenic	1.0E-03	1.0E+00	1.0E+00	1.0E-03	2.0E+00	5.6E-03	3.1E+00		**5.6E-09**	5.0E-01		**5.0E-07**
Barium	1.0E-03	1.0E+00	1.0E+00	1.0E-03	2.0E+00	5.6E-03	3.1E+00		**5.6E-09**	5.0E-01		**5.0E-07**
Beryllium	1.0E-03	1.0E+00	1.0E+00	1.0E-03	2.0E+00	5.6E-03	3.1E+00		**5.6E-09**	5.0E-01		**5.0E-07**
Cadmium	1.0E-03	1.0E+00	1.0E+00	1.0E-03	2.0E+00	5.6E-03	3.1E+00		**5.6E-09**	5.0E-01		**5.0E-07**
Chromium	2.0E-03	1.0E+00	1.0E+00	1.0E-03	2.0E+00	5.6E-03	3.1E+00		**1.1E-08**	5.0E-01		**1.0E-06**
Cobalt	4.0E-04	1.0E+00	1.0E+00	1.0E-03	2.0E+00	5.6E-03	3.1E+00		**2.2E-09**	5.0E-01		**2.0E-07**
Copper	1.0E-03	1.0E+00	1.0E+00	1.0E-03	2.0E+00	5.6E-03	3.1E+00		**5.6E-09**	5.0E-01		**5.0E-07**
Lead	1.0E-04	1.0E+00	1.0E+00	1.0E-03	2.0E+00	5.6E-03	3.1E+00		**5.6E-10**	5.0E-01		**5.0E-08**
Manganese	1.0E-03	1.0E+00	1.0E+00	1.0E-03	2.0E+00	5.6E-03	3.1E+00		**5.6E-09**	5.0E-01		**5.0E-07**
Nickel	2.0E-04	1.0E+00	1.0E+00	1.0E-03	2.0E+00	5.6E-03	3.1E+00		**1.1E-09**	5.0E-01		**1.0E-07**
Selenium	1.0E-03	1.0E+00	1.0E+00	1.0E-03	2.0E+00	5.6E-03	3.1E+00		**5.6E-09**	5.0E-01		**5.0E-07**
Silver	6.0E-04	1.0E+00	1.0E+00	1.0E-03	2.0E+00	5.6E-03	3.1E+00		**3.3E-09**	5.0E-01		**3.0E-07**
Thallium	1.0E-03	1.0E+00	1.0E+00	1.0E-03	2.0E+00	5.6E-03	3.1E+00		**5.6E-09**	5.0E-01		**5.0E-07**
Vanadium	1.0E-03	1.0E+00	1.0E+00	1.0E-03	2.0E+00	5.6E-03	3.1E+00		**5.6E-09**	5.0E-01		**5.0E-07**
Zinc	6.0E-04	1.0E+00	1.0E+00	1.0E-03	2.0E+00	5.6E-03	3.1E+00		**3.3E-09**	5.0E-01		**3.0E-07**
Aroclor 1254	0.0E+00	4.6E+00	6.0E-01	1.0E-03	2.0E+00	5.6E-03	3.1E+00	2.2E-01	**0.0E+00**	5.0E-01	2.1E+00	**0.0E+00**
Alpha-BHC	1.6E-02	1.0E+00	1.0E+00	1.0E-03	2.0E+00	5.6E-03	3.1E+00	1.0E-01	**3.3E-06**	5.0E-01	9.8E-01	**3.1E-05**
2,4-Dimethylphenol	1.1E-02	5.2E-01	1.0E+00	1.0E-03	2.0E+00	5.6E-03	3.1E+00	7.4E-02	**1.6E-06**	5.0E-01	7.0E-01	**1.6E-05**
3-Methylphenol/4-Methylphenol	8.0E-03	4.3E-01	1.0E+00	1.0E-03	2.0E+00	5.6E-03	3.1E+00	6.8E-02	**1.1E-06**	5.0E-01	6.4E-01	**1.0E-05**
4-Methylphenol	8.0E-03	4.3E-01	1.0E+00	1.0E-03	2.0E+00	5.6E-03	3.1E+00	6.8E-02	**1.1E-06**	5.0E-01	6.4E-01	**1.0E-05**
Acetophenone	4.7E-03	1.0E+00	1.0E+00	1.0E-03	2.0E+00	5.6E-03	3.1E+00	1.0E-01	**9.6E-07**	5.0E-01	9.8E-01	**9.1E-06**
Acrylonitrile	1.2E-03	2.1E-01	1.0E+00	1.0E-03	2.0E+00	5.6E-03	3.1E+00	4.7E-02	**1.1E-07**	5.0E-01	4.5E-01	**1.1E-06**
Bis(2-Ethylhexyl)phthalate	2.4E-02	1.7E+01	8.0E-01	1.0E-03	2.0E+00	5.6E-03	3.1E+00	4.2E-01	**1.6E-05**	5.0E-01	4.0E+00	**1.5E-04**
Ethyl methacrylate	9.1E-03	1.0E+00	1.0E+00	1.0E-03	2.0E+00	5.6E-03	3.1E+00	1.0E-01	**1.9E-06**	5.0E-01	9.8E-01	**1.8E-05**
Naphthalene	4.7E-02	5.6E-01	1.0E+00	1.0E-03	2.0E+00	5.6E-03	3.1E+00	7.7E-02	**7.2E-06**	5.0E-01	7.3E-01	**6.9E-05**
N-Nitrosodi-n-butylamine	3.8E-03	8.2E-01	1.0E+00	1.0E-03	2.0E+00	5.6E-03	3.1E+00	9.3E-02	**7.1E-07**	5.0E-01	8.9E-01	**6.7E-06**
N-Nitrosopyrrolidine	3.4E-04	1.0E+00	1.0E+00	1.0E-03	2.0E+00	5.6E-03	3.1E+00	1.0E-01	**7.0E-08**	5.0E-01	9.8E-01	**6.7E-07**
o-Toluidine	3.0E-03	4.2E-01	1.0E+00	1.0E-03	2.0E+00	5.6E-03	3.1E+00	6.7E-02	**4.0E-07**	5.0E-01	6.3E-01	**3.8E-06**
Phenol	8.1E-03	3.6E-01	1.0E+00	1.0E-03	2.0E+00	5.6E-03	3.1E+00	6.2E-02	**1.0E-06**	5.0E-01	5.9E-01	**9.5E-06**
Pyridine	1.8E-03	1.0E+00	1.0E+00	1.0E-03	2.0E+00	5.6E-03	3.1E+00	1.0E-01	**3.8E-07**	5.0E-01	9.8E-01	**3.6E-06**
1,1,1-Trichloroethane	1.3E-02	6.0E-01	1.0E+00	1.0E-03	2.0E+00	5.6E-03	3.1E+00	8.0E-02	**2.1E-06**	5.0E-01	7.6E-01	**2.0E-05**
1,1,2-Trichloroethane	6.4E-03	6.0E-01	1.0E+00	1.0E-03	2.0E+00	5.6E-03	3.1E+00	8.0E-02	**1.0E-06**	5.0E-01	7.6E-01	**9.7E-06**
1,1-Dichloroethane	6.7E-03	3.8E-01	1.0E+00	1.0E-03	2.0E+00	5.6E-03	3.1E+00	6.4E-02	**8.5E-07**	5.0E-01	6.0E-01	**8.1E-06**
1,1-Dichloroethene	1.2E-02	3.7E-01	1.0E+00	1.0E-03	2.0E+00	5.6E-03	3.1E+00	6.3E-02	**1.5E-06**	5.0E-01	5.9E-01	**1.4E-05**

TABLE A-6
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Remedial Investigation and Feasibility Study
Sutton Brook Disposal Area Superfund Site - Tewksbury, Massachusetts

Chemical of Potential Concern	Permeability Coefficient (Kp) (cm/hour)	Tau (hour/event)	Fraction Absorbed (FA) (unitless)	Constants C2 L/cm3	2FA	Group 3-4, Facility Worker, RME te (hr/event)	pi	SQRT(6tau*t/pi)	DAfactor grp 3-4 FW	Group 3-4 Construction Worker, RME te (hr/event)	SQRT(6tau*t/pi)	DAfactor grp 3-4 CW
1,2,4-Trichlorobenzene	6.6E-02	1.1E+00	1.0E+00	1.0E-03	2.0E+00	5.6E-03	3.1E+00	1.1E-01	**1.4E-05**	5.0E-01	1.0E+00	**1.4E-04**
1,2,4-Trimethylbenzene	1.1E-01	1.0E+00	1.0E+00	1.0E-03	2.0E+00	5.6E-03	3.1E+00	1.0E-01	**2.3E-05**	5.0E-01	9.8E-01	**2.2E-04**
1,4-Dichlorobenzene	4.2E-02	7.1E-01	1.0E+00	1.0E-03	2.0E+00	5.6E-03	3.1E+00	8.7E-02	**7.3E-06**	5.0E-01	8.2E-01	**6.9E-05**
1,2-Dichloroethane	4.2E-03	3.8E-01	1.0E+00	1.0E-03	2.0E+00	5.6E-03	3.1E+00	6.4E-02	**5.3E-07**	5.0E-01	6.0E-01	**5.1E-06**
1,2-Dichloroethene	7.7E-03	3.7E-01	1.0E+00	1.0E-03	2.0E+00	5.6E-03	3.1E+00	6.3E-02	**9.7E-07**	5.0E-01	5.9E-01	**9.2E-06**
cis-1,2-Dichloroethene	7.7E-03	3.7E-01	1.0E+00	1.0E-03	2.0E+00	5.6E-03	3.1E+00	6.3E-02	**9.7E-07**	5.0E-01	5.9E-01	**9.2E-06**
1,2-Dichloropropane	7.8E-03	4.6E-01	1.0E+00	1.0E-03	2.0E+00	5.6E-03	3.1E+00	7.0E-02	**1.1E-06**	5.0E-01	6.6E-01	**1.0E-05**
1,3,5-Trimethylbenzene	6.1E-02	1.0E+00	1.0E+00	1.0E-03	2.0E+00	5.6E-03	3.1E+00	1.0E-01	**1.3E-05**	5.0E-01	9.8E-01	**1.2E-04**
1,4-Dioxane	3.3E-04	3.3E-01	1.0E+00	1.0E-03	2.0E+00	5.6E-03	3.1E+00	5.9E-02	**3.9E-08**	5.0E-01	5.6E-01	**3.7E-07**
2-Butanone	1.1E-03	2.7E-01	1.0E+00	1.0E-03	2.0E+00	5.6E-03	3.1E+00	5.4E-02	**1.2E-07**	5.0E-01	5.1E-01	**1.1E-06**
2-Hexanone	4.5E-03	1.0E+00	1.0E+00	1.0E-03	2.0E+00	5.6E-03	3.1E+00	1.0E-01	**9.3E-07**	5.0E-01	9.8E-01	**8.8E-06**
4-Methyl-2-pentanone	4.0E-03	3.9E-01	1.0E+00	1.0E-03	2.0E+00	5.6E-03	3.1E+00	6.4E-02	**5.1E-07**	5.0E-01	6.1E-01	**4.8E-06**
Acetone	5.2E-04	1.0E+00	1.0E+00	1.0E-03	2.0E+00	5.6E-03	3.1E+00	1.0E-01	**1.1E-07**	5.0E-01	9.8E-01	**1.0E-06**
Benzene	1.5E-02	2.9E-01	1.0E+00	1.0E-03	2.0E+00	5.6E-03	3.1E+00	5.5E-02	**1.7E-06**	5.0E-01	5.3E-01	**1.6E-05**
Carbon tetrachloride	1.6E-02	7.8E-01	1.0E+00	1.0E-03	2.0E+00	5.6E-03	3.1E+00	9.1E-02	**2.9E-06**	5.0E-01	8.6E-01	**2.8E-05**
Chlorobenzene	2.8E-02	4.6E-01	1.0E+00	1.0E-03	2.0E+00	5.6E-03	3.1E+00	7.0E-02	**3.9E-06**	5.0E-01	6.6E-01	**3.7E-05**
Chloroethane	6.1E-03	2.4E-01	1.0E+00	1.0E-03	2.0E+00	5.6E-03	3.1E+00	5.0E-02	**6.2E-07**	5.0E-01	4.8E-01	**5.8E-06**
Chloroform	6.8E-03	5.0E-01	1.0E+00	1.0E-03	2.0E+00	5.6E-03	3.1E+00	7.3E-02	**9.9E-07**	5.0E-01	6.9E-01	**9.4E-06**
Dichlorodifluoromethane	9.0E-03	5.1E-01	1.0E+00	1.0E-03	2.0E+00	5.6E-03	3.1E+00	7.4E-02	**1.3E-06**	5.0E-01	7.0E-01	**1.3E-05**
Ethyl Ether	2.3E-03	2.8E-01	1.0E+00	1.0E-03	2.0E+00	5.6E-03	3.1E+00	5.5E-02	**2.5E-07**	5.0E-01	5.2E-01	**2.4E-06**
Ethylbenzene	4.9E-02	4.2E-01	1.0E+00	1.0E-03	2.0E+00	5.6E-03	3.1E+00	6.7E-02	**6.5E-06**	5.0E-01	6.3E-01	**6.2E-05**
Isopropylbenzene	7.0E-02	1.0E+00	1.0E+00	1.0E-03	2.0E+00	5.6E-03	3.1E+00	1.0E-01	**1.4E-05**	5.0E-01	9.8E-01	**1.4E-04**
Methylene Chloride	3.5E-03	3.2E-01	1.0E+00	1.0E-03	2.0E+00	5.6E-03	3.1E+00	5.8E-02	**4.1E-07**	5.0E-01	5.5E-01	**3.9E-06**
2-Methylnaphthalene	4.7E-02	5.6E-01	1.0E+00	1.0E-03	2.0E+00	5.6E-03	3.1E+00	7.7E-02	**7.2E-06**	5.0E-01	7.3E-01	**6.9E-05**
n-Propylbenzene	9.2E-02	1.0E+00	1.0E+00	1.0E-03	2.0E+00	5.6E-03	3.1E+00	1.0E-01	**1.9E-05**	5.0E-01	9.8E-01	**1.8E-04**
p-Isopropyltoluene	1.4E-01	1.0E+00	1.0E+00	1.0E-03	2.0E+00	5.6E-03	3.1E+00	1.0E-01	**2.9E-05**	5.0E-01	9.8E-01	**2.7E-04**
Styrene	3.7E-02	4.1E-01	1.0E+00	1.0E-03	2.0E+00	5.6E-03	3.1E+00	6.6E-02	**4.9E-06**	5.0E-01	6.3E-01	**4.6E-05**
n-Butylbenzene	1.8E-01	1.0E+00	1.0E+00	1.0E-03	2.0E+00	5.6E-03	3.1E+00	1.0E-01	**3.7E-05**	5.0E-01	9.8E-01	**3.5E-04**
tert-Butylbenzene	1.4E-01	1.0E+00	1.0E+00	1.0E-03	2.0E+00	5.6E-03	3.1E+00	1.0E-01	**2.9E-05**	5.0E-01	9.8E-01	**2.7E-04**
Tetrachloroethene	3.3E-02	9.1E-01	1.0E+00	1.0E-03	2.0E+00	5.6E-03	3.1E+00	9.8E-02	**6.5E-06**	5.0E-01	9.3E-01	**6.2E-05**
Tetrahydrofuran	1.3E-03	1.0E+00	1.0E+00	1.0E-03	2.0E+00	5.6E-03	3.1E+00	1.0E-01	**2.7E-07**	5.0E-01	9.8E-01	**2.5E-06**
Toluene	3.1E-02	3.5E-01	1.0E+00	1.0E-03	2.0E+00	5.6E-03	3.1E+00	6.1E-02	**3.8E-06**	5.0E-01	5.8E-01	**3.6E-05**
Trichloroethene	1.2E-02	5.8E-01	1.0E+00	1.0E-03	2.0E+00	5.6E-03	3.1E+00	7.8E-02	**1.9E-06**	5.0E-01	7.4E-01	**1.8E-05**
Trichlorofluoromethane	1.3E-02	6.3E-01	1.0E+00	1.0E-03	2.0E+00	5.6E-03	3.1E+00	8.2E-02	**2.1E-06**	5.0E-01	7.8E-01	**2.0E-05**
Vinyl chloride	5.6E-03	2.4E-01	1.0E+00	1.0E-03	2.0E+00	5.6E-03	3.1E+00	5.0E-02	**5.7E-07**	5.0E-01	4.8E-01	**5.4E-06**
Xylenes (total)	7.0E-02	4.2E-01	1.0E+00	1.0E-03	2.0E+00	5.6E-03	3.1E+00	6.7E-02	**9.4E-06**	5.0E-01	6.3E-01	**8.9E-05**

Notes:

1. ADI_{dermal} (mg/kg-d) = DA_{event} * EV * EF * ED * SA * 1/BW * 1/AT * 1/C1

   Where for inorganics: DA_{event} = EPC * Kp * C2 * t-e

   Where for organics: DA_{event} = EPC * 2 FA * Kp * C2 * SQRT{(6 * tau-event * t-e)/pi}

   (short-duration exposures)

   and DA_{event} = EPC * FA * Kp * C2 * [(t-event/1 + B) + 2 tau-event $\{(1 + 3 B + 3 B^2)/(1 + B)^2\}$]

   (long-duration exposures)

2. DA_{factor} includes all above variables except for the groundwater EPC. (DA_{factor} = DA_{event} / EPC)

3. CT = Central Tendency; RME = Reasonable Maximum Exposure; EPC = groundwater exposure point concentration

TABLE A-6
CALCULATION OF THE AQUEOUS DERMAL ABSORBED (DA) FACTOR
Remedial Investigation and Feasibility Study
Sutton Brook Disposal Area Superfund Site - Tewksbury, Massachusetts

Chemical of Potential Concern	Permeability Coefficient (Kp) (cm/hour)	Tau (hour/event)	Fraction Absorbed (FA) (unitless)	Constants C2 L/cm3	2FA	Group 3-4 Resident, RME te 1-6yr (hr/event)	te 7-31yr (hr/event)	1-6yr SQRT(6tau*t/pi)	7-31yr SQRT(6tau*t/pi)	DAfactor grp 3-4 Res NC	DAfactor grp 3-4 Res C	Group 5 Trespasser/Future Resident, RME te (hr/event)	SQRT(6tau*t/pi)	DAfactor grp 5 TP/FR
Antimony	1.0E-03	1.0E+00	1.0E+00	1.0E-03	2.0E+00	1.0E+00	5.8E-01			**1.0E-06**	**5.8E-07**	1.0E+00		**1.0E-06**
Arsenic	1.0E-03	1.0E+00	1.0E+00	1.0E-03	2.0E+00	1.0E+00	5.8E-01			**1.0E-06**	**5.8E-07**	1.0E+00		**1.0E-06**
Barium	1.0E-03	1.0E+00	1.0E+00	1.0E-03	2.0E+00	1.0E+00	5.8E-01			**1.0E-06**	**5.8E-07**	1.0E+00		**1.0E-06**
Beryllium	1.0E-03	1.0E+00	1.0E+00	1.0E-03	2.0E+00	1.0E+00	5.8E-01			**1.0E-06**	**5.8E-07**	1.0E+00		**1.0E-06**
Cadmium	1.0E-03	1.0E+00	1.0E+00	1.0E-03	2.0E+00	1.0E+00	5.8E-01			**1.0E-06**	**5.8E-07**	1.0E+00		**1.0E-06**
Chromium	2.0E-03	1.0E+00	1.0E+00	1.0E-03	2.0E+00	1.0E+00	5.8E-01			**2.0E-06**	**1.2E-06**	1.0E+00		**2.0E-06**
Cobalt	4.0E-04	1.0E+00	1.0E+00	1.0E-03	2.0E+00	1.0E+00	5.8E-01			**4.0E-07**	**2.3E-07**	1.0E+00		**4.0E-07**
Copper	1.0E-03	1.0E+00	1.0E+00	1.0E-03	2.0E+00	1.0E+00	5.8E-01			**1.0E-06**	**5.8E-07**	1.0E+00		**1.0E-06**
Lead	1.0E-04	1.0E+00	1.0E+00	1.0E-03	2.0E+00	1.0E+00	5.8E-01			**1.0E-07**	**5.8E-08**	1.0E+00		**1.0E-07**
Manganese	1.0E-03	1.0E+00	1.0E+00	1.0E-03	2.0E+00	1.0E+00	5.8E-01			**1.0E-06**	**5.8E-07**	1.0E+00		**1.0E-06**
Nickel	2.0E-04	1.0E+00	1.0E+00	1.0E-03	2.0E+00	1.0E+00	5.8E-01			**2.0E-07**	**1.2E-07**	1.0E+00		**2.0E-07**
Selenium	1.0E-03	1.0E+00	1.0E+00	1.0E-03	2.0E+00	1.0E+00	5.8E-01			**1.0E-06**	**5.8E-07**	1.0E+00		**1.0E-06**
Silver	6.0E-04	1.0E+00	1.0E+00	1.0E-03	2.0E+00	1.0E+00	5.8E-01			**6.0E-07**	**3.5E-07**	1.0E+00		**6.0E-07**
Thallium	1.0E-03	1.0E+00	1.0E+00	1.0E-03	2.0E+00	1.0E+00	5.8E-01			**1.0E-06**	**5.8E-07**	1.0E+00		**1.0E-06**
Vanadium	1.0E-03	1.0E+00	1.0E+00	1.0E-03	2.0E+00	1.0E+00	5.8E-01			**1.0E-06**	**5.8E-07**	1.0E+00		**1.0E-06**
Zinc	6.0E-04	1.0E+00	1.0E+00	1.0E-03	2.0E+00	1.0E+00	5.8E-01			**6.0E-07**	**3.5E-07**	1.0E+00		**6.0E-07**
Aroclor 1254	0.0E+00	4.6E+00	6.0E-01	1.0E-03	2.0E+00	1.0E+00	5.8E-01	3.0E+00	2.3E+00	**0.0E+00**	**0.0E+00**	1.0E+00	3.0E+00	**0.0E+00**
Alpha-BHC	1.6E-02	1.0E+00	1.0E+00	1.0E-03	2.0E+00	1.0E+00	5.8E-01	1.4E+00	1.1E+00	**4.4E-05**	**3.4E-05**	1.0E+00	1.4E+00	**4.4E-05**
2,4-Dimethylphenol	1.1E-02	5.2E-01	1.0E+00	1.0E-03	2.0E+00	1.0E+00	5.8E-01	1.0E+00	7.6E-01	**2.2E-05**	**1.7E-05**	1.0E+00	1.0E+00	**2.2E-05**
3-Methylphenol/4-Methylphenol	8.0E-03	4.3E-01	1.0E+00	1.0E-03	2.0E+00	1.0E+00	5.8E-01	9.1E-01	6.9E-01	**1.5E-05**	**1.1E-05**	1.0E+00	9.1E-01	**1.5E-05**
4-Methylphenol	8.0E-03	4.3E-01	1.0E+00	1.0E-03	2.0E+00	1.0E+00	5.8E-01	9.1E-01	6.9E-01	**1.5E-05**	**1.1E-05**	1.0E+00	9.1E-01	**1.5E-05**
Acetophenone	4.7E-03	1.0E+00	1.0E+00	1.0E-03	2.0E+00	1.0E+00	5.8E-01	1.4E+00	1.1E+00	**1.3E-05**	**9.8E-06**	1.0E+00	1.4E+00	**1.3E-05**
Acrylonitrile	1.2E-03	2.1E-01	1.0E+00	1.0E-03	2.0E+00	1.0E+00	5.8E-01	6.3E-01	4.8E-01	**1.5E-06**	**1.2E-06**	1.0E+00	6.3E-01	**1.5E-06**
Bis(2-Ethylhexyl)phthalate	2.4E-02	1.7E+01	8.0E-01	1.0E-03	2.0E+00	1.0E+00	5.8E-01	5.6E+00	4.3E+00	**2.2E-04**	**1.6E-04**	1.0E+00	5.6E+00	**2.2E-04**
Ethyl methacrylate	9.1E-03	1.0E+00	1.0E+00	1.0E-03	2.0E+00	1.0E+00	5.8E-01	1.4E+00	1.1E+00	**2.5E-05**	**1.9E-05**	1.0E+00	1.4E+00	**2.5E-05**
Naphthalene	4.7E-02	5.6E-01	1.0E+00	1.0E-03	2.0E+00	1.0E+00	5.8E-01	1.0E+00	7.9E-01	**9.7E-05**	**7.4E-05**	1.0E+00	1.0E+00	**9.7E-05**
N-Nitrosodi-n-butylamine	3.8E-03	8.2E-01	1.0E+00	1.0E-03	2.0E+00	1.0E+00	5.8E-01	1.3E+00	9.5E-01	**9.5E-06**	**7.2E-06**	1.0E+00	1.3E+00	**9.5E-06**
N-Nitrosopyrrolidine	3.4E-04	1.0E+00	1.0E+00	1.0E-03	2.0E+00	1.0E+00	5.8E-01	1.4E+00	1.1E+00	**9.5E-07**	**7.2E-07**	1.0E+00	1.4E+00	**9.5E-07**
o-Toluidine	3.0E-03	4.2E-01	1.0E+00	1.0E-03	2.0E+00	1.0E+00	5.8E-01	9.0E-01	6.8E-01	**5.4E-06**	**4.1E-06**	1.0E+00	9.0E-01	**5.4E-06**
Phenol	8.1E-03	3.6E-01	1.0E+00	1.0E-03	2.0E+00	1.0E+00	5.8E-01	8.3E-01	6.3E-01	**1.3E-05**	**1.0E-05**	1.0E+00	8.3E-01	**1.3E-05**
Pyridine	1.8E-03	1.0E+00	1.0E+00	1.0E-03	2.0E+00	1.0E+00	5.8E-01	1.4E+00	1.1E+00	**5.0E-06**	**3.8E-06**	1.0E+00	1.4E+00	**5.0E-06**
1,1,1-Trichloroethane	1.3E-02	6.0E-01	1.0E+00	1.0E-03	2.0E+00	1.0E+00	5.8E-01	1.1E+00	8.2E-01	**2.8E-05**	**2.1E-05**	1.0E+00	1.1E+00	**2.8E-05**
1,1,2-Trichloroethane	6.4E-03	6.0E-01	1.0E+00	1.0E-03	2.0E+00	1.0E+00	5.8E-01	1.1E+00	8.2E-01	**1.4E-05**	**1.0E-05**	1.0E+00	1.1E+00	**1.4E-05**
1,1-Dichloroethane	6.7E-03	3.8E-01	1.0E+00	1.0E-03	2.0E+00	1.0E+00	5.8E-01	8.5E-01	6.5E-01	**1.1E-05**	**8.7E-06**	1.0E+00	8.5E-01	**1.1E-05**
1,1-Dichloroethene	1.2E-02	3.7E-01	1.0E+00	1.0E-03	2.0E+00	1.0E+00	5.8E-01	8.4E-01	6.4E-01	**2.0E-05**	**1.5E-05**	1.0E+00	8.4E-01	**2.0E-05**

TABLE A-6
CALCULATION OF THE AQUEOUS DERMAL ABSORBED (DA) FACTOR
Remedial Investigation and Feasibility Study
Sutton Brook Disposal Area Superfund Site - Tewksbury, Massachusetts

Chemical of Potential Concern	Permeability Coefficient (Kp) (cm/hour)	Tau (hour/event)	Fraction Absorbed (FA) (unitless)	Constants C2 L/cm3	2FA	Group 3-4 Resident, RME te 1-6yr (hr/event)	te 7-31yr (hr/event)	1-6yr SQRT(6tau*t/pi)	7-31yr SQRT(6tau*t/pi)	DAfactor grp 3-4 Res NC	DAfactor grp 3-4 Res C	Group 5 Trespasser/Future Resident, RME te (hr/event)	SQRT(6tau*t/pi)	DAfactor grp 5 TP/FR
1,2,4-Trichlorobenzene	6.6E-02	1.1E+00	1.0E+00	1.0E-03	2.0E+00	1.0E+00	5.8E-01	1.5E+00	1.1E+00	**1.9E-04**	**1.5E-04**	1.0E+00	1.5E+00	**1.9E-04**
1,2,4-Trimethylbenzene	1.1E-01	1.0E+00	1.0E+00	1.0E-03	2.0E+00	1.0E+00	5.8E-01	1.4E+00	1.1E+00	**3.0E-04**	**2.3E-04**	1.0E+00	1.4E+00	**3.0E-04**
1,4-Dichlorobenzene	4.2E-02	7.1E-01	1.0E+00	1.0E-03	2.0E+00	1.0E+00	5.8E-01	1.2E+00	8.9E-01	**9.8E-05**	**7.5E-05**	1.0E+00	1.2E+00	**9.8E-05**
1,2-Dichloroethane	4.2E-03	3.8E-01	1.0E+00	1.0E-03	2.0E+00	1.0E+00	5.8E-01	8.5E-01	6.5E-01	**7.2E-06**	**5.5E-06**	1.0E+00	8.5E-01	**7.2E-06**
1,2-Dichloroethene	7.7E-03	3.7E-01	1.0E+00	1.0E-03	2.0E+00	1.0E+00	5.8E-01	8.4E-01	6.4E-01	**1.3E-05**	**9.9E-06**	1.0E+00	8.4E-01	**1.3E-05**
cis-1,2-Dichloroethene	7.7E-03	3.7E-01	1.0E+00	1.0E-03	2.0E+00	1.0E+00	5.8E-01	8.4E-01	6.4E-01	**1.3E-05**	**9.9E-06**	1.0E+00	8.4E-01	**1.3E-05**
1,2-Dichloropropane	7.8E-03	4.6E-01	1.0E+00	1.0E-03	2.0E+00	1.0E+00	5.8E-01	9.4E-01	7.1E-01	**1.5E-05**	**1.1E-05**	1.0E+00	9.4E-01	**1.5E-05**
1,3,5-Trimethylbenzene	6.1E-02	1.0E+00	1.0E+00	1.0E-03	2.0E+00	1.0E+00	5.8E-01	1.4E+00	1.1E+00	**1.7E-04**	**1.3E-04**	1.0E+00	1.4E+00	**1.7E-04**
1,4-Dioxane	3.3E-04	3.3E-01	1.0E+00	1.0E-03	2.0E+00	1.0E+00	5.8E-01	7.9E-01	6.0E-01	**5.2E-07**	**4.0E-07**	1.0E+00	7.9E-01	**5.2E-07**
2-Butanone	1.1E-03	2.7E-01	1.0E+00	1.0E-03	2.0E+00	1.0E+00	5.8E-01	7.2E-01	5.5E-01	**1.6E-06**	**1.2E-06**	1.0E+00	7.2E-01	**1.6E-06**
2-Hexanone	4.5E-03	1.0E+00	1.0E+00	1.0E-03	2.0E+00	1.0E+00	5.8E-01	1.4E+00	1.1E+00	**1.2E-05**	**9.5E-06**	1.0E+00	1.4E+00	**1.2E-05**
4-Methyl-2-pentanone	4.0E-03	3.9E-01	1.0E+00	1.0E-03	2.0E+00	1.0E+00	5.8E-01	8.6E-01	6.6E-01	**6.9E-06**	**5.2E-06**	1.0E+00	8.6E-01	**6.9E-06**
Acetone	5.2E-04	1.0E+00	1.0E+00	1.0E-03	2.0E+00	1.0E+00	5.8E-01	1.4E+00	1.1E+00	**1.4E-06**	**1.1E-06**	1.0E+00	1.4E+00	**1.4E-06**
Benzene	1.5E-02	2.9E-01	1.0E+00	1.0E-03	2.0E+00	1.0E+00	5.8E-01	7.4E-01	5.7E-01	**2.2E-05**	**1.7E-05**	1.0E+00	7.4E-01	**2.2E-05**
Carbon tetrachloride	1.6E-02	7.8E-01	1.0E+00	1.0E-03	2.0E+00	1.0E+00	5.8E-01	1.2E+00	9.3E-01	**3.9E-05**	**3.0E-05**	1.0E+00	1.2E+00	**3.9E-05**
Chlorobenzene	2.8E-02	4.6E-01	1.0E+00	1.0E-03	2.0E+00	1.0E+00	5.8E-01	9.4E-01	7.1E-01	**5.3E-05**	**4.0E-05**	1.0E+00	9.4E-01	**5.3E-05**
Chloroethane	6.1E-03	2.4E-01	1.0E+00	1.0E-03	2.0E+00	1.0E+00	5.8E-01	6.8E-01	5.2E-01	**8.3E-06**	**6.3E-06**	1.0E+00	6.8E-01	**8.3E-06**
Chloroform	6.8E-03	5.0E-01	1.0E+00	1.0E-03	2.0E+00	1.0E+00	5.8E-01	9.8E-01	7.4E-01	**1.3E-05**	**1.0E-05**	1.0E+00	9.8E-01	**1.3E-05**
Dichlorodifluoromethane	9.0E-03	5.1E-01	1.0E+00	1.0E-03	2.0E+00	1.0E+00	5.8E-01	9.9E-01	7.5E-01	**1.8E-05**	**1.4E-05**	1.0E+00	9.9E-01	**1.8E-05**
Ethyl Ether	2.3E-03	2.8E-01	1.0E+00	1.0E-03	2.0E+00	1.0E+00	5.8E-01	7.3E-01	5.6E-01	**3.4E-06**	**2.6E-06**	1.0E+00	7.3E-01	**3.4E-06**
Ethylbenzene	4.9E-02	4.2E-01	1.0E+00	1.0E-03	2.0E+00	1.0E+00	5.8E-01	9.0E-01	6.8E-01	**8.8E-05**	**6.7E-05**	1.0E+00	9.0E-01	**8.8E-05**
Isopropylbenzene	7.0E-02	1.0E+00	1.0E+00	1.0E-03	2.0E+00	1.0E+00	5.8E-01	1.4E+00	1.1E+00	**1.9E-04**	**1.5E-04**	1.0E+00	1.4E+00	**1.9E-04**
Methylene Chloride	3.5E-03	3.2E-01	1.0E+00	1.0E-03	2.0E+00	1.0E+00	5.8E-01	7.8E-01	6.0E-01	**5.5E-06**	**4.2E-06**	1.0E+00	7.8E-01	**5.5E-06**
2-Methylnaphthalene	4.7E-02	5.6E-01	1.0E+00	1.0E-03	2.0E+00	1.0E+00	5.8E-01	1.0E+00	7.9E-01	**9.7E-05**	**7.4E-05**	1.0E+00	1.0E+00	**9.7E-05**
n-Propylbenzene	9.2E-02	1.0E+00	1.0E+00	1.0E-03	2.0E+00	1.0E+00	5.8E-01	1.4E+00	1.1E+00	**2.5E-04**	**1.9E-04**	1.0E+00	1.4E+00	**2.5E-04**
p-Isopropyltoluene	1.4E-01	1.0E+00	1.0E+00	1.0E-03	2.0E+00	1.0E+00	5.8E-01	1.4E+00	1.1E+00	**3.9E-04**	**2.9E-04**	1.0E+00	1.4E+00	**3.9E-04**
Styrene	3.7E-02	4.1E-01	1.0E+00	1.0E-03	2.0E+00	1.0E+00	5.8E-01	8.9E-01	6.7E-01	**6.5E-05**	**5.0E-05**	1.0E+00	8.9E-01	**6.5E-05**
n-Butylbenzene	1.8E-01	1.0E+00	1.0E+00	1.0E-03	2.0E+00	1.0E+00	5.8E-01	1.4E+00	1.1E+00	**5.0E-04**	**3.8E-04**	1.0E+00	1.4E+00	**5.0E-04**
tert-Butylbenzene	1.4E-01	1.0E+00	1.0E+00	1.0E-03	2.0E+00	1.0E+00	5.8E-01	1.4E+00	1.1E+00	**3.9E-04**	**2.9E-04**	1.0E+00	1.4E+00	**3.9E-04**
Tetrachloroethene	3.3E-02	9.1E-01	1.0E+00	1.0E-03	2.0E+00	1.0E+00	5.8E-01	1.3E+00	1.0E+00	**8.7E-05**	**6.6E-05**	1.0E+00	1.3E+00	**8.7E-05**
Tetrahydrofuran	1.3E-03	1.0E+00	1.0E+00	1.0E-03	2.0E+00	1.0E+00	5.8E-01	1.4E+00	1.1E+00	**3.6E-06**	**2.7E-06**	1.0E+00	1.4E+00	**3.6E-06**
Toluene	3.1E-02	3.5E-01	1.0E+00	1.0E-03	2.0E+00	1.0E+00	5.8E-01	8.2E-01	6.2E-01	**5.1E-05**	**3.9E-05**	1.0E+00	8.2E-01	**5.1E-05**
Trichloroethene	1.2E-02	5.8E-01	1.0E+00	1.0E-03	2.0E+00	1.0E+00	5.8E-01	1.1E+00	8.0E-01	**2.5E-05**	**1.9E-05**	1.0E+00	1.1E+00	**2.5E-05**
Trichlorofluoromethane	1.3E-02	6.3E-01	1.0E+00	1.0E-03	2.0E+00	1.0E+00	5.8E-01	1.1E+00	8.4E-01	**2.9E-05**	**2.2E-05**	1.0E+00	1.1E+00	**2.9E-05**
Vinyl chloride	5.6E-03	2.4E-01	1.0E+00	1.0E-03	2.0E+00	1.0E+00	5.8E-01	6.8E-01	5.2E-01	**7.6E-06**	**5.8E-06**	1.0E+00	6.8E-01	**7.6E-06**
Xylenes (total)	7.0E-02	4.2E-01	1.0E+00	1.0E-03	2.0E+00	1.0E+00	5.8E-01	9.0E-01	6.8E-01	**1.3E-04**	**9.6E-05**	1.0E+00	9.0E-01	**1.3E-04**

Notes:

1. ADI_{dermal} (mg/kg-d) = DA_{event} * EV * EF * ED * SA * 1/BW * 1/AT * 1/C1

   Where for inorganics: DA_{event} = EPC * Kp * C2 * t-e

   Where for organics: DA_{event} = EPC * 2 FA * Kp * C2 * SQRT{(6 * tau-event * t-e)/pi}
   (short-duration exposures)

   and DA_{event} = EPC * FA * Kp * C2 * [(t-event/1 + B) + 2 tau-event {(1 + 3 B + 3]
   (long-duration exposures)

2. DA_{factor} includes all above variables except for the groundwater EPC. (DA_{factor} = DA_{event} / EPC)

3. CT = Central Tendency; RME = Reasonable Maximum Exposure; EPC = groundwater exposure point concentration

APPENDIX A-7
CALCULATION OF CANCER RISKS AND RISK-BASED CLEANUP GOALS FOR COPCS WITH A MUTAGENIC MODE OF ACTION
REASONABLE MAXIMUM EXPOSURE
Remedial Investigation and Feasibility Study
Sutton Brook Disposal Area Superfund Site - Tewksbury, Massachusetts

Exposure Point:	Site
Exposure Medium:	Upland Soil (0-10')
Receptor:	Future Site Resident

Exposure Pathway	COPC	EPC (mg/kg)	Age (years)	BW (kg)	IR (mg/day)	EF (days/year)	ED (years)	AT (days)	CF (kg/mg)	SF (mg/kg-d)-1	ADAF (unitless)	Risk
Incidental Ingestion of Soil	Benzo(a)anthracene	38.0	1 through <2	15	200	150	1	25550	1.00E-06	0.73	10	2.2E-05
		38.0	2 through <6	15	200	150	4	25550	1.00E-06	0.73	3	2.6E-05
		38.0	6 through <16	45	100	150	10	25550	1.00E-06	0.73	3	1.1E-05
		38.0	16-31	70	100	150	15	25550	1.00E-06	0.73	1	3.5E-06
	CUMULATIVE RISK - Incidental Ingestion of Soil:Benzo(a)anthracene											*6.2E-05*
	Benzo(a)pyrene	22.8	1 through <2	15	200	150	1	25550	1.00E-06	7.3	10	1.3E-04
		22.8	2 through <6	15	200	150	4	25550	1.00E-06	7.3	3	1.6E-04
		22.8	6 through <16	45	100	150	10	25550	1.00E-06	7.3	3	6.5E-05
		22.8	16-31	70	100	150	15	25550	1.00E-06	7.3	1	2.1E-05
	CUMULATIVE RISK - Incidental Ingestion of Soil:Benzo(a)pyrene											*3.7E-04*
	Benzo(b)fluoranthene	16.1	1 through <2	15	200	150	1	25550	1.00E-06	0.73	10	9.2E-06
		16.1	2 through <6	15	200	150	4	25550	1.00E-06	0.73	3	1.1E-05
		16.1	6 through <16	45	100	150	10	25550	1.00E-06	0.73	3	4.6E-06
		16.1	16-31	70	100	150	15	25550	1.00E-06	0.73	1	1.5E-06
	CUMULATIVE RISK - Incidental Ingestion of Soil:Benzo(b)fluoranthene											*2.6E-05*
	Benzo(k)fluoranthene	20.3	1 through <2	15	200	150	1	25550	1.00E-06	0.073	10	1.2E-06
		20.3	2 through <6	15	200	150	4	25550	1.00E-06	0.073	3	1.4E-06
		20.3	6 through <16	45	100	150	10	25550	1.00E-06	0.073	3	5.8E-07
		20.3	16-31	70	100	150	15	25550	1.00E-06	0.073	1	1.9E-07
	CUMULATIVE RISK - Incidental Ingestion of Soil:Benzo(k)fluoranthene											*3.3E-06*
	Dibenzo(a,h)anthracene	3.88	1 through <2	15	200	150	1	25550	1.00E-06	7.3	10	2.2E-05
		3.88	2 through <6	15	200	150	4	25550	1.00E-06	7.3	3	2.7E-05
		3.88	6 through <16	45	100	150	10	25550	1.00E-06	7.3	3	1.1E-05
		3.88	16-31	70	100	150	15	25550	1.00E-06	7.3	1	3.6E-06
	CUMULATIVE RISK - Incidental Ingestion of Soil:Dibenzo(a,h)anthracene											*6.3E-05*
	Indeno(1,2,3-cd)pyrene	8.49	1 through <2	15	200	150	1	25550	1.00E-06	0.73	10	4.9E-06
		8.49	2 through <6	15	200	150	4	25550	1.00E-06	0.73	3	5.8E-06
		8.49	6 through <16	45	100	150	10	25550	1.00E-06	0.73	3	2.4E-06
		8.49	16-31	70	100	150	15	25550	1.00E-06	0.73	1	7.8E-07
	CUMULATIVE RISK - Incidental Ingestion of Soil:Indeno(1,2,3-cd)pyrene											*1.4E-05*
	CUMULATIVE RISK: Incidental Ingestion of Soil											**5.4E-04**

Exposure Pathway	COPC	EPC (mg/kg)	Age (years)	BW (kg)	SA (cm2)	ABSd (unitless)	AF mg/cm^2	EF (days/year)	ED (years)	AT (days)	CF (kg/mg)	SF (mg/kg-d)-1	ADAF (unitless)	Risk
Dermal Contact with Soil	Benzo(a)anthracene	38.0	1 through <2	15	2800	0.13	0.2	150	1	25550	1.00E-06	0.73	10	7.9E-06
		38.0	2 through <6	15	2800	0.13	0.2	150	4	25550	1.00E-06	0.73	3	9.5E-06
		38.0	6 through <16	45	5700	0.13	0.07	150	10	25550	1.00E-06	0.73	3	5.6E-06
		38.0	16-31	70	5700	0.13	0.07	150	15	25550	1.00E-06	0.73	1	1.8E-06
	CUMULATIVE RISK - Dermal Contact with Soil:Benzo(a)anthracene													*2.5E-05*
	Benzo(a)pyrene	22.8	1 through <2	15	2800	0.13	0.2	150	1	25550	1.00E-06	7.3	10	4.7E-05
		22.8	2 through <6	15	2800	0.13	0.2	150	4	25550	1.00E-06	7.3	3	5.7E-05
		22.8	6 through <16	45	5700	0.13	0.07	150	10	25550	1.00E-06	7.3	3	3.4E-05
		22.8	16-31	70	5700	0.13	0.07	150	15	25550	1.00E-06	7.3	1	1.1E-05
	CUMULATIVE RISK - Dermal Contact with Soil:Benzo(a)pyrene													*1.5E-04*
	Benzo(b)fluoranthene	16.1	1 through <2	15	2800	0.13	0.2	150	1	25550	1.00E-06	0.73	10	3.3E-06
		16.1	2 through <6	15	2800	0.13	0.2	150	4	25550	1.00E-06	0.73	3	4.0E-06
		16.1	6 through <16	45	5700	0.13	0.07	150	10	25550	1.00E-06	0.73	3	2.4E-06
		16.1	16-31	70	5700	0.13	0.07	150	15	25550	1.00E-06	0.73	1	7.7E-07
	CUMULATIVE RISK - Dermal Contact with Soil:Benzo(b)fluoranthene													*1.1E-05*
	Benzo(k)fluoranthene	20.3	1 through <2	15	2800	0.13	0.2	150	1	25550	1.00E-06	0.073	10	4.2E-07
		20.3	2 through <6	15	2800	0.13	0.2	150	4	25550	1.00E-06	0.073	3	5.1E-07
		20.3	6 through <16	45	5700	0.13	0.07	150	10	25550	1.00E-06	0.073	3	3.0E-07
		20.3	16-31	70	5700	0.13	0.07	150	15	25550	1.00E-06	0.073	1	9.7E-08
	CUMULATIVE RISK - Dermal Contact with Soil:Benzo(k)fluoranthene													*1.3E-06*
	Dibenzo(a,h)anthracene	3.88	1 through <2	15	2800	0.13	0.2	150	1	25550	1.00E-06	7.3	10	8.1E-06
		3.88	2 through <6	15	2800	0.13	0.2	150	4	25550	1.00E-06	7.3	3	9.7E-06
		3.88	6 through <16	45	5700	0.13	0.07	150	10	25550	1.00E-06	7.3	3	5.8E-06
		3.88	16-31	70	5700	0.13	0.07	150	15	25550	1.00E-06	7.3	1	1.8E-06
	CUMULATIVE RISK - Dermal Contact with Soil:Dibenzo(a,h)anthracene													*2.5E-05*
	Indeno(1,2,3-cd)pyrene	8.49	1 through <2	15	2800	0.13	0.2	150	1	25550	1.00E-06	0.73	10	1.8E-06
		8.49	2 through <6	15	2800	0.13	0.2	150	4	25550	1.00E-06	0.73	3	2.1E-06
		8.49	6 through <16	45	5700	0.13	0.07	150	10	25550	1.00E-06	0.73	3	1.3E-06
		8.49	16-31	70	5700	0.13	0.07	150	15	25550	1.00E-06	0.73	1	4.0E-07
	CUMULATIVE RISK - Dermal Contact with Soil:Indeno(1,2,3-cd)pyrene													*5.5E-06*
	CUMULATIVE RISK: Dermal Contact with Soil													**2.2E-04**
CUMULATIVE RISK, Site, Upland Soil (0-10') : Future Site Resident														**7.6E-04**

Notes:
COPC = chemical of potential concern; BW = body weight; IR = soil or sediment ingestion rate; EF = exposure frequency; ED = exposure duration; AT = averaging time; CF = units conversion factor;
SA = skin surface area; AF =skin-soil adherence factor; ABSd = dermal absorption fraction; SF = oral/dermal cancer slope factor; ADAF = age-dependent adjustment factor (USEPA 2005);
Risk = Incremental lifetime cancer risk.

Incidental Ingestion: Risk = EPC * IR * EF * ED * CF * SF * ADAF *1/BW * 1/AT
Dermal Contact: Risk = EPC * SA * AF * ABSd * EF * ED * CF * SF * ADAF *1/BW * 1/AT

Derivation of Risk-Based Cleanup Levels for Upland Soil, Residential Exposures (RME)

Target RBCG (mg/kg) = EPC * Target Risk / Cumulative Risk

	EPC	Cumulative Risk	TARGET RBCG
Benzo(a)anthracene:	38.00	8.7E-05	**4E-01**
Benzo(a)pyrene:	22.80	5.2E-04	**4E-02**
Benzo(b)fluoranthene:	16.100	3.7E-05	**4E-01**
Benzo(k)fluoranthene:	20.3	4.6E-06	**4E+00**
Dibenzo(a,h)anthracene:	3.88	8.9E-05	**4E-02**
Indeno(1,2,3-cd)pyrene:	8.490	1.9E-05	**4E-01**
Target Cancer Risk:		**1E-06**	

TABLE A-8

DERMAL ABSORPTION FRACTIONS FOR SOIL

Remedial Investigation and Feasibility Study

Sutton Brook Disposal Area Superfund Site - Tewksbury, Massachusetts

Chemical of Potential Concern	Dermal Absorption Fraction from Soil	Source*
Organics		
1,1,1-Trichloroethane		Not available*
1,1,2-Trichloroethane		Not available*
1,1-Dichloroethane		Not available*
1,1-Dichloroethene		Not available*
1,2,4-Trimethylbenzene		Not available*
1,2-Dichloroethane		Not available*
1,2-Dichloroethene		Not available*
1,2-Dichloropropane		Not available*
1,3,5-Trimethylbenzene		Not available*
1,4-Dichlorobenzene		Not available*
1,4-Dioxane		Not available*
1-Methylnaphthalene	1.30E-01	Default for PAHs; USEPA 2004
2,4-Dimethylphenol	1.00E-01	Default for SVOCs; USEPA 2004
2-Butanone		Not available*
2-Methylnaphthalene	1.30E-01	Default for PAHs; USEPA 2004
2-Methylphenol	1.00E-01	Default for SVOCs; USEPA 2004
3-Methylphenol/4-Methylphenol	1.00E-01	Default for SVOCs; USEPA 2004
4-Chloro-3-methylphenol	1.00E-01	Default for SVOCs; USEPA 2004
4-Methyl-2-pentanone		Not available*
4-Methylphenol	1.00E-01	Default for SVOCs; USEPA 2004
Acetone		Not available*
Alpha-BHC	1.00E-01	Default for SVOCs; USEPA 2004
Aroclor 1254	1.40E-01	Value from USEPA 2004
Benzene		Not available*
Benzo(a)anthracene	1.30E-01	Default for PAHs; USEPA 2004
Benzo(a)pyrene	1.30E-01	Default for PAHs; USEPA 2004
Benzo(b)fluoranthene	1.30E-01	Default for PAHs; USEPA 2004
Benzo(e)pyrene	1.30E-01	Default for PAHs; USEPA 2004
Benzo(k)fluoranthene	1.30E-01	Default for PAHs; USEPA 2004
Bis(2-Chloroethoxy)methane	1.00E-01	Default for SVOCs; USEPA 2004
Bis(2-ethylhexyl)phthalate	1.00E-01	Default for SVOCs; USEPA 2004
C11-C22 Aromatics	1.00E-01	Default for SVOCs; USEPA 2004
Carbazole	1.00E-01	Default for SVOCs; USEPA 2004
Carbon tetrachloride		Not available*
Chloroethane		Not available*
Chloroform		Not available*
cis-1,2-Dichloroethene		Not available*
Dibenzo(a,h)anthracene	1.30E-01	Default for PAHs; USEPA 2004
Dibenzofuran	1.00E-01	Default for SVOCs; USEPA 2004
Di-n-octylphthalate	1.00E-01	Default for SVOCs; USEPA 2004
Ethylbenzene		Not available*
Indeno(1,2,3-cd)pyrene	1.30E-01	Default for PAHs; USEPA 2004
Isopropylbenzene		Not available*
Methylene Chloride		Not available*
Naphthalene	1.30E-01	Default for PAHs; USEPA 2004

TABLE A-8

DERMAL ABSORPTION FRACTIONS FOR SOIL

Remedial Investigation and Feasibility Study

Sutton Brook Disposal Area Superfund Site - Tewksbury, Massachusetts

Chemical of Potential Concern	Dermal Absorption Fraction from Soil	Source*
n-Butylbenzene		Not available*
n-Propylbenzene		Not available*
Perylene	1.30E-01	Default for PAHs; USEPA 2004
Phenanthrene	1.30E-01	Default for PAHs; USEPA 2004
Phenol	1.00E-01	Default for SVOCs; USEPA 2004
Styrene		Not available*
tert-Butylbenzene		Not available*
Tetrachloroethene		Not available*
Tetrahydrofuran	1.00E-01	Default for SVOCs; USEPA 2004
Toluene		Not available*
Trichloroethene		Not available*
Trichlorofluoromethane		Not available*
Vinyl Chloride		Not available*
Xylenes (total)		Not available*
Inorganics		
Antimony		Not available*
Arsenic	3.00E-02	Value from USEPA 2004
Barium		Not available*
Beryllium		Not available*
Cadmium	1.00E-03	Value from USEPA 2004
Chromium		Not available*
Cobalt		Not available*
Copper		Not available*
Lead		Not available*
Manganese		Not available*
Nickel		Not available*
Selenium		Not available*
Silver		Not available*
Thallium		Not available*
Vanadium		Not available*
Zinc		Not available*

Footnotes:

*Unless otherwise noted, values are from USEPA 2004. Risk Assessment Guidance for Superfund Volume 1: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment), Final. EPA/540/R/99/005.

Risks associated with dermal exposure to volatile organic compounds and inorganics are qualitatively evaluated in the uncertainty analysis.

TABLE A-9a
NON-CANCER TOXICITY DATA - ORAL/DERMAL
Remedial Investigation and Feasibility Study
Sutton Brook Disposal Area Superfund Site - Tewksbury, Massachusetts

Chemical of Potential Concern	Basis of Study (Chronic/ Subchronic)	Oral RfD		Oral Absorption Efficiency for Dermal (ABS_g) (1)	Absorbed RfD for Dermal (2)		Primary Target Organ(s)	Combined Uncertainty/Modifying Factors	RfD: Source	
		Value	Units		Value	Units			Source	Date
Organics										
1,1,1-Trichloroethane	Chronic	7.00E-01	mg/kg/day	--	7.00E-01	mg/kg/day	Nervous system	100	ATSDR MRL (intermediate)/STSC	5/23/2006
1,1,2-Trichloroethane	Chronic	4.00E-03	mg/kg/day	--	4.00E-03	mg/kg/day	Blood	1000 x 1	IRIS	3/7/2007
1,1-Dichloroethane	Chronic	2.00E-01	mg/kg/day	--	2.00E-01	mg/kg/day	Nervous system		PPRTV	1/27/2005
1,1-Dichloroethene	Chronic	5.00E-02	mg/kg/day	--	5.00E-02	mg/kg/day	Liver	100 x 1	IRIS	3/7/2007
1,2,4-Trimethylbenzene		--	--	--	--	--				
1,2-Dichloroethane	Chronic	2.00E-01	mg/kg/day	--	2.00E-01	mg/kg/day	Kidney	300 x 1	ATSDR MRL (intermediate)	9/1/2001
1,2-Dichloroethene	Chronic	9.00E-03	mg/kg/day	--	9.00E-03	mg/kg/day	Liver		HEAST	1997
1,2-Dichloropropane		--	--	--	--	--				
1,3,5-Trimethylbenzene		--	--	--	--	--				
1,4-Dichlorobenzene	Chronic	9.00E-02	mg/kg/day	--	9.00E-02	mg/kg/day	None observed	1000 x 1	IRIS (4)	3/7/2007
1,4-Dioxane	Chronic	1.00E-01	mg/kg/day	--	1.00E-01	mg/kg/day	Liver	100 x 1	ATSDR MRL	10/1/2004
1-Methylnaphthalene	Chronic	4.00E-03	mg/kg/day	--	4.00E-03	mg/kg/day	Lungs	1000 x 1	IRIS (value for 2-methylnaphthalene)	4/13/2006
2,4-Dimethylphenol	Chronic	2.00E-02	mg/kg/day	--	2.00E-02	mg/kg/day	Blood; whole body	3000 x 1	IRIS	3/7/2007
2,4-Dinitrotoluene	Chronic	2.00E-03	mg/kg/day	--	2.00E-03	mg/kg/day	Nervous system; liver	100 x 1	IRIS	3/7/2007
2-Butanone	Chronic	6.00E-01	mg/kg/day	--	6.00E-01	mg/kg/day	Whole body	1000 x 1	IRIS	3/7/2007
2-Hexanone		--	--	--	--	--				
2-Methylnaphthalene	Chronic	4.00E-03	mg/kg/day	--	4.00E-03	mg/kg/day	Lungs	1000 x 1	IRIS	3/7/2007
2-Methylphenol	Chronic	5.00E-02	mg/kg/day	--	5.00E-02	mg/kg/day	Whole body; nervous system	1000 x 1	IRIS	3/7/2007
3-Methylphenol/4-Methylphenol	Chronic	5.00E-02	mg/kg/day	--	5.00E-02	mg/kg/day	Whole body; nervous system	1000 x 1	IRIS (value for 3-methylphenol)	3/7/2007
4-Chloro-3-methylphenol	Chronic	7.00E-02	mg/kg/day	--	7.00E-02	mg/kg/day	Whole body		PPRTV**	4/14/2005
4-Methyl-2-pentanone	Chronic	8.00E-02	mg/kg/day	--	8.00E-02	mg/kg/day	Whole body	3000	HEAST	1997
4-Methylphenol	Chronic	5.00E-02	mg/kg/day	--	5.00E-02	mg/kg/day	Whole body; nervous system	1000 x 1	IRIS (value for 3-methylphenol)	3/7/2007
Acetone	Chronic	9.00E-01	mg/kg/day	--	9.00E-01	mg/kg/day	Kidney	1000 x 1	IRIS	3/7/2007
Acetophenone	Chronic	1.00E-01	mg/kg/day	--	1.00E-01	mg/kg/day	Whole body	3000 x 1	IRIS	3/7/2007
Acrylonitrile	Chronic	1.00E-03	mg/kg/day		1.00E-03	mg/kg/day	Reproductive	1000	HEAST	1997
Alpha-BHC		--	--	--	--	--				
Aroclor 1254	Chronic	2.00E-05	mg/kg/day	--	2.00E-05	mg/kg/day	Eyes; immune system	300 x 1	IRIS	3/7/2007
Benzene	Chronic	4.00E-03	mg/kg/day	--	4.00E-03	mg/kg/day	Blood; immune system	300 x 1	IRIS	3/7/2007
Benzo(a)anthracene		--	--	--	--	--				
Benzo(a)pyrene		--	--	--	--	--				
Benzo(b)fluoranthene		--	--	--	--	--				
Benzo(e)pyrene		--	--	--	--	--				
Benzo(k)fluoranthene		--	--	--	--	--				
Benzyl alcohol	Chronic	5.00E-01	mg/kg/day	--	5.00E-01	mg/kg/day	None observed		PPRTV	9/29/2005
Bis(2-Chloroethoxy)methane		--	--	--	--	--				
Bis(2-ethylhexyl)phthalate	Chronic	2.00E-02	mg/kg/day	--	2.00E-02	mg/kg/day	Liver	1000 x 1	IRIS	3/7/2007
C11-C22 Aromatics	Chronic	3.00E-02	mg/kg/day	--	3.00E-02	mg/kg/day	Kidney		MADEP	2003

TABLE A-9a
NON-CANCER TOXICITY DATA - ORAL/DERMAL
Remedial Investigation and Feasibility Study
Sutton Brook Disposal Area Superfund Site - Tewksbury, Massachusetts

Chemical of Potential Concern	Basis of Study (Chronic/ Subchronic)	Oral RfD		Oral Absorption Efficiency for Dermal (ABS_{gi}) (1)	Absorbed RfD for Dermal (2)		Primary Target Organ(s)	Combined Uncertainty/Modifying Factors	RfD: Source	
		Value	Units		Value	Units			Source	Date
Carbazole		--	--	--	--	--				
Carbon tetrachloride	Chronic	7.00E-04	mg/kg/day	--	7.00E-04	mg/kg/day	Liver	1000 x 1	IRIS	3/7/2007
Chlorobenzene	Chronic	2.00E-02	mg/kg/day	--	2.00E-02	mg/kg/day	Liver	1000 x 1	IRIS	3/7/2007
Chloroethane		--	--	--	--	--				
Chloroform	Chronic	1.00E-02	mg/kg/day	--	1.00E-02	mg/kg/day	Liver	100 x 1	IRIS	3/7/2007
Chloromethane		--	--	--	--	--				
cis-1,2-Dichloroethene	Chronic	1.00E-02	mg/kg/day	--	1.00E-02	mg/kg/day	Blood		PPRTV	3/1/2006
Dibenzo(a,h)anthracene		--	--	--	--	--				
Dibenzofuran	Chronic	2.00E-03	mg/kg/day	--	2.00E-03	mg/kg/day	Not available		EPA Region 9	2004
Dichlorodifluoromethane	Chronic	2.00E-01	mg/kg/day	--	2.00E-01	mg/kg/day	Whole body	100 x 1	IRIS	3/7/2007
Di-n-octylphthalate	Chronic	4.00E-02	mg/kg/day	--	4.00E-02	mg/kg/day	Not available		EPA Region 9	2004
Ethyl ether	Chronic	2.00E-01	mg/kg/day	--	2.00E-01	mg/kg/day	Whole body	3000 x 1	IRIS	3/7/2007
Ethylbenzene	Chronic	1.00E-01	mg/kg/day	--	1.00E-01	mg/kg/day	Liver; kidney	1000 x 1	IRIS	3/7/2007
Ethyl methacrylate	Chronic	9.00E-02	mg/kg/day	--	9.00E-02	mg/kg/day	Kidney	100	HEAST	1997
Indeno(1,2,3-cd)pyrene		--	--	--	--	--				
Isopropylbenzene	Chronic	1.00E-01	mg/kg/day	--	1.00E-01	mg/kg/day	Kidney	1000 x 1	IRIS	3/7/2007
Methylene Chloride	Chronic	6.00E-02	mg/kg/day	--	6.00E-02	mg/kg/day	Liver	100 x 1	IRIS	3/7/2007
Naphthalene	Chronic	2.00E-02	mg/kg/day	--	2.00E-02	mg/kg/day	Whole body	3000 x 1	IRIS	3/7/2007
n-Butylbenzene		--	--	--	--	--				
n-Nitrosodi-n-butylamine		--	--	--	--	--				
n-Nitrosopyrrolidine		--	--	--	--	--				
n-Propylbenzene		--	--	--	--	--				
o-Chlorotoluene	Chronic	2.00E-02	mg/kg/day	--	2.00E-02	mg/kg/day	Whole body	1000 x 1	IRIS	3/7/2007
o-Toluidine		--	--	--	--	--				
p-Isopropyltoluene	Chronic	1.00E-01	mg/kg/day	--	1.00E-01	mg/kg/day	Kidney	1000 x 1	IRIS (value for isopropylbenzene)	3/7/2007
Perylene		--	--	--	--	--				
Phenanthrene		--	--	--	--	--				
Phenol	Chronic	3.00E-01	mg/kg/day	--	3.00E-01	mg/kg/day	Development/Fetus	300 x 1	IRIS	3/7/2007
Pyridine	Chronic	1.00E-03	mg/kg/day	--	1.00E-03	mg/kg/day	Liver	1000 x 1	IRIS	3/7/2007
Styrene	Chronic	2.00E-01	mg/kg/day	--	2.00E-01	mg/kg/day	Blood; liver	1000 x 1	IRIS	3/7/2007
tert-Butylbenzene		--	--	--	--	--				
Tetrachloroethene	Chronic	1.00E-02	mg/kg/day	--	1.00E-02	mg/kg/day	Liver	1000 x 1	IRIS	3/7/2007
Tetrahydrofuran		--	--	--	--	--				
Toluene	Chronic	8.00E-02	mg/kg/day	--	8.00E-02	mg/kg/day	Kidney	3000 x 1	IRIS	3/7/2007
Trichloroethene		--	--	--	--	--				
Trichlorofluoromethane	Chronic	3.00E-01	mg/kg/day	--	3.00E-01	mg/kg/day	Whole body	1000 x 1	IRIS	3/7/2007
Vinyl Chloride	Chronic	3.00E-03	mg/kg/day	--	3.00E-03	mg/kg/day	Liver	30 x 1	IRIS	3/7/2007
Xylenes (total)	Chronic	2.00E-01	mg/kg/day	--	2.00E-01	mg/kg/day	Whole body	1000 x 1	IRIS	3/7/2007

TABLE A-9a
NON-CANCER TOXICITY DATA - ORAL/DERMAL
Remedial Investigation and Feasibility Study
Sutton Brook Disposal Area Superfund Site - Tewksbury, Massachusetts

Chemical of Potential Concern	Basis of Study (Chronic/ Subchronic)	Oral RfD		Oral Absorption Efficiency for Dermal (ABS_{gi}) (1)	Absorbed RfD for Dermal (2)		Primary Target Organ(s)	Combined Uncertainty/Modifying Factors	RfD: Source	
		Value	Units		Value	Units			Source	Date
Inorganics		--	--	--	--	--				
Antimony	Chronic	4.00E-04	mg/kg/day	0.15	6.00E-05	mg/kg/day	Blood; whole body	1000 x 1	IRIS	3/7/2007
Arsenic	Chronic	3.00E-04	mg/kg/day	--	3.00E-04	mg/kg/day	Skin; cardiovascular system	3 x 1	IRIS	3/7/2007
Barium	Chronic	2.00E-01	mg/kg/day	0.07	1.40E-02	mg/kg/day	Kidney	300 x 1	IRIS	3/7/2007
Beryllium	Chronic	2.00E-03	mg/kg/day	0.007	1.40E-05	mg/kg/day	Intestines	300 x 1	IRIS	3/7/2007
Chromium	Chronic	3.00E-03	mg/kg/day	0.025	7.50E-05	mg/kg/day	None observed	3000 x 3	IRIS (values for hexavalent Cr)	3/7/2007
Cadmium		pathway-specific	mg/kg/day		pathway-specific	mg/kg/day				
Food	Chronic	1.00E-03	mg/kg/day	0.025	2.50E-05	mg/kg/day	Kidney	10 x 1	IRIS	3/7/2007
Water	Chronic	5.00E-04	mg/kg/day	0.05	2.50E-05	mg/kg/day	Kidney	10 x 1	IRIS	3/7/2007
Cobalt		--	--	--	--	--				
Copper		--	--	--	--	--				
Lead		NA (3)	--		NA (3)	mg/kg/day			IRIS	3/7/2007
Thallium	Chronic	8.00E-05	mg/kg/day	--	8.00E-05	mg/kg/day	Blood	3000 x 1	IRIS*	3/7/2007
Manganese		pathway-specific	mg/kg/day		pathway-specific	mg/kg/day				
Diet, soil	Chronic	1.40E-01	mg/kg/day	0.04	5.60E-03	mg/kg/day	Nervous system	1 x 1	IRIS	3/7/2007
Water	Chronic	4.67E-02	mg/kg/day	0.04	1.87E-03	mg/kg/day	Nervous system	1 x 1	IRIS (5)	3/7/2007
Nickel	Chronic	2.00E-02	mg/kg/day	0.04	8.00E-04	mg/kg/day	Whole body	300 x 1	IRIS	3/7/2007
Selenium	Chronic	5.00E-03	mg/kg/day	--	5.00E-03	mg/kg/day	Cardiovascular, alimentary and nervous systems	3 x 1	IRIS	3/7/2007
Silver	Chronic	5.00E-03	mg/kg/day	0.04	2.00E-04	mg/kg/day	Skin	3 x 1	IRIS	3/7/2007
Vanadium	Chronic	9.00E-03	mg/kg/day	0.026	2.34E-04	mg/kg/day	Hair cysteine	100 x 1	IRIS	3/7/2007
Zinc	Chronic	3.00E-01	mg/kg/day	--	3.00E-01	mg/kg/day	Blood	3 x 1	IRIS	3/7/2007

Footnotes:

IRIS = USEPA's Integrated Risk Information System (www.epa.gov/iris). Searched March 2007.

PPRTV = Provisional Peer-Review Toxicity Values, obtained from Superfund Technical Support Center (individual PPRTV dates reported above).

Region 9 = USEPA Region 9 Preliminary Remediation Goal (PRG) table, October 2004 (with December 2004 updates).

Region 6 = USEPA Region 6 Human Health Medium-Specific Screening Levels, 2006. (Revised 12/22/05). http://www.epa.gov/arkansas/6pd/rcra_c/pd-u/screenexpanded.xls

MADEP, 2003 = Massachusetts Department of Environmental Protection. 2003. Updated Petroleum Hydrocarbon Fraction Toxicity Values for the VPH/EPH/APH Methodology.

ATSDR MRL = Minimal Risk Levels, December 2005. (http://www.atsdr.cdc.gov/mrllist_12_05.pdf)

HEAST = National Center for Exposure Assessment, Health Effects Assessment Summary Tables, 1997.

-- = No information available.

* Value for Thallium chloride and thallium carbonate.

**Note: Only a subchronic value of 0.7 mg/kg-d was available for 4-chloro-3-methylphenol. We have adjusted the subchronic value by an uncertainty factor of 10 for chronic effects.

(1) Source: Exhibit 4-1, from USEPA, Risk Assessment Guidance for Superfund, Volume 1: Human Health Evaluation Manual, Part E (Supplemental Guidance for Dermal Risk Assessment), Final, July 2004. Compounds lacking ABSgi values were assumed to have an oral absorption efficiency of 100%.

(2) Derivation of dermal RfD based on absorbed dose

$$RfD_{ABS} = RfD_o * ABS_{GI} \quad \text{(USEPA, 2004)}$$

(3) Lead risks were calculated using EPA's IEUBK model and Adult Lead Model. See Appendix E for details.

(4) RfD for 1,2-Dichlorobenzene used as surrogate.

(5) A modifying factor of 3 was applied to the oral RfD for manganese to account for drinking water exposures, in accordance with EPA IRIS recommendations.

TABLE A-9b
NONCANCER TOXICITY DATA - INHALATION
Remedial Investigation and Feasibility Study
Sutton Brook Disposal Area Superfund Site - Tewksbury, Massachusetts

Chemical of Potential Concern	Chronic/ Subchronic	Inhalation RfC		Primary Target Organ(s)	Combined Uncertainty/Modifying Factors	RfC:Source	
		Value	Units			Source	Date
Organics							
1,1,1-Trichloroethane	Chronic	3.80E+00	(mg/m³)	Nervous system		ATSDR MRL (intermediate)/STSC	5/23/2006
1,1,2-Trichloroethane	Chronic	1.40E-02	(mg/m³)	Blood		Calculated (1)	
1,1-Dichloroethane	Chronic	5.00E-01	(mg/m³)	None observed		HEAST	1997
1,1-Dichloroethene	Chronic	2.00E-01	(mg/m³)	Liver	30 x 1	IRIS	3/7/2007
1,2,4-Trimethylbenzene		--	--				
1,2-Dichloroethane	Chronic	2.43E+00	(mg/m³)	Liver	90	ATSDR MRL (0.6 ppm)	2005
1,2-Dichloroethene	Chronic	6.00E-02	(mg/m³)	Respiratory system; liver		PPRTV (value for trans isomer)	3/1/2006
1,2-Dichloropropane	Chronic	4.00E-03	(mg/m³)	Nasal mucosa	300 x 1	IRIS	3/7/2007
1,3,5-Trimethylbenzene		--	--				
1,4-Dichlorobenzene	Chronic	8.00E-01	(mg/m³)	Liver	100 X 1	IRIS	3/7/2007
1,4-Dioxane	Chronic	3.00E+00	(mg/m³)	Not available		CalEPA REL	9/21/2006
1-Methylnaphthalene	Chronic	2.45E-01	(mg/m³)	Respiratory system	1000	ATSDR MRL (Calculated from RfD)	2005
2,4-Dimethylphenol	Chronic	7.00E-02	(mg/m³)	Blood; whole body		Calculated (1)	
2,4-Dinitrotoluene		--	--				
2-Butanone	Chronic	5.00E+00	(mg/m³)	Development/fetus	300 x 1	IRIS	3/7/2007
2-Hexanone		--	--				
2-Methylnaphthalene	Chronic	1.40E-01	(mg/m³)	Respiratory system	100	ATSDR MRL (Calculated from RfD)	2005
2-Methylphenol	Chronic	1.75E-01	(mg/m³)	Whole body; nervous system		Calculated (1)	
3-Methylphenol/4-Methylphenol	Chronic	1.75E-02	(mg/m³)	Whole body; nervous system		Calculated (1)	
4-Chloro-3-methylphenol		--	--				
4-Methyl-2-pentanone	Chronic	3.00E+00	(mg/m³)	Development/fetus	300 x 1	IRIS	3/7/2007
4-Methylphenol	Chronic	1.75E-02	(mg/m³)	Whole body; nervous system		Calculated (1)	
Acetone	Chronic	3.15E+00	(mg/m³)	Kidney		Calculated (1)	
Acetophenone		--	--				
Acrylonitrile	Chronic	3.50E-03	(mg/m³)	Respiratory system	1000 x 1	IRIS (value for isopropylbenzene; calculated from RfD)	3/7/2007
Alpha-BHC	Chronic	1.75E-03	(mg/m³)	Not available		Calculated (1)	
Aroclor 1254	Chronic	7.00E-05	(mg/m³)	Eyes; immune system		Calculated (1)	
Benzene	Chronic	3.00E-02	(mg/m³)	Blood; immune system	300 x 1	IRIS	3/7/2007
Benzo(a)anthracene		--	--				
Benzo(a)pyrene		--	--				
Benzo(b)fluoranthene		--	--				
Benzo(e)pyrene		--	--				
Benzo(k)fluoranthene		--	--				
Benzyl alcohol		--	--				

TABLE A-9b
NONCANCER TOXICITY DATA - INHALATION
Remedial Investigation and Feasibility Study
Sutton Brook Disposal Area Superfund Site - Tewksbury, Massachusetts

Chemical of Potential Concern	Chronic/ Subchronic	Inhalation RfC		Primary Target Organ(s)	Combined Uncertainty/Modifying Factors	RfC:Source	
		Value	Units			Source	Date
Bis(2-Chloroethoxy)methane		--	--				
Bis(2-ethylhexyl)phthalate	Chronic	7.00E-02	(mg/m³)	Liver		Calculated (1)	
C11-C22 Aromatics	Chronic	5.00E-02	(mg/m³)	Liver, kidney		MADEP	2003
Carbazole		--	--				
Carbon tetrachloride	Chronic	2.45E-03	(mg/m³)	Liver		Calculated (1)	
Chlorobenzene	Chronic	5.00E-02	(mg/m³)	Kidney; liver	1000 x 3	PPRTV	10/17/2005
Chloroethane	Chronic	1.00E+01	(mg/m³)	Development/fetus	300 x 1	IRIS	3/7/2007
Chloroform	Chronic	3.00E-01	(mg/m³)	Kidney; development/fetus; alimentary system		CalEPA REL	9/21/2006
Chloromethane	Chronic	9.00E-02	(mg/m³)	Nervous system	1000 x 1	IRIS	3/7/2007
cis-1,2-Dichloroethene	Chronic	6.00E-02	(mg/m³)	Respiratory system; liver		PPRTV (value for trans isomer)	3/1/2006
Dibenzo(a,h)anthracene		--	--				
Dibenzofuran	Chronic	7.00E-03	(mg/m³)	Not available		Calculated (1)	
Dichlorodifluoromethane	Chronic	2.00E-01	(mg/m³)	None observed		HEAST	1997
Di-n-octylphthalate	Chronic	1.40E-01	(mg/m³)	Not available		Calculated (1)	
Ethyl ether	Chronic	7.00E-01	(mg/m³)	Whole body		Calculated (1)	
Ethylbenzene	Chronic	1.00E+00	(mg/m³)	Development/fetus	300 x 1	IRIS	3/7/2007
Ethyl methacrylate	Chronic	3.15E-01	(mg/m³)	Kidney		Calculated (1)	
Indeno(1,2,3-cd)pyrene		--	--				
Isopropylbenzene	Chronic	4.00E-01	(mg/m³)	Kidney/adrenal gland	1000 x 1	IRIS	3/7/2007
Methylene Chloride	Chronic	3.00E+00	(mg/m³)	Liver	100 x 1	HEAST	1997
Naphthalene	Chronic	3.00E-03	(mg/m³)	Respiratory system	3000 x 1	IRIS	3/7/2007
n-Butylbenzene	Chronic	1.40E-01	(mg/m³)	Not available		Calculated (1)	
n-Nitrosodi-n-butylamine		--	--				
n-Nitrosopyrrolidine		--	--				
n-Propylbenzene	Chronic	1.40E-01	(mg/m³)	Not available		Calculated (1)	
o-Chlorotoluene	Chronic	7.00E-02	(mg/m³)	Whole body		Calculated (1)	
o-Toluidine		--	--				
p-Isopropyltoluene	Chronic	4.00E-01	(mg/m³)	Kidney/adrenal gland	1000 x 1	IRIS	3/7/2007
Perylene		--	--				
Phenanthrene		--	--				
Phenol	Chronic	2.00E-01	(mg/m³)	Alimentary, cardiovascular, nervous systems; kidney		CalEPA REL	9/21/2006
Pyridine	Chronic	3.50E-03	(mg/m³)	Liver		Calculated (1)	
Styrene	Chronic	1.00E+00	(mg/m³)	Nervous system	30 x 1	IRIS	3/7/2007
tert-Butylbenzene	Chronic	1.40E-01	(mg/m³)	Not available		Calculated (1)	
Tetrachloroethene	Chronic	3.50E-02	(mg/m³)	Nervous system; eyes; respiratory system		CalEPA REL	1/17/2006
Tetrahydrofuran	Chronic	3.01E-01	(mg/m³)			Calculated (1)	
Toluene	Chronic	5.00E+00	(mg/m³)	Nervous system	10 x 1	IRIS	3/7/2007

TABLE A-9b
NONCANCER TOXICITY DATA - INHALATION
Remedial Investigation and Feasibility Study
Sutton Brook Disposal Area Superfund Site - Tewksbury, Massachusetts

Chemical of Potential Concern	Chronic/ Subchronic	Inhalation RfC		Primary Target Organ(s)	Combined Uncertainty/Modifying Factors	RfC:Source	
		Value	Units			Source	Date
Trichloroethene	Chronic	6.00E-01	(mg/m³)	Nervous system; eyes		CalEPA REL	9/21/2006
Trichlorofluoromethane		--	--				
Vinyl Chloride	Chronic	1.00E-01	(mg/m³)	Liver	30 x 1	IRIS	3/7/2007
Xylenes (total)	Chronic	1.00E-01	(mg/m³)	Nervous system	300 x 1	IRIS	3/7/2007
Inorganics		--	--				
Antimony		--	--				
Arsenic	Chronic	3.00E-05	(mg/m³)	Not available		CalEPA REL	9/21/2006
Barium	Chronic	5.00E-04	(mg/m³)	Fetus	1000	HEAST	1997
Beryllium	Chronic	2.00E-05	(mg/m³)	Respiratory system	10 x 1	IRIS	3/7/2007
Cadmium		--	--				
Chromium	Chronic	1.00E-04	(mg/m³)	Respiratory system	300 x 1	IRIS (hexavalent Cr)	3/7/2007
Cobalt	Chronic	1.00E-04	(mg/m³)	Respiratory system	10 x 1	ATSDR MRL	10/1/2004
Copper		--	--				
Lead		NA (2)	--				
Manganese	Chronic	5.00E-05	(mg/m³)	Nervous system	1000 x 1	IRIS	3/7/2007
Nickel	Chronic	5.00E-05	(mg/m³)	Not available		CalEPA REL	9/21/2006
Selenium		--	--				
Silver		--	--				
Thallium		--	--				
Vanadium		--	--				
Zinc		--	--				

Footnotes:

IRIS = USEPA's Integrated Risk Information System (www.epa.gov/iris). Searched March 2007.

CalEPA = California Environmental Protection Agency. REL = Reference Exposure Level. PELs are chronic unless otherwise noted. February, 2005. http://www.oehha.ca.gov/air/chronic_rels/AllChrels.html

PPRTV = Provisional Peer-Review Toxicity Values, obtained from Superfund Technical Support Center (individual PPRTV dates reported above).

MADEP, 2003 = Massachusetts Department of Environmental Protection. 2003. Updated Petroleum Hydrocarbon Fraction Toxicity Values for the VPH/EPH/APH Methodology.

ATSDR MRL = Minimal Risk Levels, December 2005. (http://www.atsdr.cdc.gov/mrllist_12_05.pdf)

HEAST = National Center for Exposure Assessment, Health Effects Assessment Summary Tables, 1997.

-- = No information available.

(1) RfC calculated from the oral RfD or, if no oral RfD was available, from the inhalation RfD provided in the EPA Region 9 PRG table (October 2004). RfC = RfDi * (70 kg / 20 m^3/day).

(2) Lead risks were calculated using EPA's IEUBK model and Adult Lead Model. See Appendix E for details.

TABLE A-9c
CANCER TOXICITY DATA - ORAL/DERMAL
Remedial Investigation and Feasibility Study
Sutton Brook Disposal Area Superfund Site - Tewksbury, Massachusetts

Chemical of Potential Concern	Oral Cancer Slope Factor		Oral Absorption Efficiency for Dermal (ABS_{gi}) (1)	Absorbed Cancer Slope Factor for Dermal (1)		USEPA 1986 Weight of Evidence/ Cancer Guideline Description	CSF: Source	
	Value	Units		Value	Units		Source	Date
Organics								
1,1,1-Trichloroethane	--	--	--	--	--	D		
1,1,2-Trichloroethane	5.70E-02	$(mg/kg\text{-}day)^{-1}$	--	5.70E-02	$(mg/kg\text{-}day)^{-1}$	C	IRIS	3/7/2007
1,1-Dichloroethane	--	--	--	--	--	C		
1,1-Dichloroethene	--	--	--	--	--	C		
1,2,4-Trimethylbenzene	--	--	--	--	--	--		
1,2-Dichloroethane	9.10E-02	$(mg/kg\text{-}day)^{-1}$	--	9.10E-02	$(mg/kg\text{-}day)^{-1}$	B2	IRIS	3/7/2007
1,2-Dichloroethene	--	--	--	--	--	--		
1,2-Dichloropropane	6.80E-02	$(mg/kg\text{-}day)^{-1}$	--	6.80E-02	$(mg/kg\text{-}day)^{-1}$	--	HEAST	1997
1,3,5-Trimethylbenzene	--	--	--	--	--	--		
1,4-Dichlorobenzene	2.40E-02	$(mg/kg\text{-}day)^{-1}$	--	2.40E-02	$(mg/kg\text{-}day)^{-1}$	--	HEAST	1997
1,4-Dioxane	1.10E-02	$(mg/kg\text{-}day)^{-1}$	--	1.10E-02	$(mg/kg\text{-}day)^{-1}$	B2	IRIS	3/7/2007
1-Methylnaphthalene	--	--	--	--	--	--		
2,2'-Oxybis(1-chloropropane)	--	--	--	--	--	--		
2,4-Dimethylphenol	--	--	--	--	--	--		
2,4-Dinitrotoluene	3.10E-01	$(mg/kg\text{-}day)^{-1}$	--			B2	CalEPA	2005
2-Butanone	--	--	--	--	--	--		
2-Hexanone	--	--	--	--	--	--		
2-Methylnaphthalene	--	--	--	--	--	--		
2-Methylphenol	--	--	--	--	--	C		
3-Methylphenol/4-Methylphenol	--	--	--	--	--	--		
4-Chloro-3-methylphenol	--	--	--	--	--	--		
4-Methyl-2-pentanone	--	--	--	--	--	--		
4-Methylphenol	--	--	--	--	--	C		
Acetone	--	--	--	--	--	--		
Acetophenone	--	--	--	--	--	D		
Acrylonitrile	5.40E-01	$(mg/kg\text{-}day)^{-1}$		5.40E-01	$(mg/kg\text{-}day)^{-1}$	B1	IRIS	3/7/2007
Alpha-BHC	6.30E+00	$(mg/kg\text{-}day)^{-1}$	--	6.30E+00	$(mg/kg\text{-}day)^{-1}$	B2	IRIS	3/7/2007
Aroclor 1254	Pathway-specific	$(mg/kg\text{-}day)^{-1}$	--	Pathway-specific	$(mg/kg\text{-}day)^{-1}$	--		
Aroclor 1254-Food/soil	2.00E+00	$(mg/kg\text{-}day)^{-1}$	--	2.00E+00	$(mg/kg\text{-}day)^{-1}$	B2	IRIS	3/7/2007
Aroclor 1254-Water	4.00E-01	$(mg/kg\text{-}day)^{-1}$	--	4.00E-01	$(mg/kg\text{-}day)^{-1}$	B2	IRIS	3/7/2007
Benzene	5.50E-02	$(mg/kg\text{-}day)^{-1}$	--	5.50E-02	$(mg/kg\text{-}day)^{-1}$	A	IRIS	3/7/2007
Benzo(a)anthracene	7.30E-01	$(mg/kg\text{-}day)^{-1}$	--	7.30E-01	$(mg/kg\text{-}day)^{-1}$	--	IRIS (2)	3/7/2007
Benzo(a)pyrene	7.30E+00	$(mg/kg\text{-}day)^{-1}$	--	7.30E+00	$(mg/kg\text{-}day)^{-1}$	B2	IRIS	3/7/2007
Benzo(b)fluoranthene	7.30E-01	$(mg/kg\text{-}day)^{-1}$	--	7.30E-01	$(mg/kg\text{-}day)^{-1}$	B2	IRIS (2)	3/7/2007
Benzo(e)pyrene	--	--	--	--	--	--		
Benzo(k)fluoranthene	7.30E-02	$(mg/kg\text{-}day)^{-1}$	--	7.30E-02	$(mg/kg\text{-}day)^{-1}$	B2	IRIS (2)	3/7/2007
Benzyl alcohol	--	--	--	--	--	--		
Bis(2-Chloroethoxy)methane	--	--	--	--	--	D		
Bis(2-ethylhexyl)phthalate	1.40E-02	$(mg/kg\text{-}day)^{-1}$	--	1.40E-02	$(mg/kg\text{-}day)^{-1}$	B2	IRIS	3/7/2007

TABLE A-9c
CANCER TOXICITY DATA - ORAL/DERMAL
Remedial Investigation and Feasibility Study
Sutton Brook Disposal Area Superfund Site - Tewksbury, Massachusetts

Chemical of Potential Concern	Oral Cancer Slope Factor		Oral Absorption Efficiency for Dermal (ABS_{gi}) (1)	Absorbed Cancer Slope Factor for Dermal (1)		USEPA 1986 Weight of Evidence/ Cancer Guideline Description	CSF: Source	
	Value	Units		Value	Units		Source	Date
C11-C22 Aromatics	--	--	--	--	--	--		
Carbazole	2.00E-02	$(mg/kg\text{-}day)^{-1}$	--	2.00E-02	$(mg/kg\text{-}day)^{-1}$	--	HEAST	1997
Carbon tetrachloride	1.30E-01	$(mg/kg\text{-}day)^{-1}$	--	1.30E-01	$(mg/kg\text{-}day)^{-1}$	B2	IRIS	3/7/2007
Chlorobenzene	--	--	--	--	--	D		
Chloroethane	--	--	--	--	--	--		
Chloroform	3.10E-02	$(mg/kg\text{-}day)^{-1}$	--	3.10E-02	$(mg/kg\text{-}day)^{-1}$	B2	CalEPA	2005
Chloromethane	--	--	--	--	--	D		
cis-1,2-Dichloroethene	--	--	--	--	--	D		
Dibenzo(a,h)anthracene	7.30E+00	$(mg/kg\text{-}day)^{-1}$	--	7.30E+00	$(mg/kg\text{-}day)^{-1}$	B2	IRIS (2)	3/7/2007
Dibenzofuran	--	--	--	--	--	D		
Dichlorodifluoromethane	--	--	--	--	--	--		
Di-n-octylphthalate	--	--	--	--	--	--		
Ethyl ether	--	--	--	--	--	--		
Ethylbenzene	--	--	--	--	--	D		
Ethyl methacrylate	--	--	--	--	--	--		
Indeno(1,2,3-cd)pyrene	7.30E-01	$(mg/kg\text{-}day)^{-1}$	--	7.30E-01	$(mg/kg\text{-}day)^{-1}$	B2	IRIS (2)	3/7/2007
Isopropylbenzene	--	--	--	--	--	--		
Methylene Chloride	7.50E-03	$(mg/kg\text{-}day)^{-1}$	--	7.50E-03	$(mg/kg\text{-}day)^{-1}$	B2	IRIS	3/7/2007
Naphthalene	--	--	--	--	--	C		
n-Butylbenzene	--	--	--	--	--	--		
n-Nitrosodi-n-butylamine	5.40E+00	$(mg/kg\text{-}day)^{-1}$	--	5.40E+00	$(mg/kg\text{-}day)^{-1}$	B2	IRIS	3/7/2007
n-Nitrosopyrrolidine	2.10E+00	$(mg/kg\text{-}day)^{-1}$	--	2.10E+00	$(mg/kg\text{-}day)^{-1}$	B2	IRIS	3/7/2007
n-Propylbenzene	--	--	--	--	--	--		
o-Chlorotoluene	--	--	--	--	--	--		
o-Toluidine	2.40E-01	$(mg/kg\text{-}day)^{-1}$	--	2.40E-01	$(mg/kg\text{-}day)^{-1}$	--	HEAST	1997
p-Isopropyltoluene	--	--	--	--	--	--		
Perylene	--	--	--	--	--	--		
Phenanthrene	--	--	--	--	--	D		
Phenol	--	--	--	--	--	D		
Pyridine	--	--	--	--	--	--		
Styrene	--	--	--	--	--	--		
tert-Butylbenzene	--	--	--	--	--	--		
Tetrachloroethene	5.40E-01	$(mg/kg\text{-}day)^{-1}$	--	5.40E-01	$(mg/kg\text{-}day)^{-1}$	B1	CalEPA	2005
Tetrahydrofuran	--	--	--	--	--	--		
Toluene	--	--	--	--	--	--		
Trichloroethene	4.00E-01	$(mg/kg\text{-}day)^{-1}$	--	4.00E-01	$(mg/kg\text{-}day)^{-1}$	--	EPA	2001
Trichlorofluoromethane	--	--	--	--	--	--		

TABLE A-9c
CANCER TOXICITY DATA - ORAL/DERMAL
Remedial Investigation and Feasibility Study
Sutton Brook Disposal Area Superfund Site - Tewksbury, Massachusetts

Chemical of Potential Concern	Oral Cancer Slope Factor		Oral Absorption Efficiency for Dermal (ABS_{gi}) (1)	Absorbed Cancer Slope Factor for Dermal (1)		USEPA 1986 Weight of Evidence/ Cancer Guideline Description	CSF: Source	
	Value	Units		Value	Units		Source	Date
Vinyl Chloride	age-specific	$(mg/kg\text{-}day)^{-1}$	--	age-specific	$(mg/kg\text{-}day)^{-1}$	--		
Vinyl chloride-Adult exposure	7.20E-01	$(mg/kg\text{-}day)^{-1}$	--	7.20E-01	$(mg/kg\text{-}day)^{-1}$	A	IRIS	3/7/2007
Vinyl chloride-Lifetime exposure	1.50E+00	$(mg/kg\text{-}day)^{-1}$	--	1.50E+00	$(mg/kg\text{-}day)^{-1}$	A	IRIS	3/7/2007
Xylenes (total)	--	--	--	--	--	--		
Inorganics	--	--	--	--	--			
Antimony	--	--	--	--	--	--		
Arsenic	1.50E+00	$(mg/kg\text{-}day)^{-1}$	--	1.50E+00	$(mg/kg\text{-}day)^{-1}$	A	IRIS	3/7/2007
Barium	--	--	--	--	--	D		
Beryllium	--	--	--	--	--	B1		
Cadmium	--	--	--	--	--	B1 (via inhalation)		
Chromium	--	--	--	--	--	A (via inhalation)		
Cobalt	--	--	--	--	--	--		
Copper	--	--	--	--	--	D		
Lead	--	--	--	--	--	B2		
Manganese	--	--	--	--	--	D		
Nickel	--	--	--	--	--	--		
Selenium	--	--	--	--	--	D		
Silver	--	--	--	--	--	D		
Thallium	--	--	--	--	--	D		
Vanadium	--	--	--	--	--	--		
Zinc	--	--	--	--	--	D		

Footnotes:

References apply to both oral and dermal slope factors.

IRIS = USEPA's Integrated Risk Information System (www.epa.gov/iris). Searched March 2007.

CalEPA = California Environmental Protection Agency, Office of Environmental Health Hazard Assessment, Toxicity Criteria Database. August 10, 2005. http://www.oehha.ca.gov/risk/pdf/cancerpotalpha81005.pdf.

Region 9 = USEPA Region 9 Preliminary Remediation Goal (PRG) table, October 2004.

HEAST = National Center for Exposure Assessment, Health Effects Assessment Summary Tables, 1997.

EPA 2001. Trichloroethylene Health Risk Assessment: Synthesis and Characterization (External Review Draft). EPA/600/P-01/002A. August 1, 2001. Office of Research and Development, National Center for Environmental Assessment, Washington Office, Washington, D.C.

-- = No information available.

(1) Derivation of dermal CSF based on absorbed dose

$$SF_{ABS} = SF_o / ABS_{GI}$$

Source: Exhibit 4-1, from USEPA, Risk Assessment Guidance for Superfund, Volume 1: Human Health Evaluation Manual, Part E (Supplemental Guidance for Dermal Risk Assessment), Final, July 2004.

(2) The following toxicity equivalency factors (TEFs) were applied to the toxicity value for benzo(a)pyrene to derive a toxicity value for the seven carcinogenic PAHs:

Benzo(a)pyrene	1	chrysene	0.001
Benzo(a)anthracene	0.1	dibenz(a,h)anthracene	1
benzo(b)fluoranthene	0.1	indeno(1,2,3-cd)pyrene	0.1
benzo(k)fluoranthene	0.01		

TABLE A-9d

CANCER TOXICITY DATA - INHALATION

Remedial Investigation and Feasibility Study

Sutton Brook Disposal Area Superfund Site - Tewksbury, Massachusetts

Chemical of Potential Concern	Unit Risk		Inhalation Cancer Slope Factor		Weight of Evidence/ Cancer Guideline Description	Unit Risk or Inhalation CSF: Source	
	Value	Units	Value	Units		Source	Date
Organics							
1,1,1-Trichloroethane	--	--	--	--	D		
1,1,2-Trichloroethane	1.60E-02	$(mg/m^3)^{-1}$	5.60E-02	$(mg/kg\text{-}d)^{-1}$	C	IRIS*	3/7/2007
1,1-Dichloroethane	--	--	--	--	C		
1,1-Dichloroethene	--	--	--	--	C		
1,2,4-Trimethylbenzene	--	--	--	--	--		
1,2-Dichloroethane	2.60E-02	$(mg/m^3)^{-1}$	9.10E-02	$(mg/kg/day)^{-1}$	B2	IRIS*	3/7/2007
1,2-Dichloroethene	--	--	--	--	--		
1,2-Dichloropropane	--	--	--	--	--		
1,3,5-Trimethylbenzene	--	--	--	--	--		
1,4-Dichlorobenzene	--	--	--	--	--		
1,4-Dioxane	7.70E-03	$(mg/m^3)^{-1}$	2.70E-02	$(mg/kg\text{-}d)^{-1}$	B2	CalEPA*	2005
1-Methylnaphthalene	--	--	--	--	--		
2,2'-Oxybis(1-chloropropane)	--	--	--	--	--		
2,4-Dimethylphenol	--	--	--	--	--		
2,4-Dinitrotoluene	8.90E-02	$(mg/m^3)^{-1}$	3.12E-01	$(mg/kg\text{-}d)^{-1}$	B2	CalEPA*	2005
2-Butanone	--	--	--	--	--		
2-Hexanone	--	--	--	--	--		
2-Methylnaphthalene	--	--	--	--	--		
2-Methylphenol	--	--	--	--	C		
3-Methylphenol/4-Methylphenol	--	--	--	--	--		
4-Chloro-3-methylphenol	--	--	--	--	--		
4-Methyl-2-pentanone	--	--	--	--	--		
4-Methylphenol	--	--	--	--	C		
Acetone	--	--	--	--	--		
Acetophenone	--	--	--	--	D		
Acrylonitrile	6.80E-02	$(mg/m^3)^{-1}$	2.38E-01	$(mg/kg/day)^{-1}$	B1	IRIS	3/7/2007
Alpha-BHC	1.80E+00	$(mg/m^3)^{-1}$	6.30E+00	$(mg/kg\text{-}d)^{-1}$	B2	IRIS*	3/7/2007
Aroclor 1254	Pathway-specific	$(mg/m^3)^{-1}$	Pathway-specific	$(mg/kg\text{-}d)^{-1}$			
Aroclor 1254-Food/soil	5.71E-01	$(mg/m^3)^{-1}$	2.00E+00	$(mg/kg\text{-}d)^{-1}$	B2	IRIS*	3/7/2007
Aroclor 1254-Water/air	1.00E-01	$(mg/m^3)^{-1}$	3.50E-01	$(mg/kg\text{-}d)^{-1}$	B2	IRIS*	3/7/2007
Benzene	7.80E-03	$(mg/m^3)^{-1}$	2.73E-02	$(mg/kg/day)^{-1}$	A	IRIS*	3/7/2007
Benzo(a)anthracene	1.10E-01	$(mg/m^3)^{-1}$	3.90E-01	$(mg/kg/day)^{-1}$	--	CalEPA	2005
Benzo(a)pyrene	1.10E+00	$(mg/m^3)^{-1}$	3.90E+00	$(mg/kg/day)^{-1}$	B2	CalEPA	2005
Benzo(b)fluoranthene	1.10E-01	$(mg/m^3)^{-1}$	3.90E-01	$(mg/kg/day)^{-1}$	B2	CalEPA	2005
Benzo(e)pyrene	--	--	--	--	--		
Benzo(k)fluoranthene	1.10E-01	$(mg/m^3)^{-1}$	3.90E-01	$(mg/kg/day)^{-1}$	B2	CalEPA	2005
Benzyl alcohol	--	--	--	--	--		

TABLE A-9d

CANCER TOXICITY DATA - INHALATION

Remedial Investigation and Feasibility Study

Sutton Brook Disposal Area Superfund Site - Tewksbury, Massachusetts

Chemical of Potential Concern	Unit Risk		Inhalation Cancer Slope Factor		Weight of Evidence/ Cancer Guideline Description	Unit Risk or Inhalation CSF: Source	
	Value	Units	Value	Units		Source	Date
Bis(2-Chloroethoxy)methane	--	--	--	--	D		
Bis(2-ethylhexyl)phthalate	2.40E-03	$(mg/m^3)^{-1}$	8.40E-03	$(mg/kg/day)^{-1}$	B2	CalEPA	2005
C11-C22 Aromatics	--	--	--	--	--		
Carbazole	--	--	--	--	--		
Carbon tetrachloride	1.50E-02	$(mg/m^3)^{-1}$	5.25E-02	$(mg/kg\text{-}d)^{-1}$	B2	IRIS*	3/7/2007
Chlorobenzene	--	--	--	--	D		
Chloroethane	--	--	--	--	--		
Chloroform	2.30E-02	$(mg/m^3)^{-1}$	8.05E-02	$(mg/kg\text{-}d)^{-1}$	B2	IRIS*	3/7/2007
Chloromethane	--	--	--	--	D		
cis-1,2-Dichloroethene	--	--	--	--	D		
Dibenzo(a,h)anthracene	1.20E+00	$(mg/m^3)^{-1}$	4.10E+00	$(mg/kg/day)^{-1}$	B2	CalEPA	2005
Dibenzofuran	--	--	--	--	D		
Dichlorodifluoromethane	--	--	--	--	--		
Di-n-octylphthalate	--	--	--	--	--		
Ethyl ether	--	--	--	--	--		
Ethylbenzene	--	--	--	--	D		
Ethyl methacrylate	--	--	--	--	--		
Indeno(1,2,3-cd)pyrene	1.10E-01	$(mg/m^3)^{-1}$	3.90E-01	$(mg/kg/day)^{-1}$	B2	CalEPA	2005
Isopropylbenzene	--	--	--	--	--		
Methylene Chloride	4.70E-04	$(mg/m^3)^{-1}$	1.65E-03	$(mg/kg/day)^{-1}$	B2	IRIS*	3/7/2007
Naphthalene	--	--	--	--	C		
n-Butylbenzene	--	--	--	--	--		
n-Nitrosodi-n-butylamine	1.60E+00	$(mg/m^3)^{-1}$	5.60E+00	$(mg/kg/day)^{-1}$	B2	IRIS*	3/7/2007
n-Nitrosopyrrolidine	6.10E-01	$(mg/m^3)^{-1}$	2.14E+00	$(mg/kg/day)^{-1}$	B2	IRIS*	3/7/2007
n-Propylbenzene	--	--	--	--	--		
o-Chlorotoluene	--	--	--	--	--		
o-Toluidine	--	--	--	--	--		
p-Isopropyltoluene	--	--	--	--	--		
Perylene	--	--	--	--	--		
Phenanthrene	--	--	--	--	D		
Phenol	--	--	--	--	D		
Pyridine	--	--	--	--	--		
Styrene	--	--	--	--	--		
tert-Butylbenzene	--	--	--	--	--		
Tetrachloroethene	5.90E-03	$(mg/m^3)^{-1}$	2.07E-02	$(mg/kg/day)^{-1}$	B1	CalEPA	2005
Tetrahydrofuran	--	--	--	--	--		
Toluene	--	--	--	--	--		
Trichloroethene	2.00E-03	$(mg/m^3)^{-1}$	7.00E+00	$(mg/kg/day)^{-1}$	--	CalEPA	2005

TABLE A-9d

CANCER TOXICITY DATA - INHALATION

Remedial Investigation and Feasibility Study

Sutton Brook Disposal Area Superfund Site - Tewksbury, Massachusetts

Chemical of Potential Concern	Unit Risk		Inhalation Cancer Slope Factor		Weight of Evidence/ Cancer Guideline Description	Unit Risk or Inhalation CSF: Source	
	Value	Units	Value	Units		Source	Date
Trichlorofluoromethane	--	--	--	--	--		
Vinyl Chloride	age-specific	$(mg/m^3)^{-1}$	age-specific	$(mg/kg/day)^{-1}$	--		
Vinyl chloride-Adult exposure	4.40E-03	$(mg/m^3)^{-1}$	1.54E-02	$(mg/kg/day)^{-1}$	A	IRIS*	3/7/2007
Vinyl chloride-Lifetime exposure	8.80E-03	$(mg/m^3)^{-1}$	3.08E-02	$(mg/kg/day)^{-1}$	A	IRIS*	3/7/2007
Xylenes (total)	--	--	--	--	--		
Inorganics	--	--	--	--			
Antimony	--	--	--	--	--		
Arsenic	4.30E+00	$(mg/m^3)^{-1}$	1.5E+01	$(mg/kg/day)^{-1}$	A	IRIS*	3/7/2007
Barium	--	--	--	--	D		
Beryllium	2.40E+00	$(mg/m^3)^{-1}$	8.40E+00	$(mg/kg\text{-}d)^{-1}$	B1	IRIS*	3/7/2007
Cadmium	1.80E+00	$(mg/m^3)^{-1}$	6.30E+00	$(mg/kg/day)^{-1}$	B1 (via inhalation)	IRIS*	3/7/2007
Chromium	1.20E+01	$(mg/m^3)^{-1}$	4.20E+01	$(mg/kg\text{-}d)^{-1}$	A (via inhalation)	IRIS*	3/7/2007
Cobalt	--	--	--	--	--		
Copper	--	--	--	--	D		
Lead	--	--	--	--	B2		
Manganese	--	--	--	--	D		
Nickel	--	--	--	--	--		
Selenium	--	--	--	--	D		
Silver	--	--	--	--	D		
Thallium	--	--	--	--	D		
Vanadium	--	--	--	--	--		
Zinc	--	--	--	--	D		

Footnotes:

References apply to both slope factors and unit risk values, unless otherwise noted (* indicates slope factor calculated from unit risk; ** indicates unit risk calculated from slope factor).

Slope factors were calculated from unit risk values using the following equation: SF = 70 kg/ 20 m^3-d^{-1} * UR

Unit risk values were calculated from slope factors using the following equation: UR = 20 m^3-d^{-1} / 70 kg * SF

IRIS = USEPA's Integrated Risk Information System (www.epa.gov/iris). Searched March 2007.

CalEPA = California Environmental Protection Agency, Office of Environmental Health Hazard Assessment, Toxicity Criteria Database. August 10, 2005. http://www.oehha.ca.gov/risk/pdf/cancerpotalpha81005.pdf.

Region 9 = USEPA Region 9 Preliminary Remediation Goal (PRG) table, October 2004 (with December 2004 updates).

A blank space indicates that no toxicity information is available.

APPENDIX B: NATURAL ATTENUATION EVALUATION SUPPORTING INFORMATION

Appendix B

Natural Attenuation Evaluation Supporting Information

A discussion of groundwater monitoring activities and an evaluation of natural attenuation processes was presented in Section 7.2 of this document. As indicated in this section, the following tasks were performed as part of the evaluation. Supporting information to these tasks is provided in this Appendix, as follows.

A statistical analysis of the groundwater data collected at the source areas, and at areas intermediate, and downgradient from those source areas was performed to further evaluate plume stability. The Mann-Kendall Test was used to examine concentrations of total VOCs at: MW-7M and MW-9 (FDDA source wells); MW-8M and MW-11 (FDDA intermediate/downgradient wells); MW-4S, MW-4B, and MW-5 (Southern lobe source wells); MW-22M (Southern lobe intermediate/ downgradient well); and MW-13D and MW-17D (downgradient wells). The Mann-Kendall Test worksheets for these wells are attached.

The Natural Attenuation Software (NAS) (Widdowson, version 2) was utilized as a screening tool to evaluate if natural attenuation processes are occurring on-site (and therefore aid in the analysis of utilizing MNA as a remedial technology for the site) and to evaluate what degree of source remediation may be required to meet site RAOs (in a quicker timeframe).

The model was run using groundwater data from both the FDDA and Southern Lobe source wells as well as downgradient locations. Groundwater data consisted of the November 2004 and June 2006 groundwater data sets. A summary of the hydrogeologic, contaminant and geochemical data utilized in the model for the FDDA is provided as Table B1 and for the Southern Lobe as Table B2. In addition, examples of the NAS model output for two wells are also provided in this Appendix.

Appendix

Mann Kendall Trend Analysis Results - Groundwater (Total VOCs)
Remedial Investigation and Feasibility Study
Sutton Brook Disposal Area Superfund Site - Tewksbury, Massachusetts

TOTAL VOCs (Results of Mann-Kendall Trend Analysis)

alpha = 95 %

			n =
MW-9	=	No Significant Trend	9
MW-7M	=	No Significant Trend	5
MW-8M	=	No Significant Trend	5
MW-11	=	Significant Downward Trend	7
MW-4S	=	No Significant Trend	10
MW-4B	=	No Significant Trend	10
MW-5	=	No Significant Trend	8
MW-22M	=	No Significant Trend	6
MW-13D	=	No Significant Trend	9
MW-17D	=	No Significant Trend	7

Mann Kendall Trend Analysis Results - Groundwater (Total VOCs)
Remedial Investigation and Feasibility Study
Sutton Brook Disposal Area Superfund Site - Tewksbury, Massachusetts

TOTAL VOCs (μg/L)

MW-9	6/23/99	6/30/99	9/17/99	11/17/04	9/21/05	12/19/05	2/16/06	6/8/06	10/3/06
	98783	117087	1493600	358600	407700	419400	442890	352200	269950
		18304	1394817	259817	308917	320617	344107	253417	171167
			1376513	241513	290613	302313	325803	235113	152863
				-1135000	-1085900	-1074200	-1050710	-1141400	-1223650
					49100	60800	84290	-6400	-88650
						11700	35190	-55500	-137750
							23490	-67200	-149450
								-90690	-172940
									-82250

	Number +	Number -
	8	0
	7	0
	0	6
	3	2
	2	2
	1	2
	0	2
	0	1
Total:	21	-15
S:	(+0)+(-0)=	6

n = 9
alpha = 0.05

MW-9

S = 6
n = 9
From Table A18 (Gilbert, 1987), probability equals = 0.306

No Significant Trend

MW-11	6/30/99	11/18/04	9/21/05	12/19/05	2/16/06	6/7/06	10/3/06
	5090	1134	1048	834	873	976	814
		-3957	-4042	-4256	-4217	-4114	-4276
			-86	-300	-261	-158	-320
				-214	-175	-72	-234
					39	142	-20
						103	-59
							-162

	Number +	Number -
	0	6
	0	5
	0	4
	2	1
	1	1
	0	1
Total:	3	-18
S:	(+0)+(-0)=	-15

n = 7
alpha = 0.05

MW-11

S = -15
n = 7
From Table A18 (Gilbert, 1987), probability equals = 0.015

Significant Downward Trend

Notes: 1. n = number of samples; alpha = statistical significance (0.05 = 95%)

2. Probability here is defined as the probability of obtaining a value of S equal to or exceeding the calculated S for the given n and when no upward/downward trend is present.

3. If Probability > alpha, data shows No Significant Trend; If Probability < alpha and S is negative (-), data shows Significant Downward Trend; and if Probability < alpha and S is positive (+), data shows Significant Upward Trend.

4. (Gilbert, 1987) Statistical Methods for Environmental Pollution Monitoring

Mann Kendall Trend Analysis Results - Groundwater (Total VOCs)
Remedial Investigation and Feasibility Study
Sutton Brook Disposal Area Superfund Site - Tewksbury, Massachusetts

TOTAL VOCs (µg/L)

MW-13D	7/2/99	9/15/99	3/15/01	11/16/04	9/20/05	12/15/05	2/14/06	6/6/06	10/4/06
	0.0	0.0	1.9	150.2	87.7	109.2	24.6	11.0	20.4
		0.0	1.9	150.2	87.7	109.2	24.6	11.0	20.4
			1.9	150.2	87.7	109.2	24.6	11.0	20.4
				148.4	85.9	107.4	22.8	9.1	18.5
					-62.5	-41.0	-125.6	-139.2	-129.9
						21.5	-63.1	-76.8	-67.4
							-84.6	-98.2	-88.9
								-13.6	-4.3
									9.4

7/2/99 = ND
9/15/99 = ND

	Number +	Number -
	7	0
	7	0
	6	0
	0	5
	1	3
	0	3
	0	2
	1	0
Total:	22	-13
S:	(+0)+(-0)=	9

n = 9
alpha = 0.05

MW-13D

S = 9
n = 9
From Table A18 (Gilbert, 1987), probability equals = 0.209

No Significant Trend

MW-17D	3/15/01	11/18/04	9/21/05	12/15/05	2/15/06	6/6/06	10/3/06
	66.6	121.8	22.1	108.2	84.6	102.9	54.4
		55.2	-44.5	41.6	18.0	36.3	-12.2
			-99.7	-13.6	-37.2	-18.9	-67.4
				86.1	62.5	80.8	32.3
					-23.6	-5.3	-53.8
						18.3	-30.2
							-48.5

	Number +	Number -
	4	2
	0	5
	4	0
	0	3
	1	1
	0	1
Total:	9	-12
S:	(+0)+(-0)=	-3

n = 7
alpha = 0.05

MW-17D

S = -3
n = 7
From Table A18 (Gilbert, 1987), probability equals = 0.386

No Significant Trend

Notes: 1. n = number of samples; alpha = statistical significance (0.05 = 95%)

2. Probability here is defined as the probability of obtaining a value of S equal to or exceeding the calculated S for the given n and when no upward/downward trend is present.

3. If Probability > alpha, data shows No Significant Trend; If Probability < alpha and S is negative (-), data shows Significant Downward Trend; and if Probability < alpha and S is positive (+), data shows Significant Upward Trend.

4. (Gilbert, 1987) Statistical Methods for Environmental Pollution Monitoring

Mann Kendall Trend Analysis Results - Groundwater (Total VOCs)
Remedial Investigation and Feasibility Study
Sutton Brook Disposal Area Superfund Site - Tewksbury, Massachusetts

TOTAL VOCs (μg/L)

MW-7M	6/29/95	6/2/99	6/30/99	11/17/04	6/8/06
	4225	11490	5644	20615	18757
		7265	1419	16391	14533
			-5846	9125	7267
				14972	13114
					-1858

Number +	Number -
4	0
2	1
2	0
0	1

n = 5
alpha = 0.05

Total:	8	-2
S:	(+0)+(-0)=	6

MW-7M

S = 6
n = 5
From Table A18 (Gilbert, 1987), probability equals = 0.117

No Significant Trend

MW-8M	6/30/99	9/16/99	3/13/01	11/18/04	6/7/06
	27019	31458	52811	9103	16660
		4439	25792	-17916	-10359
			21353	-22355	-14798
				-43708	-36151
					7557

Number +	Number -
2	2
1	2
0	2
1	0

n = 5
alpha = 0.05

Total:	4	-6
S:	(+0)+(-0)=	-2

MW-8M

S = -2
n = 5
From Table A18 (Gilbert, 1987), probability equals = 0.408

No Significant Trend

Notes: 1. n = number of samples; alpha = statistical significance (0.05 = 95%)

2. Probability here is defined as the probability of obtaining a value of S equal to or exceeding the calculated S for the given n and when no upward/downward trend is present.

3. If Probability > alpha, data shows No Significant Trend; If Probability < alpha and S is negative (-), data shows Significant Downward Trend; and if Probability < alpha and S is positive (+), data shows Significant Upward Trend.

4. (Gilbert, 1987) Statistical Methods for Environmental Pollution Monitoring

Mann Kendall Trend Analysis Results - Groundwater (Total VOCs)
Remedial Investigation and Feasibility Study
Sutton Brook Disposal Area Superfund Site - Tewksbury, Massachusetts

TOTAL VOCs (μg/L)

MW-4S	6/28/95	7/8/99	9/16/99	3/14/01	11/15/04	9/20/05	12/15/05	2/15/06	6/5/06	10/4/06
	4979	5447	29447	67389	32425	47612	45510	36550	38500	28930
		469	24469	62411	27447	42634	40532	31572	33522	23952
			24000	61942	26978	42165	40063	31103	33053	23483
				37942	2978	18165	16063	7103	9053	-517
					-34964	-19777	-21879	-30839	-28889	-38459
						15187	13085	4125	6075	-3495
							-2102	-11062	-9112	-18682
								-8960	-7010	-16580
									1950	-7620
										-9570

	Number +	Number -
	9	0
	8	0
	6	1
	0	6
	4	1
	0	4
	0	3
	1	1
	0	1
Total:	28	-17
S:	(+0)+(-0)=	11

n = 10
alpha = 0.05

MW-4S

S = 11
n = 10
From Table A18 (Gilbert, 1987), probability equals = 0.190

No Significant Trend

MW-4B	6/28/95	7/8/99	9/14/99	3/14/01	11/15/04	9/20/05	12/15/05	2/15/06	6/5/06	10/4/06
	2176	6424	31590	49866	14810	8748	17255	25515	19263	10068
		4248	29414	47691	12634	6572	15079	23339	17087	7892
			25166	43442	8386	2324	10831	19091	12839	3644
				18276	-16780	-22842	-14335	-6075	-12327	-21522
					-35056	-41118	-32611	-24351	-30603	-39798
						-6062	2445	10705	4453	-4742
							8507	16767	10515	1320
								8260	2008	-7187
									-6252	-15447
										-9195

	Number +	Number -
	9	0
	8	0
	1	6
	0	6
	3	2
	4	0
	2	1
	0	2
	0	1
Total:	27	-18
S:	(+0)+(-0)=	9

n = 10
alpha = 0.05

MW-4B

S = 9
n = 10
From Table A18 (Gilbert, 1987), probability[1] equals = 0.242

No Significant Trend

Notes: 1. n = number of samples; alpha = statistical significance (0.05 = 95%)

2. Probability here is defined as the probability of obtaining a value of S equal to or exceeding the calculated S for the given n and when no upward/downward trend is present.

3. If Probability > alpha, data shows No Significant Trend; If Probability < alpha and S is negative (-), data shows Significant Downward Trend; and if Probability < alpha and S is positive (+), data shows Significant Upward Trend.

4. (Gilbert, 1987) Statistical Methods for Environmental Pollution Monitoring

Mann Kendall Trend Analysis Results - Groundwater (Total VOCs)
Remedial Investigation and Feasibility Study
Sutton Brook Disposal Area Superfund Site - Tewksbury, Massachusetts

TOTAL VOCs (μg/L)

MW-5	6/28/95	7/8/99	11/15/04	9/20/05	12/14/05	2/14/06	6/5/06	10/5/06
	2288	1484	7423	7419	9383	7499	5986	11847
		-804	5134	5131	7095	5211	3698	9559
			5939	5935	7899	6015	4502	10363
				-4	1960	76	-1437	4424
					1964	80	-1433	4428
						-1884	-3397	2464
							-1513	4348
								5861

	Number +	Number -
	6	1
	6	0
	3	2
	3	1
	1	2
	1	1
	1	0
Total:	21	-7
S:	(+0)+(-0)=	14

n = 8
alpha = 0.05

MW-5

S = 14
n = 8
From Table A18 (Gilbert, 1987), probability equals = 0.054

No Significant Trend

MW-22M	3/17/05	9/21/05	12/15/05	2/15/06	6/5/06	10/3/06
	3749	4706	4381	4363	4260	3003
		957	632	614	511	-746
			-325	-343	-446	-1703
				-18	-121	-1378
					-103	-1360
						-1257

	Number +	Number -
	4	1
	0	4
	0	3
	0	2
	0	1
Total:	4	-11
S:	(+0)+(-0)=	-7

n = 6
alpha = 0.05

MW-22M

S = -7
n = 6
From Table A18 (Gilbert, 1987), probability equals = 0.136

No Significant Trend

Notes: 1. n = number of samples; alpha = statistical significance (0.05 = 95%)

2. Probability here is defined as the probability of obtaining a value of S equal to or exceeding the calculated S for the given n and when no upward/downward trend is present.

3. If Probability > alpha, data shows No Significant Trend; If Probability < alpha and S is negative (-), data shows Significant Downward Trend; and if Probability < alpha and S is positive (+), data shows Significant Upward Trend.

4. (Gilbert, 1987) Statistical Methods for Environmental Pollution Monitoring

APPENDIX B
TABLE B1
NATURAL ATTENUATION SOFTWARE INPUTS - FDDA

Hydrogeologic Data and Contaminant Transport Calculations

	Maximum	Average	Minimum		NAPL Source	
Hydr. Conductivity [ft/d]	6.4	2.9	0.896	NAPL Source Length [ft]	200.0	Length: feet
Hydraulic Gradient [ft/ft]	0.0011	0.001	0.0009	NAPL Source Width [ft]	100.0	Time: days
Total Porosity [-]		0.22		Contaminated Aquifer Thickness [ft]	5.0	Mass: kilograms
Effective Porosity [-]		0.22				
Groundwater Vel. [ft/d]	0.032	0.013	0.004			

Sorption Parameters

Fraction Org. Carbon [-]	
Maximum	0.001
Average	0.001
Minimum	0.001

	Total BTEX	Benzene	Toluene	Ethylbenzene	Xylene	MEK	MIBK	1,4-dioxane
Koc [L/kg]	300	38	135	95	240	4.5	19	1.23
Retardation Factor [-]								
Maximum	3.82	1.36	2.27	1.89	3.25	1.04	1.18	1.01
Average	3.82	1.36	2.27	1.89	3.25	1.04	1.18	1.01
Minimum	3.82	1.36	2.27	1.89	3.25	1.04	1.18	1.01

Contaminant Concentration Profiles (06/07/2006)

Well Name	Distance [ft]	Total BTEX [µg/L]	Benzene [µg/L]	Toluene [µg/L]	Ethylbenzene [µg/L]	Xylene [µg/L]	MEK [µg/L]	MIBK [µg/L]	1,4-dioxane [µg/L]
MW-9	0	96800.	BD	67000.	7100.	22700.	55000.	130000.	2000.
MW-8M	140	12420.	BD	8800.	880.	2740.	210.	420.	470.
MW-11	320	91.1	6.6	BD	16.	68.5	BD	BD	480.
MW-16D	660	0.78	BD	BD	BD	0.78	BD	BD	3.7
GP-24	830	BD	BD	BD	BD	BD	NS	NS	NS

APPENDIX B
TABLE B1
NATURAL ATTENUATION SOFTWARE INPUTS - FDDA

Redox Indicator Concentration Profiles (06/07/2006)

Well Name	Distance [ft]	Oxygen [mg/L]	Iron(II) [mg/L]	Sulfate [mg/L]	Methane [mg/L]	Redox Condition
MW-9	0	0.18	294.	3.	6.31	SO4/CO2-red.
MW-8M	140	NS	33.	BD	17.8	SO4/CO2-red.
MW-11	320	0.17	20.	BD	13.5	SO4/CO2-red.
MW-16D	660	NS	4.9	13.5	0.378	Ferrogenic
GP-24	830	NS	5.8	33.8	0.104	Ferrogenic

Contaminant Concentration Profiles (11/2004)

Well Name	Distance [ft]	Total BTEX [µg/L]	Benzene [µg/L]	Toluene [µg/L]	Ethylbenzene [µg/L]	Xylene [µg/L]	MEK [µg/L]	MIBK [µg/L]	1,4-dioxane [µg/L]
MW-9	0	56600.	BD	40000.	4400.	12200.	66000.	160000.	3000.
MW-8M	140	6400.	BD	4300.	550.	1550.	BD	62.	BD
MW-11	320	169.6	8.3	1.3	17.	143.	BD	BD	BD
MW-16D	660	BD	BD	BD	BD	BD	BD	BD	BD
GP-24	830	BD	BD	BD	BD	BD	BD	BD	BD

Redox Indicator Concentration Profiles (11/2004)

Well Name	Distance [ft]	Oxygen [mg/L]	Iron(II) [mg/L]	Sulfate [mg/L]	Methane [mg/L]	Redox Condition
MW-9	0	0.19	NS	NS	NS	SO4/CO2-
MW-8M	140	0.41	17.	NS	8670.	SO4/CO2-
MW-11	320	0.2	9.7	NS	19200.	SO4/CO2-
MW-16D	660	0.19	NS	NS	NS	SO4/CO2-
GP-24	830	NS	NS	NS	NS	SO4/CO2-

APPENDIX B
TABLE B2
NATURAL ATTENUATION SOFTWARE INPUTS - SOUTHERN LOBE

Hydrogeologic Data and Contaminant Transport Calculations

	Maximum	Average	Minimum
Hydr. Conductivity [ft/d]	6.3	2.9	0.896
Hydraulic Gradient [ft/ft]	0.004	0.0035	0.003
Total Porosity [-]		0.22	
Effective Porosity [-]		0.22	
Groundwater Vel. [ft/d]	0.115	0.046	0.012

	NAPL Source
NAPL Source	400.0
NAPL Source	150.0
Contaminate	10.0

Sorption Parameters

Fraction Org. Carbon [-]	
Maximum	0.001
Average	0.001
Minimum	0.001

	Total BTEX	Benzene	Toluene	Ethylbenzene	Xylene	MIBK	MEK	1,4-dioxane	THF
Koc [L/kg]	300	38	135	95	240	19	4.5	1.23	0.95
Retardation Factor [-]									
Maximum	3.82	1.78	3.82	11.34	8.8	1.18	1.04	1.01	1.01
Average	3.82	1.78	3.82	11.34	8.8	1.18	1.04	1.01	1.01
Minimum	29.19	8.8	29.19	104.35	78.98	2.79	1.42	1.12	1.09

Contaminant Concentration Profiles - Maximum

Well Name	Distance [ft]	Total BTEX [µg/L]	Benzene [µg/L]	Toluene [µg/L]	Ethylbenzene [µg/L]	Xylene [µg/L]	MIBK [µg/L]	MEK [µg/L]	1,4-dioxane [µg/L]	THF [µg/L]
SOURCE	0	29938.	38.	21000.	2000.	6900.	10000.	27000.	350.	8600.
INTERMEDIATE	380	1770.1	22.	8.1	420.	1320.	1.	5.	220.	2100.
DOWNGRAD	820	0.35	0.35	BD	BD	BD	BD	BD	71.	2.1

Redox Indicator Concentration Profiles (06/07/2006)

Well Name	Distance [ft]	Oxygen [mg/L]	Iron(II) [mg/L]	Sulfate [mg/L]	Methane [mg/L]	Redox Condition
MW-4S	0	0.5	485.61	2.7	3.49	Ferrogenic
MW-22M	380	0.4	120.92	BD	3.29	Ferrogenic
MW-17D	820	0.16	BD	17.6	0.147	SO4/CO2-

Note:
Source wells include - MW-4S, MW-5, GP-11 through GP-16

APPENDIX B
EXAMPLE B1 - NAS OUTPUT FOR FDDA - POC AT MW-11

Facility Name: Sutton Brook -
Site Name: FDDA - BTEX

Length:	feet	
Time:	days	
Mass:	kilograms	

Hydrogeologic Data and

	Maximum	Average	Minimum		NAPL Source
Hydr. Conductivity [ft/d]	6.4	2.9	0.896	NAPL Source	200.0
Hydraulic Gradient [ft/ft]	0.0011	0.001	0.0009	NAPL Source	100.0
Total Porosity [-]		0.22		Contaminated	5.0
Effective Porosity [-]		0.22			
Groundwater Vel. [ft/d]	0.032	0.013	0.004		

	Total BTEX	Benzene	Toluene	Ethylbenzene	Xylene	MEK	MIBK	1,4-dioxane
Koc [L/kg]	300	38	135	95	240	4.5	19	1.23
Retardation Factor [-]								
Maximum	3.82	1.36	2.27	1.89	3.25	1.04	1.18	1.01
Average	3.82	1.36	2.27	1.89	3.25	1.04	1.18	1.01
Minimum	3.82	1.36	2.27	1.89	3.25	1.04	1.18	1.01

Contaminant Concentration Profiles (06/07/2006)

Well Name	Distance [ft]	Total BTEX [μg/L]	Benzene [μg/L]	Toluene [μg/L]	Ethylbenzene [μg/L]	Xylene [μg/L]	MEK [μg/L]	MIBK [μg/L]	1,4-dioxane [μg/L]
MW-9	0	96800.	BD	67000.	7100.	22700.	55000.	130000.	2000.
MW-8M	140	12420.	BD	8800.	880.	2740.	210.	420.	470.
MW-11	320	91.1	6.6	BD	16.	68.5	BD	BD	480.
MW-16D	660	0.78	BD	BD	BD	0.78	BD	BD	3.7
GP-24	830	BD	BD	BD	BD	BD	NS	NS	NS

Redox Indicator Concentration Profiles (06/07/2006)

Well Name	Distance [ft]	Oxygen [mg/L]	Iron(II) [mg/L]	Sulfate [mg/L]	Methane [mg/L]	Redox Condition
MW-9	0	0.18	294.	3.	6.31	SO4/CO2-red.
MW-8M	140	NS	33.	BD	17.8	SO4/CO2-red.
MW-11	320	0.17	20.	BD	13.5	SO4/CO2-red.
MW-16D	660	NS	4.9	13.5	0.378	Ferrogenic
GP-24	830	NS	5.8	33.8	0.104	Ferrogenic

Attenuation Rates

	Total BTEX	Benzene	Toluene	Ethylbenzene	Xylene	MEK	MIBK	1,4-dioxane
NAC (Single Zone) [1/ft]	0.0179	N/A	0.0145	0.019	0.0154	0.0397	0.0409	0.0089

Time of Stabilization(TOS) and

Distance to POC [ft] 320.0

Contaminant	RCC [μg/L]	Well	Source Reduction Conc [μg/L] Current	Target	Time of Breakthrough Maximum	Average	Minimum	Time to Maximum	Average	Minimum
Benzene	5.0	3	7							
Toluene	1000.0	1	67000	No Reduction Required						
Ethylbenzene	700.0	1	7100	No Reduction Required						
Xylene	10000.0	1	22700	No Reduction Required						
MEK	350.0	1	55000	No Reduction Required						
MIBK	350.0	1	130000	No Reduction Required						
1,4-dioxane	3.0	1	2000	12	203.9	56.7	23.4	525.6	146.1	60.2

APPENDIX B
EXAMPLE B2 - NAS OUTPUT FOR SOUTHERN LOBE - POC AT MW-17D

Facility Name: Sutton Brook - Southern Lobe
Site Name: Southern Lobe

Length: feet
Time: days
Mass: kilograms

Hydrogeologic Data and Contaminant Transport Calculations

	Maximum	Average	Minimum
Hydr. Conductivity [ft/d]	6.3	2.9	0.896
Hydraulic Gradient [ft/ft]	0.004	0.0035	0.003
Total Porosity [-]		0.22	
Effective Porosity [-]		0.22	
Groundwater Vel. [ft/d]	0.115	0.046	0.012

	NAPL Source
NAPL Source Length [ft]	500.0
NAPL Source Width [ft]	150.0
Contaminated Aquifer Thickness [ft]	10.0

Dispersion Parameters
Sorption Parameters

	Benzene	Toluene	Ethylbenzene	Xylene	MIBK	MEK	1,4-dioxane	THF
Koc [L/kg]	38	135	95	240	19	4.5	1.23	0.95
Retardation Factor [-]								
Maximum	1.36	2.27	1.89	3.25	1.18	1.04	1.01	1.01
Average	1.36	2.27	1.89	3.25	1.18	1.04	1.01	1.01
Minimum	4.57	13.68	9.93	23.55	2.79	1.42	1.12	1.09

Contaminant Concentration Profiles (02/07/2007)

Well Name	Distance [ft]	Total BTEX [μg/L]	Benzene [μg/L]	Toluene [μg/L]	Ethylbenzene [μg/L]	Xylene [μg/L]	MIBK [μg/L]	MEK [μg/L]	1,4-dioxane [μg/L]	THF [μg/L]
SOURCE	0	29938.	38.	21000.	2000.	6900.	10000.	27000.	350.	8600.
INTERMEDIATE	380	1770.1	22.	8.1	420.	1320.	1.	5.	220.	2100.
DOWNGRAD	820	0.35	0.35	BD	BD	BD	BD	BD	71.	2.1

Redox Indicator Concentration Profiles (06/05/2006)

Well Name	Distance [ft]	Oxygen [mg/L]	Iron(II) [mg/L]	Sulfate [mg/L]	Methane [mg/L]	Redox Condition
MW-4S	0	0.5	485.61	2.7	3.49	Ferrogenic
MW-22M	380	0.4	120.92	BD	3.29	Ferrogenic
MW-17D	820	0.16	BD	17.6	0.147	SO4/CO2-red.

Attenuation Rates

	Benzene	Toluene	Ethylbenzene	Xylene	MIBK	MEK	1,4-dioxane	THF
NAC (Single Zone) [1/ft]	0.0056	0.0206	0.004	0.0042	0.0241	0.0225	0.0017	0.01

Time of Stabilization(TOS) and Max Source Conc. Calculations

Distance to POC [ft] 820.0

Contaminant	RCC [μg/L]	Well	Source Reduction Conc [μg/L] Current	Target	Time of Stabilization [years] Breakthrough Time Maximum	Average	Minimum	Time to Equilibrium Maximum	Average	Minimum
Benzene	5.0	1	38	13	229.1	60.7	70.3	509.6	134.9	147.5
Toluene	1000.0	1	21000	No Reduction Required						
Ethylbenzene	700.0	1	2000	No Reduction Required						
Xylene	10000.0	1	6900	No Reduction Required						
MIBK	350.0	1	10000	No Reduction Required						
MEK	350.0	1	27000	No Reduction Required						
1,4-dioxane	3.0	1	350	7	176.3	46.7	20.6	396.8	105.1	46.3
THF	1300.0	1	8600	No Reduction Required						

APPENDIX C: REMEDIAL TIMEFRAME ESTIMATES

APPENDIX C
METHODS USED TO ESTIMATE REMEDIAL TIMEFRAMES FOR GROUNDWATER

To aid in the FS detailed analysis, the timeframe to achieve PRGs in groundwater was performed for the former drum disposal area (FDDA), landfills, and downgradient groundwater (DGGW) through first-order decay of source material combined with batch flushing for dissolved compounds. This assumed a combination of two processes was occurring in each of these areas: dissolution of material from soil or waste into groundwater and dilution of dissolved VOCs by flushing.

The timeframes were calculated for the DGGW for two scenarios: with or without upgradient source zone mass reduction measures implemented. The calculations assumed that the majority of source material mass will be removed from the FDDA; however complete removal of all impacted material is unlikely, therefore providing potential for a reduced amount of future leaching into groundwater. For the Southern lobe, although containment of the waste will significantly reduce future groundwater impacts, the source material will remain in place, providing the opportunity for potential continued leaching over time (i.e. seasonal groundwater fluctuation into the waste, etc.). For the landfill and FDDA alternatives (where excavation of impacted soil was proposed), the source dissolution component of the calculations assumed current (2006) groundwater concentrations would initially remain following source control measures; the dissolution/treatment of this material was utilized for the remedial timeframes.

The calculations were run for organic compounds only. Arsenic, as the most prevalent inorganic detected above its MCL across the site, was the primary inorganic evaluated for both natural attenuation processes and attainment of PRGs. However, since arsenic is naturally occurring in the area and observed above the MCL in upgradient locations, attaining the MCL on-site will be difficult in the foreseeable timeframe, regardless of the selected remedial alternative. As a result, other groundwater risk drivers were evaluated to determine relative timeframes for this FS comparison purposes.

A summary of the estimated timeframes are provided as Table C1 and a more detailed description of the methods is provided below.

Long-Term Point of Compliance The long-term point of compliance (e.g., end point of the remedial process) is the point at which all groundwater within the impacted aquifer meets the PRGs. The NCP indicates that the groundwater is considered "restored" when protective levels are achieved. This has significant implications for remedial timeframe estimates, as it requires the selected remedy to meet PRGs throughout the entire aquifer over time.

Because several subsurface mechanisms contribute to the remediation of VOCs (e.g., biodegradation, dispersion, diffusion, dilution, sorption, and volatilization), several models/methods were evaluated, and applied as appropriate, to estimate the remediation time frame for each remedial alternative. The following is a brief description of each method/model used to estimate remedial time frames, with a discussion of the input parameters and assumptions. One example of the models and calculations is included as Attachments C-1 (for FDDA-5).

VOC Mass Flux Calculations to Determine Residual Source Dissolution Rate Since an accurate measure of the remaining source material present in the FDDA and landfills is not currently attainable, the change in mass dissolved in groundwater was used to calculate the anticipated site specific decay rate. With the assumption that flux rate and VOC concentrations in groundwater will be proportionate to mass of VOCs remaining in soil, the decay rate of either mass or downgradient concentration can be modeled by the first order equation:

$$M_t = M_o * e^{-kt} \quad \text{(Equation 1)}$$

-or-

$$C_t = C_o * e^{-kt} \quad \text{(Equation 2)}$$

where:

M_t = remaining mass at time t, lb;
M_o = original mass, lb;
C_t = concentration at time t, ug/L;
C_o = original concentration, ug/L;
k = decay constant, 1/yr; and
t = time, years

Utilizing the estimates of the mass of VOCs measured in groundwater during the 1999 and 2006 groundwater sampling event, the decay constant (k) was calculated. The range in decay constant (maximum and minimum calculated) was then used with the batch flushing model (as k1 Equation 4).

USEPA Batch Flushing Model This model estimates the number of groundwater pore volume flushes required to remove dissolved contaminants from the aquifer. This estimate is based on the groundwater seepage velocity and the retardation coefficient. This model only addresses the dissolved phase and does not account for a continuing source. Input parameters include aquifer properties such as porosity, bulk density, and fraction organic carbon. Contaminant properties include the organic carbon/water partitioning coefficient and dissolved contaminant concentrations. The mathematical equation for the model is as follows:

$$N = -R * \ln(C_i/C_s) = (1+K_{oc}*f_{oc}*\rho/n) * \ln(C_i/C_s) \quad \text{(Equation 3)}$$

where:

N = number of pore volume flushes required to achieve remedial goals
R = Retardation constant;
K_{oc} = compound-specific organic carbon partitioning coefficient (mL/g)
f_{oc} = fraction of organic carbon in soil (dimensionless)
ρ = bulk density of soil or rock (g/mL)
n = porosity (dimensionless)
C_s = PRG concentration (μg/L)
C_i = initial maximum concentration (2006) (μg/L)

The overall time to achieve remedial goals by flushing is determined by multiplying the number of pore volume flushes by the time required for one pore volume flush. The time for one pore volume flush was determined using the site-specific numerical groundwater flow model.

The following parameters were utilized in the remedial timeframe calculations in one or more of the areas (LF, FDDA and/or DGGW); these were selected due to their elevated presence in groundwater, their exceedance of PRGs and/or the nature of the contaminants persistence in the subsurface.

APPENDIX C
METHODS USED TO ESTIMATE REMEDIAL TIMEFRAMES FOR GROUNDWATER

Parameter	Koc *(ml/g)*	Reference
1,2,4-Trimethylbenzene	472	from EPA fact sheet – USEPA, 1994a
1,4-Dioxane	1.23	from EPA fact sheet – USEPA, 1995
2-Butanone (MEK)	4.5	from EPA fact sheet – USEPA, 1994b
4-Methyl-2-pentanone (MIBK)	19	from EPA fact sheet – USEPA, 1994c
Acetone	0.58	USEPA, 2000
Chloroethane	15	USEPA, 2000
Ethylbenzene	95	USEPA, 1996, references ASTM 1995 (E-1737-95)
Tetrahydrofuran	0.95	USEPA, 2000
Toluene	135	USEPA, 1996, references ASTM 1995 (E-1737-95)
Xylenes	240	USEPA, 1996, references ASTM 1995 (E-1737-95)

USEPA, 1994a. Chemical Summary for 1,2,4-Trimethylbenzene, EPA 749-F-94-022a, August. http://www.epa.gov/opptintr/chemfact/s_trimet.txt

USEPA, 1994b. Chemical Summary for Methyl Ethyl Ketone, EPA 749-F-94-015a, September. http://www.epa.gov/opptintr/chemfact/s_mek.txt

USEPA, 1994c. Chemical Summary for Methyl Isobutyl Ketone, EPA 749-F-94-009a, September. http://www.epa.gov/opptintr/chemfact/s_mibk.txt

USEPA, 1995. OPPT Chemical Fact Sheets, 1,4-Dioxane Fact Sheet: Support Document (CAS No. 123-9-1), EPA 749-F-95-010a, February. http://www.epa.gov/opptintr/chemfact/dioxa-sd.pdf

USEPA, 1996. BIOSCREEN, Natural Attenuation Decision Support System, User's Manual, Version 1.3, EPA 600-R-96-087.

USEPA, 2000. Contaminant Physical Chemical Data for Volatile Organic Compounds, Region 9. October. http://www.epa.gov/region09/waste/sfund/prg/files/04physchem.pdf

Combined Equation. To combine the two processes (source material converting to dissolved phase and dissolved phase decreasing by dilution), Equations 2 and 3 take the form of Equation 4 which describes any scenario in which substance A (residual source material) converts to substance B (dissolved VOCs) at some rate constant k1 (determined above), and B degrades at some rate constant k2.

$$C_t = C_{od}*e^{-k2t} + [k1*C_{os}/(k2-k1)]*(e^{-k1t}-e^{-k2t}) \quad \text{(Equation 4)}$$

Where:

C_t = concentration at time t, ug/L;
C_{od} = 2006 concentration associated with dissolved phase, ug/L;
C_{os} = original max. concentration associated with source material, ug/L;
k1 = source decay constant, 1/yr;
k2 = flushing decay constant = 1/RF, 1/yr;
R = Retardation constant;
F = time per pore volume flush, years; and
t = time, years

Equation 4 can not be solved explicitly, but it can be solved by trial and error. Therefore, for each scenario the time was varied manually until the concentration met the PRG. This was performed for the contaminants with the highest calculated pore volumes required to meet PRGs (Equation 3).

APPENDIX C
TABLE C1
SUMMARY OF TIMEFRAMES TO MEET RAOs

Alternative	Assumptions in Determining Timeframes	Limiting Factor	Estimated Relative Timeframe to meet RAOs
LF-1	- No remedial actions implemented	Waste	Will not achieve RAOs
LF-2	- Landfill lobes have low permeability final cover systems constructed - Vertical groundwater containment barrier is installed along the northern and eastern perimeter of the Southern landfill lobe - Focused groundwater treatment at downgradient edge of Southern lobe and vertical barrier - LF-2a phased groundwater approach incorporating monitored natural attenuation with the potential for future enhancements; LF-2b active treatment (assumed extraction at 15 gpm).	Groundwater	65 to 210 years
LF-3	- Landfill lobes have low permeability final cover systems constructed - Groundwater extraction and ex-situ treatment operating at a combined flowrate of 245 gpm (95 gpm for Southern lobe and 150 gpm for Northern lobe)	Groundwater	52 to 164 years
LF-4	- Landfill lobes have low permeability final cover systems constructed - Brook is re-routed to the south of the Southern lobe - Vertical groundwater containment barrier is installed along the southern perimeter of the Southern landfill lobe - Focused active groundwater treatment at downgradient edge of Southern lobe and vertical barrier (assumed extraction at 15 gpm)	Groundwater	65 to 210 years
FDDA-1	- No remedial actions implemented	Soil	Will not achieve RAOs
FDDA-2	- Soil containment barrier constructed - Hydraulic containment with groundwater extraction and ex-situ treatment operating at a flowrate of 20 gpm	Groundwater	30 to 134 years
FDDA-3	- Source area soil excavated - Hydraulic containment with groundwater extraction and ex-situ treatment operating at a flowrate of 24 gpm	Groundwater	24 to 89 years

APPENDIX C
TABLE C1
SUMMARY OF TIMEFRAMES TO MEET RAOs

Alternative	Assumptions in Determining Timeframes	Limiting Factor	Estimated Relative Timeframe to meet RAOs
FDDA-4	- Source area soil excavated - Focused groundwater treatment with the FDDA - phased groundwater approach incorporating monitored natural attenuation with the potential for future enhancements.	Groundwater	36 to 103 years
FDDA-5	- Source area soil excavated - Groundwater extraction and ex-situ treatment operating at a flowrate of 50 gpm	Groundwater	23 to 85 years
GSA-1	- No remedial actions implemented	Soil	Will not achieve RAOs
GSA-2	- Source area soil excavated	Soil	1 to 2 years
DGGW-1	- No remedial actions implemented	Groundwater	Will not achieve RAOs
DGGW-2	- In-situ natural attenuation mechanisms with the potential for future enhancements.	Groundwater	With Source Control - 67 to 79 years Without Source Control - 81 to 98 years
DGGW-3	- Hydraulic containment with groundwater extraction and ex-situ treatment operating at a combined flowrate of 75 gpm	Groundwater	With Source Control - 57 to 68 years Without Source Control - 70 to 86 years
DGGW-4	- Groundwater extraction and ex-situ treatment operating at a combined flowrate of 140 gpm	Groundwater	With Source Control - 40 to 49 years Without Source Control - 53 to 66 years

Notes:
DGGW timeframes estimated with and without source control measures (i.e. FDDA soil excavation)

APPENDIX C
ATTACHMENT C1
REMEDIAL TIMEFRAME CALCULATIONS - FDDA-5

Excavation, treatment and/or disposal of soil with groundwater extraction and ex-situ treatment for area-wide contaminant reduction

Given: Residual VOC and SVOC impacts in soil are excavated, existing dissolved VOCs removed via groundwater extraction and ex-situ treatment for area-wide contaminant reduction.

Find: 1) Time to achieve PRGs (i.e. MCLs) in FDDA groundwater through a combination of two processes: removal of residual source material via excavation and dilution of dissolved VOCs by flushing.

Assumed: 1) This alternative utilizes excavation to remove residual source material in the FDDA, reducing future leaching into groundwater, combined with extraction and ex-situ treatment of groundwater for mass reduction in an accelerated timeframe.
2) Flux rate and VOC concentrations in groundwater will be proportionate to mass of VOCs remaining; SVOCs have remained in soil, but not leached into groundwater at an expedited rate (little to no SVOC mass present in groundwater); only VOCs are addressed below for time to reach groundwater RAOs.
3) Extraction of 50 gpm from this area is assumed for this alternative for mass reduction/ aquifer restoration, as modeled in MODFLOW.
4) Decay rate of source material is similar to dissolved state rate of decay.

Method: First-order decay for source material combined with batch flushing model for dissolved constituents

Source Area Dissolution Component

The mass flux can be estimated given the mass determined to be dissolved in the plume coupled with the assumption that mass remaining in soil in the source area is removed (excavated), and the mass flux rate is decreasing in proportion to the mass remaining in the source area.

a) Determine VOC mass dissolved in groundwater in 1999 and 2006:

Sub-Area ID	Surface Area (square feet)	Saturated Thickness (feet)	Porosity	1999 Average Conc. (ug/L)	1999 MAX Conc. (ug/L)	Lower Mass Estimate (pounds)	Upper Mass Estimate (pounds)	
Area 1	20,190	15.0	0.22	569,823	1,493,600	2,373	6,220	
Area 2	35,566	15.0	0.22	8,567	11,490	63	84	
Area 3	13,926	15.0	0.22	29,238	31,458	84	90	
Total	69,682					2,436	6,304	*Estimated mass in groundwater - 1999*

Sub-Area ID	Surface Area (square feet)	Saturated Thickness (feet)	Porosity	2006 Average Conc. (ug/L)	2006 MAX Conc. (ug/L)	Lower Mass Estimate (pounds)	Upper Mass Estimate (pounds)	
Area 1	20,190	15.0	0.22	355,013	442,890	1,478	1,844	
Area 2	35,566	15.0	0.22	18,757	18,757	138	138	
Area 3	13,926	15.0	0.22	888	976	3	3	
Total	69,682					1,616	1,982	*Estimated mass in groundwater - 2006*

APPENDIX C
ATTACHMENT C1
REMEDIAL TIMEFRAME CALCULATIONS - FDDA-5

b) Determine the rate of decay in the FDDA in the past 7 years.

If the rate of flux decreases in proportion to the mass remaining in the source area, and the concentation of VOCs immediately downgradient of the source decays is assumed to be in proportion to the mass flux, the decay rate of either mass or downgradient concentration can be modeled by the first order equation:

$\mathbf{M_t = M_o * e^{-kt}}$ **(Equation 1)**

-or-

$\mathbf{C_t = C_o * e^{-kt}}$ **(Equation 2)**

where:

Mt = remaining mass at time t (2006), lb;
Mo = original mass (1999), lb;
Ct = concentration at time t (2006), ug/L;
Co = original concentration (1999), ug/L;
k = decay constant, 1/yr; and
t = time (7), years

Utilizing the estimates of the mass of VOCs dissolved in groundwater in 1999 and 2006, the decay constant (k) can be calculated. The range in decay constant (maximum and minimum calculated) is then utilized with the batch flushing model (as k1 in Equation 4 below).

	Former VOC Mass - 1999 (lb)	Current VOC Mass in Plume (lb)	Decay Constant (1/yr)	
Case 1	2,436	1,616	0.059	
Case 2	2,436	1,982	0.029	** utilized in Equation 4 below
Case 3	6,304	1,616	0.194	** utilized in Equation 4 below
Case 4	6,304	1,982	0.165	

Batch Flushing

The conventional batch flushing model is presented below. The batch flushing model assumes there is no continuing source. The model assumes a first order removal rate and a linear partitioning model $C_w = f_{oc}*K_{oc}*C_i$, where, C_w=conc. in soil matrix, C_i=conc. in groundwater.

Minimum number of pore volume flushes required to achieve PRGs

$\mathbf{N = -R*\ln(C_s/C_i)}$ **(Equation 3)**

where:

N = number of pore volumes
R = retardation coefficient
= $(1+K_{oc} * f_{oc} *$ bulk density/porosity)

bulk density = 1.76 g/cm^3
porosity = 0.22

K_{oc} = organic carbon partition coefficient
f_{oc} = estimated fraction of organic carbon
= 0.0001 lower range
= 0.001 upper range
C_s = Target concentration (e.g. MCL), ug/L
C_i = Initial concentration, ug/L (average 2006 data at source - MW-9)

APPENDIX C
ATTACHMENT C1
REMEDIAL TIMEFRAME CALCULATIONS - FDDA-5

Years per pore volume flush (from Modflow model)

For this alternative, one pore volume flush is the average time required for a particle to travel through the FDDA with the groundwater extraction system operating at 50 gpm.

Time per pore volume flush = 221 days, based on Modflow modeling
0.6 years

If foc is **0.0001** then retardation is as follows:

Parameter	C_s (ug/l)	C_i (ug/l)	K_{oc} (ml/g)	R	Number of Pore Volumes
1,4-Dioxane	3	1,633	1.23	1.0	6
2-Butanone (MEK)	350	61,333	4.5	1.0	5
Methyl-2-pentanone (MIBK)	350	126,667	19	1.0	6
Acetone	3,000	55,000	0.58	1.0	3
Ethylbenzene	700	7,367	95	1.1	3
Xylenes	10,000	24,567	240	1.2	1
Tetrahydrofuran	1,300	17,000	0.95	1.0	3
Toluene	1,000	70,333	135	1.1	5

Maximum number of pore volume flushes = 6
Years/pore volume flush = 1

Estimated time to achieve MCLs for all contaminants = 4 years
(Batch flushing only)

If foc is **0.001** then retardation is as follows:

Parameter	Cs (ug/l)	Ci (ug/l)	Koc (ml/g)	R	Number of Pore Volumes
1,4-Dioxane	3	1,633	1.23	1.0	6
2-Butanone (MEK)	350	61,333	4.5	1.0	5
Methyl-2-pentanone (MIBK)	350	126,667	19	1.2	7
Acetone	3,000	55,000	0.58	1.0	3
Ethylbenzene	700	7,367	95	1.8	4
Xylenes	10,000	24,567	240	2.9	3
Tetrahydrofuran	1,300	17,000	0.95	1.0	3
Toluene	1,000	70,333	135	2.1	9

Maximum number of pore volume flushes = 9
Years/pore volume flush = 1

Estimated time to achieve MCLs for all contaminants = 5 years
(Batch flushing only)

Note: Shading indicates compounds with the higher number of pore volume flushes.

APPENDIX C
ATTACHMENT C1
REMEDIAL TIMEFRAME CALCULATIONS - FDDA-5

If we combine the two mechanisms: source material converting to dissolved phase; and dissolved phase decreasing by dilution, Equations 2 and 3 above are combined and takes the form of Equation 4, which describes any scenario in which A converts to B at some rate constant k1, and B degrades at some rate constant k2:

$$Ct = Cod*e-k2t + [k1*Cos/(k2-k1)]*(e^{-k1t}-e^{-k2t}) \quad \text{(Equation 4)}$$

Ct = concentration at time t, ug/L;
Cod = average 2006 concentration associated with dissolved phase in source (MW-9), ug/L;
Cos = original max. concentration associated with source material - max 2006 at MW-9, ug/L;
k1 = source decay constant, 1/yr (calculated above);
k2 = flushing decay constant = 1/RF, 1/yr;
R = Retardation constant;
F = time per pore volume flush, years; and
t = time, years

Equation 4 can not be solved explicitly, but it can be solved by trial and error. Therefore, for each scenario the time was varied manually until the concentration met the PRG. The table below evaluates the range of source decay constants and retardation coefficients to obtain a range of remedial timeframes. The equations were only calculated for 1,4-dioxane, 4-Methyl-2-pentanone, Toluene and 2-Butanone since these are the rate limiting compounds, as shown above.

Based on Equation 4 above, the range of cleanup times is as follows:

Constants - **1,4-dioxane**

C_{od}	1,633	ug/L 1,4-dioxane (assumes current dissolved levels (2006 avg) remain after source is removed))
C_{os}	2,000	ug/L 1,4-dioxane (max source concentration - 2006)
C_t	3	ug/L 1,4-dioxane
F	0.61	years

Variables

k1	R	k2	Cleanup time (years)	Round to Nearest Year	1,4-dioxane Conc. at Cleanup Time (ug/L)
0.029	1.00	1.65	84.70	85	3.00
0.194	1.00	1.65	23.08	23	3.00
0.029	1.01	1.64	85.00	85	3.00
0.194	1.01	1.64	23.14	23	3.00

Constants - **4-Methyl-2-pentanone**

C_{od}	126,667	ug/L 4-Methyl-2-pentanone (assumes current dissolved levels (2006 avg) remain after source is removed))
C_{os}	150,000	ug/L 4-Methyl-2-pentanone (max source concentration - 2006)
C_t	350	ug/L 4-Methyl-2-pentanone (MCL)
F	0.61	years

Variables

k1	R	k2	Cleanup time (years)	Round to Nearest Year	4-Methyl-2-pentanone Conc. at Cleanup Time (ug/L)
0.029	1.02	1.63	70.10	70	350.84
0.194	1.02	1.63	20.89	21	350.44
0.029	1.15	1.43	74.50	75	350.66
0.194	1.15	1.43	21.64	22	350.18

APPENDIX C
ATTACHMENT C1
REMEDIAL TIMEFRAME CALCULATIONS - FDDA-5

Constants - **Toluene**

C_{od}	70,333	ug/L Toluene (assumes current dissolved levels (2006 avg) remain after source is removed))
C_{os}	75,000	ug/L Toluene (max source concentration - 2006)
C_t	1000	ug/L Toluene (MCL)
F	0.61	years

Variables

k1	R	k2	Cleanup time (years)	Round to Nearest Year	Toluene Conc. at Cleanup Time (ug/L)
0.029	1.11	1.49	14.04	14	1,000.00
0.194	1.11	1.49	12.45	12	1,000.66
0.029	2.08	0.79	36.05	36	1,000.04
0.194	2.08	0.79	16.42	16	1,000.59

Constants - 2-Butanone (MEK)

C_{od}	61,333	ug/L 2-Butanone (MEK) (assumes current dissolved levels (2006 avg) remain after source is removed))
C_{os}	77,000	ug/L 2-Butanone (MEK) (max source concentration - 2006)
C_t	350	ug/L 2-Butanone (MEK) (GW-1)
F	0.61	years

Variables

k1	R	k2	Cleanup time (years)	Round to Nearest Year	2-Butanone (MEK) Conc. at Cleanup
0.029	1.00	1.65	47.10	47	350.46
0.194	1.00	1.65	17.40	17	350.02
0.029	1.04	1.59	48.20	48	350.47
0.194	1.04	1.59	17.58	18	350.42

Summary:

	Minimum (years)	Maximum (years)
1,4-Dioxane	23	85
4-Methyl-2-pentanone (MIBK)	21	75
Toluene	12	36
2-Butanone (MEK)	17	48
Range of Timeframes (in years):	23	85

APPENDIX D: REMEDIAL ALTERNATIVE COST ESTIMATES

Appendix D

Remedial Alternative Cost Estimates

Utilizing the detailed descriptions of each remedial alternative (presented as in Section 8 of the FS), feasibility level cost estimates were developed. Costs presented in this analysis are based on existing data and knowledge of the site and will be reevaluated at the time of remedial design of the selected alternative. Per the RI/FS guidance (USACE and USEPA, 2000), the costs are intended to be within the target accuracy range of -30 to +50 percent of actual cost. For comparison purposes, the costs for each alternative are estimated for 30 years, regardless of the anticipated time frames beyond 30 years to meet RAOs. The relative change in present value O&M costs is minimal past the 30 year timeframe.

Separate back-up cost estimates for each remedial alternative retained in the detailed analyses are provided using the following worksheets:

- Summary
- Capital costs
- Operations and Maintenance costs
- Periodic costs

A summary of the costs for each alternative relative to one another is presented on an overall summary table at the beginning of this appendix.

APPENDIX D
TABLE D0
FEASIBILITY STUDY SUMMARY OF COST ESTIMATES

	ALTERNATIVE DESCRIPTION	RATE AND PERIOD	CAPITAL COSTS	OM&M COSTS	PERIODIC COSTS	TOTAL PRESENT WORTH
	LANDFILL LOBES					
LF-1	No Action	7%, 30 years	$ -	$ 68,000	$ 43,000	$111,000
LF-2a	Containment of waste, vent landfill gas, restoration of wetlands and brook, partial containment of groundwater with a vertical barrier and groundwater treatment	7%, 30 years (MNA) or 7%, 3 years (MNA) and 27 years (system operation)	$ 17,500,000	$ 2,900,000	$ 120,000	$20,520,000
LF-2b			$ 19,700,000	$ 5,400,000	$ 120,000	$25,220,000
LF-3	Containment of waste, vent landfill gas, restoration of wetlands and brook, and contaminated groundwater collection and treatment	7%, 30 years	$ - to $ 24,900,000	$ 15,900,000 to $ 26,100,000	$ 130,000	$40,930,000 -- $51,130,000
LF-4	Containment of waste, vent landfill gas, re-routing of the brook, excavation of impacted sediment hot spots, partial containment of groundwater (vertical barrier) with groundwater treatment	7%, 3 years (MNA) and 27 years (system operation)	$ - to $ 25,900,000	$ - to $ 5,400,000	$ 120,000	$31,420,000
	FORMER DRUM DISPOSAL AREA					
FDDA-1	No Action	7%, 30 years	$ -	$ 41,000	$ 43,000	$84,000
FDDA-2	Containment of soil (with cap) and groundwater (through extraction and ex-situ treatment)	7%, 30 years	$ 3,100,000	$ 4,300,000 to $ 5,100,000	$ 130,000	$7,530,000 -- $8,330,000
FDDA-3	Excavation, treatment and/or disposal of soil with hydraulic containment of groundwater (through extraction and ex-situ treatment)	7%, 25 years (system operation), 30 years (GW monitoring)	$ 3,400,000	$ 4,100,000 to $ 5,700,000	$ 120,000	$7,620,000 -- $9,220,000
FDDA-4	Excavation, treatment and/or disposal of soil with groundwater treatment (focused mass reduction)	7%, 30 years (MNA)	$ 1,000,000 to $ -	$ 1,700,000 to $ -	$ 110,000	$2,810,000
FDDA-5	Excavation, treatment and/or disposal of soil with groundwater extraction and ex-situ treatment for area-wide contaminant reduction	7%, 25 years (system operation), 30 years (GW monitoring)	$ 4,500,000	$ 5,300,000 to $ 7,700,000	$ 130,000	$9,930,000 -- $12,330,000
	GARAGE AND STORAGE AREA					
GSA-1	No Action	7%, 30 years	$ -	$ 40,000	$ 10,000	$50,000
GSA-2	Excavation and on-site disposal of soil	7%, 3 years	$ 184,000	$ -	$ 16,000	$200,000
	NON-SOURCE AREA SEDIMENT AND WETLAND SOIL					
NSSD-1	No Action	7%, 30 years	--	--	--	*Not estimated at this time*
NSSD-2	Limited Action (Natural Recovery)	7%, 30 years	--	--	--	*Not estimated at this time*
NSSD-3	Excavation with on-site disposal and wetland restoration	7%, 5 years	-	--	--	*Not estimated at this time*
	DOWNGRADIENT GROUNDWATER					
DGGW-1	No Action	7%, 30 years	$ -	$ 41,000	$ 43,000	$84,000
DGGW-2	In-situ treatment	7%, 30 years (MNA)	$ 230,000	$ 1,400,000	$ 120,000	$1,750,000
DGGW-3	Groundwater Containment and Treatment	7%, 30 years	$ 2,900,000	$ 6,800,000 to $ 9,800,000	$ 130,000	$9,830,000 to $12,830,000
DGGW-4	Groundwater extraction and ex-situ treatment for area-wide contaminant reduction	7%, 30 years	$ 4,500,000	$ 6,500,000 to $ 12,200,000	$ 130,000	$11,130,000 to $16,830,000

NOTES:
O&M Range incorporates: 30 years of system operation with 30 years of groundwater monitoring - low: discharge to surface water, high: discharge to POTW; except for LF-2a (MNA only) and LF-2b (groundwater discharge to POTW)

APPENDIX D
ATTACHMENT D1
FEASIBILITY STUDY COST ESTIMATE SUMMARY - LANDFILL LOBES
LF-1: No Action

CAPITAL COSTS

Construction Activities		
Pilot Test	$	-
Mobilization/Demobilization	$	-
Pre-implementation Monitoring, Sampling, Testing and Analysis	$	-
Site Work	$	-
Landfill Containment	$	-
Sediment Excavation	$	-
Groundwater Treatment or Containment	$	-
Institutional Controls	$	-
SUBTOTAL - CONSTRUCTION ACTIVITIES	$	-
Contingency (10%)	$	-
TOTAL CONSTRUCTION ACTIVITIES	**$**	**-**
Profesional/ Technical Services		
Project Management	$	-
Remedial Design	$	-
Construction Management	$	-
Health and Safety	$	-
Permitting/ Legal	$	-
TOTAL PROFESSIONAL/ TECHNICAL SERVICES	$	-
TOTAL CAPITAL COSTS	$	-

ANNUAL OPERATION, MAINTENANCE AND MONITORING COSTS

Performance Monitoring	$	-
Groundwater Treatment	$	-
Annual site-wide inspection	$	5,000
O&M SUBTOTAL:	$	5,000
Contingency (10%)	$	500
TOTAL - O&M COSTS (ANNUAL)	$	5,500
TOTAL - PRESENT VALUE - O&M COSTS	$	68,200

PERIODIC COSTS - PRESENT VALUE (7%)

Five Year Site Reviews	$	43,000
Groundwater Performance and Optimization Study	$	-
Remedial Action Report	$	-
Demobilization of on-site treatment system	$	-
Well Abandonment	$	-
Update Instiutional Controls Plan	$	-
	$	-
TOTAL PRESENT VALUE PERIODIC COSTS	$	43,000

TOTAL PRESENT VALUE (30 YEARS)	**$**	**111,200**

APPENDIX D
ATTACHMENT D1
FEASIBILITY STUDY COST ESTIMATE SUMMARY - LANDFILL LOBES
LF-1: No Action

OPERATION AND MAINTENANCE COSTS

	QTY	UNIT	UNIT COST	TOTAL	NOTES
Performance Monitoring					
Landfill gas				$ -	
Groundwater - treatment system				$ -	
Groundwater - site wide				$ -	
Surface water				$ -	
SUBTOTAL:				$ -	
Groundwater Treatment					
Operations Labor				$ -	
Maintenance Labor				$ -	
Equipment Repair/replacement				$ -	
Utilities				$ -	
				$ -	
SUBTOTAL:				$ -	
Annual site-wide inspection					
Inspection	1	LS	$ 5,000	$ 5,000	
SUBTOTAL:				$ 5,000	
O&M SUBTOTAL:				$ 5,000	
Contingency (10%)				$ 500	
TOTAL - O&M COSTS (ANNUAL)				**$ 5,500**	
TOTAL - PRESENT VALUE - O&M COSTS				$ 68,200	

APPENDIX D
ATTACHMENT D1
FEASIBILITY STUDY COST ESTIMATE SUMMARY - LANDFILL LOBES

LF-1: No Action

PERIODIC COSTS

	YEAR	QTY	UNIT	UNIT COST	TOTAL	PRESENT VALUE (7%)	NOTES
Five Year Site Reviews	5, 10, 15, 20, 25, 30	6	LS	$ 20,000	$ 120,000	$ 43,000	$60K/ 3 alternatives (LF, FDDA, DGGW)
Groundwater Performance and Optimization Study		0	LS		$ -		Not applicable for this alternative
Remedial Action Report		0	LS		$ -		Not applicable for this alternative
Demobilization of on-site treatment system		0	LS		$ -		Not applicable for this alternative
Well Abandonment		0	LS		$ -		Not applicable for this alternative
Update Instiutional Controls Plan		0	LS		$ -		Not included in this alternative
					$ -		
TOTAL - PRESENT WORTH - O&M COSTS					**$120,000**	**$ 43,000**	

APPENDIX D
ATTACHMENT D2
FEASIBILITY STUDY COST ESTIMATE SUMMARY - SOURCE AREA LANDFILL LOBES

LF-2a and LF-2b: Containment of waste, vent landfill gas, restoration of wetlands and brook, partial containment of groundwater with a vertical barrier and groundwater remediation

CAPITAL COSTS		LF-2a			LF-2b
Construction Activities					
Pilot and Pump Test	$	50,000	--	$	50,000
Site Prep	$	90,000	--	$	90,000
Site Work	$	44,800	--	$	44,800
LF Containment	$	10,161,000	--	$	10,161,000
Sediment Excavation/ Brook Restoration	$	1,046,620	--	$	1,046,620
Groundwater Containment	$	1,785,000	--	$	1,785,000
In-situ groundwater remediation - MNA	$	51,000	--	$	51,000
Groundwater extraction and ex-situ treatment	$	-	--	$	1,582,000
Institutional Controls	$	50,000	--	$	50,000
SUBTOTAL - CONSTRUCTION ACTIVITIES	$	13,278,420	--	$	14,910,420
Contingency (10%)	$	1,327,900	--	$	1,491,100
TOTAL CONSTRUCTION ACTIVITIES	**$**	**14,606,320**	--	**$**	**16,401,520**
Professional/ Technical Services					
Project Management	$	730,400	--	$	820,100
Remedial Design	$	876,400	--	$	984,100
Construction Management	$	876,400	--	$	984,100
Health and Safety	$	219,100	--	$	246,100
Permitting/ Legal	$	219,100	--	$	246,100
TOTAL PROFESSIONAL/ TECHNICAL SERVICES	**$**	**2,921,400**	--	**$**	**3,280,500**
TOTAL CAPITAL COSTS	**$**	**17,527,720**	--	**$**	**19,682,020**

ANNUAL OPERATION, MAINTENANCE AND MONITORING COSTS					
LF-2a - PHASED GROUNDWATER REMEDIATION WITH MNA - 30 YEARS	$	2,935,000			
LF-2b - GROUNDWATER MONITORING - 3 YEARS, GROUNDWATER EXTRACTION, TREATMENT AND MONITORING - 27 YEARS				$	5,353,000
TOTAL - PRESENT VALUE - O&M COSTS	**$**	**2,935,000**	--	**$**	**5,353,000**

PERIODIC COSTS - PRESENT VALUE (7%)					
Five Year Site Reviews	$	43,000		$	43,000
Groundwater Performance and Optimization Study	$	11,000		$	11,000
Remedial Action Report	$	21,000		$	21,000
Demobilization of on-site treatment system	$	20,000		$	20,000
Well Abandonment	$	13,000		$	13,000
Update Institutional Controls Plan	$	7,000		$	7,000
TOTAL PRESENT VALUE PERIODIC COSTS	**$**	**115,000**		**$**	**115,000**
TOTAL PRESENT VALUE	**$**	**20,577,720**	--	**$**	**25,150,020**
		LF-2a			**LF-2b**

APPENDIX D
ATTACHMENT D2
FEASIBILITY STUDY COST ESTIMATE BACK-UP
LANDFILL SOURCE AREA

LF-2a and LF-2b: Containment of waste, vent landfill gas, restoration of wetlands and brook, partial containment of groundwater with a vertical barrier and groundwater remediation

CAPITAL COSTS

Assumptions:

- No treatment of excavated sediment prior to on-site disposal.

No. Recovery Wells	1		
Total flow rate	15	gpm	
Area of landfill final cover system			
Northern Lobe	30	acres	
Southern Lobe	10	acres	
Area of access roadways to well heads	4,900	sq ft	
Depth of fill material for roadway	3	ft	
Wetland impacts requiring replication			
Northern Lobe	64,700		sq ft
Southern Lobe	80,500		sq ft
Length of Groundwater Barrier	1,700	ft	
Depth of Groundwater Barrier	30	ft	
Brook Excavation			
Length	1,100	ft	
Area	24,000	sq ft	
Average Depth	1.0	ft	
Volume	890	cy	

	QTY	UNIT	UNIT COST	TOTAL	NOTES
Construction Activities					
Pilot and Pump Test					
Perform groundwater pump test, data analysis	1	LS	$ 50,000	$ 50,000	
Perform groundwater treatment pilot test, data analysis	1	LS	$ 50,000	$ 50,000	
SUBTOTAL:				$ 100,000	
Site Prep					
Submittals/Implementation Plans	1	LS	$ 25,000	$ 25,000	QAPP, HASP, etc
Temporary Facilities and Utilities	1	LS	$ 50,000	$ 50,000	fence, roads, signs, trailers, restrooms, etc
Survey	1	LS	$ 15,000	$ 15,000	
SUBTOTAL:				$ 90,000	
Site Work					
Clearing and Grubbing	1.00	ACRE	$ 10,000	$ 10,000	For groundwater component
Construction of gravel roadways - fill material	540	CY	$ 14	$ 7,600	For groundwater component
Construction of gravel roadways - labor and equipment	540	SY	$ 4	$ 2,200	For groundwater component
Wetland Replication - GW	0.5	ACRE	$ 50,000	$ 25,000	
SUBTOTAL:				$ 44,800	
LF Containment					
low permeability cover - Northern Lobe	1	LS	$ 7,345,000	$ 7,345,000	Refer to landfill final cover system cost back-up
low permeability cover - Southern Lobe	1	LS	$ 2,816,000	$ 2,816,000	
SUBTOTAL:				$ 10,161,000	
Sediment Excavation/ Brook Restoration					
Erosion Controls	2,200	LF	$ 9	$ 19,800	
Site Clearing	3	ACRE	$ 10,000	$ 30,000	assumes 50 ft clearing on both sides of brook
Tree Clearing/ Chipping/on-site disposal	3	ACRE	$ 20,000	$ 60,000	
Wetland mats	4	MONTH	$ 20,000	$ 80,000	
Excavation	890	CY	$ 18	$ 16,020	
On-site Disposal	890	CY	$ 25	$ 22,250	
Waste Characterization	3	EACH	$ 2,500	$ 7,500	
Confirmatory Sediment Sampling and Analysis	1	LS	$ 66,000	$ 66,000	
Sediment dewatering (capital costs)	1	LS	$ 100,000	$ 100,000	
Staging and dewatering saturated material	890	CY	$ 15	$ 13,350	
Temporary Shoring	11,000	SQ FT	$ 25	$ 275,000	Drive and Salvage - one side only since barrier by Southern lobe
Backfill	890	CY	$ 30	$ 26,700	
Temporary re-route/pipe brook	1,100	LF	$ 100	$ 110,000	
Restoration/planting	3	ACRE	$ 40,000	$ 120,000	
Reconstruct Culvert	1	LS	$ 100,000	$ 100,000	estimate
SUBTOTAL:				$ 1,046,620	
Groundwater Containment					
Sheet Piling	51,000	SQ FT	$ 35	$ 1,785,000	Drive and leave in place
SUBTOTAL:				$ 1,785,000	
In-situ groundwater remediation - MNA					
Installation of additional monitoring wells	1	LS	$ 51,000	$ 51,000	
SUBTOTAL:				$ 51,000	
Groundwater extraction and ex-situ treatment					
Extraction wells with development	1	EACH	$ 25,000	$ 25,000	
Treatment system - bldg	2,400	SQ FT	$ 70	$ 168,000	60' LX 40' W X 20' H
Treatment system - equipment	1	LS	$ 482,000	$ 482,000	
Electrical lines to site - utility pole installation	30	EACH	$ 7,500	$ 225,000	assumes 1 pole per 100 feet
Electrical lines to site - run lines from South Street to treatmen	3,000	LF	$ 50	$ 150,000	
Installation - electrical	20%	(of equip total)	$ 96,400	$ 96,400	
Installation - controls/ instrumentation	20%	(of equip total)	$ 96,400	$ 96,400	includes material and labor
Installation - piping	30%	(of equip total)	$ 144,600	$ 144,600	includes material and labor
Installation - equipment	30%	(of equip total)	$ 144,600	$ 144,600	includes material and labor
System start-up	1	LS	$ 50,000	$ 50,000	
SUBTOTAL:				$ 1,582,000	
Institutional Controls	1	LS	$ 50,000	$ 50,000	
SUBTOTAL:				$ 50,000	

APPENDIX D
ATTACHMENT D2
FEASIBILITY STUDY COST ESTIMATE BACK-UP
LANDFILL SOURCE AREA

LF-2a and LF-2b: Containment of waste, vent landfill gas, restoration of wetlands and brook, partial containment of groundwater with a vertical barrier and groundwater remediation

CAPITAL COSTS

LF-2a (phased groundwater remediation):				
SUBTOTAL - CONSTRUCTION ACTIVITIES - phased groundwater with **MNA**		$	13,278,420	
Contingency (10%)		$	1,327,900	
TOTAL CONSTRUCTION ACTIVITIES		$	14,606,320	
Professional/ Technical Services				
Project Management	5%	$	730,400	per USACE and USEPA, 2000
Remedial Design	6%	$	876,400	
Construction Management	6%	$	876,400	
Health and Safety	1.5%	$	219,100	
Permitting/ Legal	1.5%	$	219,100	
TOTAL PROFESSIONAL/ TECHNICAL SERVICES		$	2,921,400	
LF-2b (active groundwater treatment)				
SUBTOTAL - CONSTRUCTION ACTIVITIES - **Active groundwater treatment**		$	14,910,420	
Contingency (10%)		$	1,491,100	
TOTAL CONSTRUCTION ACTIVITIES		$	16,401,520	
Professional/ Technical Services				
Project Management	5%	$	820,100	per USACE and USEPA, 2000
Remedial Design	6%	$	984,100	
Construction Management	6%	$	984,100	
Health and Safety	1.5%	$	246,100	
Permitting/ Legal	1.5%	$	246,100	
TOTAL PROFESSIONAL/ TECHNICAL SERVICES		$	3,280,500	
TOTAL - CAPITAL COSTS	**$ 17,527,720 TO**	**$**	**19,682,020**	

APPENDIX D
ATTACHMENT D2
FEASIBILITY STUDY COST ESTIMATE BACK-UP
LANDFILL SOURCE AREA

LF-2a and LF-2b: Containment of waste, vent landfill gas, restoration of wetlands and brook, partial containment of groundwater with a vertical barrier and groundwater remediation

OPERATION AND MAINTENANCE COSTS

	QTY	UNIT	UNIT COST	TOTAL	NOTES
LF-2a - PHASED GROUNDWATER REMEDIATION WITH MNA - 30 YEARS					
Performance Monitoring and Reporting					
Landfill Gas Monitoring	1	LS	$ 42,000	$ 42,000	
Surface Water Monitoring	1	LS	$ 27,000	$ 27,000	
MNA Implementation	1	LS	$ 141,000	$ 141,000	
SUBTOTAL:				$ 210,000	
Annual site-wide inspection					
Inspection	1	LS	$ 5,000	$ 5,000	
SUBTOTAL:				$ 5,000	
O&M SUBTOTAL:				$ 215,000	
Contingency (10%)				$ 21,500	
TOTAL - O&M COSTS (ANNUAL)				**$ 236,500**	
TOTAL - LF-2a - PRESENT VALUE - O&M COSTS				**$ 2,935,000**	**30 years**
LF-2b - GROUNDWATER MONITORING - 3 YEARS, GROUNDWATER EXTRACTION, TREATMENT AND MONITORING - 27 YEARS					
Performance Monitoring and Reporting					
Landfill Gas Monitoring	1	LS	$ 42,000	$ 42,000	
Surface Water Monitoring	1	LS	$ 27,000	$ 27,000	
Monitoring	1	LS	$ 125,000	$ 125,000	
Annual site-wide inspection	1	LS		$ -	
Inspection	1	LS	$ 5,000	$ 5,000	
SUBTOTAL:				$ 199,000	
Contingency (10%)				$ 19,900	
TOTAL MONITORING (ANNUAL)				$ 218,900	
TOTAL MONITORING - PRESENT VALUE - 3 YEARS				**$ 574,000**	3 years of MNA and monitoring
Performance Monitoring and Reporting					
Landfill Gas Monitoring	1	LS	$ 42,000	$ 42,000	
Surface Water Monitoring	1	LS	$ 27,000	$ 27,000	
Groundwater - treatment system	1	LS	$ 73,800	$ 73,800	
Groundwater - area wide	1	LS	$ 38,800	$ 38,800	
SUBTOTAL:				$ 181,600	
Groundwater Treatment - OM&M					
Operations Labor	1	LS	$ 100,000	$ 100,000	full time operator with maintenance assistance
Equipment Repair/replacement	3%	EQUIP	$ 14,500	$ 14,500	
Utilities (metals treatment and lighting/HVAC)	1	EST	$ 25,000	$ 25,000	
O&M - Chemicals, UV Ox utilities, misc.	1	EST	$ 72,900	$ 72,900	
SUBTOTAL:				$ 212,400	
Annual site-wide inspection					
Inspection	1	LS	$ 5,000	$ 5,000	
SUBTOTAL:				$ 5,000	
Discharge to POTW					
Discharge fees	7,900	1000/gal	$ 5.60	$ 45,000	
SUBTOTAL:				$ 45,000	
O&M SUBTOTAL:				$ 444,000	
Contingency (10%)				$ 44,400	
TOTAL - O&M COSTS (ANNUAL) - TO POTW				**$ 488,400**	
TOTAL - PRESENT VALUE - O&M COSTS - TO POTW				**$ 4,779,000**	27 years of system operation
TOTAL - LF-2b - PRESENT VALUE - O&M COSTS - TO POTW				**$ 5,353,000**	

APPENDIX D
ATTACHMENT D2
FEASIBILITY STUDY COST ESTIMATE BACK-UP
LANDFILL SOURCE AREA

LF-2a and LF-2b: Containment of waste, vent landfill gas, restoration of wetlands and brook, partial containment of groundwater with a vertical barrier and groundwater remediation

PERIODIC COSTS

	YEAR	QTY	UNIT	UNIT COST	TOTAL	PRESENT VALUE (7%)	NOTES
Five Year Site Reviews	5, 10, 15, 20, 25, 30	6	LS	$ 20,000	$ 120,000	$ 43,000	$60K/ 3 alternatives (LF, FDDA, DGGW)
Groundwater Performance and Optimization Study	15	1	LS	$ 30,000	$ 30,000	$ 11,000	
Remedial Action Report	5	1	LS	$ 30,000	$ 30,000	$ 21,000	
Demobilization of on-site treatment system	30	1	LS	$ 150,000	$ 150,000	$ 20,000	
Well Abandonment	30	1	LS	$ 100,000	$ 100,000	$ 13,000	
Update Institutional Controls Plan	30	1	LS	$ 50,000	$ 50,000	$ 7,000	
TOTAL - PRESENT WORTH - O&M COSTS (PV 7%, 30 YRS)					**$ 480,000**	**$ 115,000**	

APPENDIX D
ATTACHMENT D3
FEASIBILITY STUDY COST ESTIMATE SUMMARY - SOURCE AREA LANDFILL LOBES

LF-3: Containment of waste, vent landfill gas, restoration of wetlands and brook, and contaminated groundwater collection and treatment *(30 years)*

CAPITAL COSTS

Construction Activities				
Pilot and Pump Test	--	$	100,000
Site Prep	--	$	90,000
Site Work - Groundwater Component	--	$	41,400
LF Containment	--	$	10,161,000
Sediment Excavation/ Brook Restoration	--	$	1,321,620
Groundwater extraction and ex-situ treatment	--	$	7,084,100
Institutional Controls	--	$	50,000
SUBTOTAL - CONSTRUCTION ACTIVITIES	--	$	18,848,120
Contingency (10%)	--	$	1,884,900
TOTAL CONSTRUCTION ACTIVITIES	--	**$**	**20,733,020**
Profesional/ Technical Services			
Project Management	--	$	1,036,700
Remedial Design	--	$	1,244,000
Construction Management	--	$	1,244,000
Health and Safety	--	$	311,000
Permitting/ Legal	--	$	311,000
TOTAL PROFESSIONAL/ TECHNICAL SERVICES	--	**$**	**4,146,700**
TOTAL CAPITAL COSTS	--	**$**	**24,879,720**

ANNUAL OPERATION, MAINTENANCE AND MONITORING COSTS

SCENARIO 1 - TO SURFACE WATER	$	15,884,000			
SCENARIO 2 - TO POTW				$	26,081,000
TOTAL - PRESENT VALUE - O&M COSTS	**$**	**15,884,000**	--	**$**	**26,081,000**

PERIODIC COSTS - PRESENT VALUE (7%)

Five Year Site Reviews	$	43,000
Groundwater Performance and Optimization Study	$	23,000
Remedial Action Report	$	21,000
Demobilization of on-site treatment system	$	26,000
Well Abandonment	$	13,000
Update Institutional Controls Plan	$	7,000
TOTAL PRESENT VALUE PERIODIC COSTS	**$**	**133,000**

TOTAL PRESENT VALUE	**$**	**40,896,720**	--	**$**	**51,093,720**

APPENDIX D
ATTACHMENT D3
FEASIBILITY STUDY COST ESTIMATE BACK-UP
LANDFILL SOURCE AREA

LF-3: Containment of waste, vent landfill gas, restoration of wetlands and brook, and contaminated groundwater collection and treatment (30 years)

CAPITAL COSTS

Assumptions:

- No treatment of excavated sediment prior to on-site disposal.

No. Recovery Wells	17	
Total flow rate	245	gpm
Area of landfill final cover system		
Northern Lobe	30	acres
Southern Lobe	10	acres
Area of access roadways to well heads	2,500	sq ft
Depth of fill material for roadway	4	ft
Wetland impacts requiring replication		
Northern Lobe	64,700	sq ft
Southern Lobe	80,500	sq ft
Length of Groundwater Barrier	0	ft
Depth of Groundwater Barrier	0	ft
Brook Excavation		
Length	1,100	ft
Area	24,000	sq ft
Average Depth	1.0	ft
Volume	890	cy

	QTY	UNIT	UNIT COST	TOTAL	NOTES
Construction Activities					
Pilot and Pump Test					
Perform groundwater pump test, data analysis	1	LS	$ 50,000	$ 50,000	
Perform groundwater treatment pilot test, data analysis	1	LS	$ 50,000	$ 50,000	
SUBTOTAL:				$ 100,000	
Site Prep					
Submittals/Implementation Plans	1	LS	$ 25,000	$ 25,000	QAPP, HASP, etc
Temporary Facilities and Utilities	1	LS	$ 50,000	$ 50,000	fence, roads, signs, trailers, restrooms, etc
Survey - Groundwater	1	LS	$ 15,000	$ 15,000	
SUBTOTAL:				$ 90,000	
Site Work - Groundwater Component					
Clearing and Grubbing	1.00	ACRE	$ 10,000	$ 10,000	For groundwater component
Construction of gravel roadways - fill material	380	CY	$ 14	$ 5,300	For groundwater component
Construction of gravel roadways - labor and equipment	280	SY	$ 4	$ 1,100	For groundwater component
Wetland Replication - GW	0.5	ACRE	$ 50,000	$ 25,000	
SUBTOTAL:				$ 41,400	
LF Containment					
low permeability cover - Northern Lobe	1	LS	$ 7,345,000	$ 7,345,000	Refer to landfill final cover system cost back-up
low permeability cover - Southern Lobe	1	LS	$ 2,816,000	$ 2,816,000	
SUBTOTAL:				$ 10,161,000	
Sediment Excavation/ Brook Restoration					
Erosion Controls	2,200	LF	$ 9	$ 19,800	
Site Clearing	3	ACRE	$ 10,000	$ 30,000	assumes 50 ft clearing on both sides of brook
Tree Clearing/ Chipping/on-site disposal	3	ACRE	$ 20,000	$ 60,000	
Wetland mats	4	MONTH	$ 20,000	$ 80,000	
Excavation	890	CY	$ 18	$ 16,020	
On-site Disposal	890	CY	$ 25	$ 22,250	
Waste Characterization	3	EACH	$ 2,500	$ 7,500	
Confirmatory Sediment Sampling and Analysis	1	LS	$ 66,000	$ 66,000	
Sediment dewatering (capital costs)	1	LS	$ 100,000	$ 100,000	
Staging and dewatering saturated material	890	CY	$ 15	$ 13,350	
Temporary Shoring	22,000	SQ FT	$ 25	$ 550,000	Drive and salvage
Backfill	890	CY	$ 30	$ 26,700	
Temporary re-route/pipe brook	1,100	LF	$ 100	$ 110,000	
Restoration/planting	3	ACRE	$ 40,000	$ 120,000	
Reconstruct Culvert	1	LS	$ 100,000	$ 100,000	estimate
SUBTOTAL:				$ 1,321,620	
Groundwater extraction and ex-situ treatment					
Groundwater monitoring well installation	1	LS	$ 75,300	$ 75,300	
Extraction wells with development	17	EACH	$ 25,000	$ 425,000	
Treatment system - bldg	6,000	SQ FT	$ 70	$ 420,000	100' LX 60' W X 20' H
Treatment system - equipment	1	LS	$ 4,507,000	$ 4,507,000	
Electrical lines to site - utility pole installation	30	EACH	$ 7,500	$ 225,000	assumes 1 pole per 100 feet
Electrical lines to site - run lines from South Street to treatmer	3,000	LF	$ 50	$ 150,000	
Installation - electrical	20%	(of equip total)*	$ 241,400	$ 241,400	* - excluding UV oxidation capital cost of $3M
Installation - controls/ instrumentation	20%	(of equip total)*	$ 241,400	$ 241,400	includes material and labor
Installation - piping	30%	(of equip total)*	$ 362,000	$ 362,000	includes material and labor
Installation - equipment	30%	(of equip total)*	$ 362,000	$ 362,000	
System start-up	1	LS	$ 75,000	$ 75,000	
SUBTOTAL:				$ 7,084,100	
Institutional Controls	1	LS	$ 50,000	$ 50,000	
SUBTOTAL:				$ 50,000	

APPENDIX D
ATTACHMENT D3
FEASIBILITY STUDY COST ESTIMATE BACK-UP
LANDFILL SOURCE AREA

LF-3: Containment of waste, vent landfill gas, restoration of wetlands and brook, and contaminated groundwater collection and treatment (30 years)

CAPITAL COSTS

SUBTOTAL - CONSTRUCTION ACTIVITIES		$	18,848,120	
Contingency (10%)		$	1,884,900	
TOTAL CONSTRUCTION ACTIVITIES		$	20,733,020	
Profesional/ Technical Services				
Project Management	5%	$	1,036,700	per USACE and USEPA, 2000
Remedial Design	6%	$	1,244,000	
Construction Management	6%	$	1,244,000	
Health and Safety	1.5%	$	311,000	
Permitting/ Legal	1.5%	$	311,000	
TOTAL PROFESSIONAL/ TECHNICAL SERVICES		$	4,146,700	
TOTAL - CAPITAL COSTS		**$**	**24,879,720**	

APPENDIX D
ATTACHMENT D3
FEASIBILITY STUDY COST ESTIMATE BACK-UP
LANDFILL SOURCE AREA

LF-3: Containment of waste, vent landfill gas, restoration of wetlands and brook, and contaminated groundwater collection and treatment (30 years)

OPERATION AND MAINTENANCE COSTS

SCENARIO 1 - TO SURFACE WATER	QTY	UNIT	UNIT COST	TOTAL	NOTES
Performance Monitoring and Reporting					
Landfill Gas Monitoring	1	LS	$ 42,000	$ 42,000	
Surface Water Monitoring	1	LS	$ 27,000	$ 27,000	
Groundwater - treatment system	1	LS	$ 73,800	$ 73,800	
Groundwater - area wide	1	LS	$ 38,800	$ 38,800	
SUBTOTAL:				$ 181,600	
Groundwater Treatment - OM&M					
Operations Labor	1	LS	$ 200,000	$ 200,000	two full time operators plus maintenance assistance
Equipment Repair/replacement	3%	EQUIP*	$ 36,200	$ 36,200	* - excluding UV oxidation capital cost of $3M
Utilities (metals treatment and lighting/HVAC)	1	EST	$ 50,000	$ 50,000	
O&M - Chemicals, UV Ox utilities, misc.	1	EST	$ 690,800	$ 690,800	
SUBTOTAL:				$ 977,000	
Annual site-wide inspection					
Inspection	1	LS	$ 5,000	$ 5,000	
SUBTOTAL:				$ 5,000	
O&M SUBTOTAL:				$ 1,163,600	
Contingency (10%)				$ 116,400	
TOTAL - O&M COSTS (ANNUAL) - TO SURFACE WATER				**$ 1,280,000**	ANNUAL
TOTAL - PRESENT VALUE - O&M COSTS - TO SURFACE WATER				**$ 15,884,000**	30 YEARS

SCENARIO 2 - TO POTW	QTY	UNIT	UNIT COST	TOTAL	NOTES
Performance Monitoring and Reporting					
Landfill Gas Monitoring	1	LS	$ 42,000	$ 42,000	
Surface Water Monitoring	1	LS	$ 27,000	$ 27,000	
Groundwater - treatment system	1	LS	$ 73,800	$ 73,800	
Groundwater - area wide	1	LS	$ 38,800	$ 38,800	
SUBTOTAL:				$ 181,600	
Groundwater Treatment - OM&M					
Operations Labor	1	LS	$ 200,000	$ 200,000	two full time operators plus maintenance assistance
Equipment Repair/replacement	3%	EQUIP*	$ 36,200	$ 36,200	* - excluding UV oxidation capital cost of $3M
Utilities (metals treatment and lighting/HVAC)	1	EST	$ 75,000	$ 75,000	
O&M - Chemicals, UV Ox utilities, misc.	1	EST	$ 690,800	$ 690,800	
SUBTOTAL:				$ 1,002,000	
Annual site-wide inspection					
Inspection	1	LS	$ 5,000	$ 5,000	
SUBTOTAL:				$ 5,000	
Discharge to POTW					
Discharge fees	128,800	1000/gal	$ 5.60	$ 722,000	
SUBTOTAL:				$ 722,000	
O&M SUBTOTAL:				$ 1,910,600	
Contingency (10%)				$ 191,100	
TOTAL - O&M COSTS (ANNUAL) - TO POTW				**$ 2,101,700**	ANNUAL
TOTAL - PRESENT VALUE - O&M COSTS - TO POTW				**$ 26,081,000**	30 YEARS

APPENDIX D
ATTACHMENT D3
FEASIBILITY STUDY COST ESTIMATE BACK-UP
LANDFILL SOURCE AREA

LF-3: Containment of waste, vent landfill gas, restoration of wetlands and brook, and contaminated groundwater collection and treatment (30 years)

PERIODIC COSTS

	YEAR	QTY	UNIT	UNIT COST	TOTAL	PRESENT VALUE (7%)	NOTES
Five Year Site Reviews	5, 10, 15, 20, 25, 30	6	LS	$ 20,000	$ 120,000	$ 43,000	$60K/ 3 alternatives (LF, FDDA, DGGW)
Groundwater Performance and Optimization Study	10 and 20	1	LS	$ 30,000	$ 30,000	$ 23,000	
Remedial Action Report	5	1	LS	$ 30,000	$ 30,000	$ 21,000	
Demobilization of on-site treatment system	30	1	LS	$ 200,000	$ 200,000	$ 26,000	
Well Abandonment	30	1	LS	$ 100,000	$ 100,000	$ 13,000	
Update Institutional Controls Plan	30	1	LS	$ 50,000	$ 50,000	$ 7,000	
TOTAL - PRESENT WORTH - O&M COSTS (PV 7%, 30 YRS)					**$530,000**	**$133,000**	

APPENDIX D
ATTACHMENT D4
FEASIBILITY STUDY COST ESTIMATE SUMMARY - SOURCE AREA LANDFILL LOBES

LF-4: Containment of waste, vent landfill gas, re-routing of the brook, excavation of impacted sediment hot spots, partial containment of groundwater (vertical barrier) with groundwater remediation

CAPITAL COSTS

Construction Activities			
Pilot and Pump Test	--	$	100,000
Site Prep	--	$	90,000
Site Work	--	$	54,800
LF Containment	--	$	10,161,000
Sediment Excavation/ Brook Restoration	--	$	5,925,500
Groundwater Containment	--	$	1,575,000
In-situ groundwater treatment - MNA	--	$	51,000
Groundwater extraction and ex-situ treatment	--	$	1,582,000
Institutional Controls	--	$	-
SUBTOTAL - CONSTRUCTION ACTIVITIES	--	$	19,589,300
Contingency (10%)	--	$	1,959,000
TOTAL CONSTRUCTION ACTIVITIES	--	**$**	**21,548,300**
Profesional/ Technical Services			
Project Management	--	$	1,077,500
Remedial Design	--	$	1,292,900
Construction Management	--	$	1,292,900
Health and Safety	--	$	323,300
Permitting/ Legal	--	$	323,300
TOTAL PROFESSIONAL/ TECHNICAL SERVICES	--	**$**	**4,309,900**
TOTAL CAPITAL COSTS	--	**$**	**25,858,200**

ANNUAL OPERATION, MAINTENANCE AND MONITORING COSTS

MONITORING - 3 YEARS, GROUNDWATER EXTRACTION, TREATMENT AND MONITORING - 27 YEARS		$	5,353,000
TOTAL - PRESENT VALUE - O&M COSTS	--	**$**	**5,353,000**

PERIODIC COSTS - PRESENT VALUE (7%)

Five Year Site Reviews	$	43,000
Groundwater Performance and Optimization Study	$	11,000
Remedial Action Report	$	21,000
Demobilization of on-site treatment system	$	20,000
Well Abandonment	$	13,000
Update Institutional Controls Plan	$	7,000
TOTAL PRESENT VALUE PERIODIC COSTS	**$**	**115,000**

TOTAL PRESENT VALUE	**$ 31,326,200**

APPENDIX D
ATTACHMENT D4
FEASIBILITY STUDY COST ESTIMATE SUMMARY - SOURCE AREA LANDFILL LOBES

LF-4: Containment of waste, vent landfill gas, re-routing of the brook, excavation of impacted sediment hot spots, partial containment of groundwater (vertical barrier) with groundwater remediation

CAPITAL COSTS

Assumptions:
- No treatment of excavated sediment prior to on-site disposal

No. Recovery Wells	1		
Total flow rate	15	gpm	
Area of landfill final cover system			
Northern Lobe	30	acres	
Southern Lobe	70	acres	
Area of access roadways to well heads	4,900	sq ft	
Depth of fill material for roadway	0	ft	
Wetland impacts requiring replication			
Northern Lobe	54,700	sq ft	
Southern Lobe	90,500	sq ft	
Length of Groundwater Barrier	1,500	ft	
Depth of Groundwater Barrier	30	ft	
Brook Excavation			
Length	300	ft	
Area	6,000	sq ft	assumes 25% of existing brook
Volume	300	cy	
Average Depth - existing brook	1.0	ft	
Area to be filled	24,000.0	sq ft	
Depth to be filled	5.0	ft	
Brook Re-location	2,900.0	ft	
Average Depth to excavate - new brook	4.0	ft	
Average width	20.0	ft	

	QTY	UNIT	UNIT COST	TOTAL	NOTES
Construction Activities			$ -		
Pilot and Pump Test					
Perform groundwater pump test, data analysis	1	LS	$ 50,000	$ 50,000	
Perform groundwater treatment pilot test, data analysis	1	LS	$ 50,000	$ 50,000	
SUBTOTAL:				$ 100,000	
Site Prep					
Submittals/Implementation Plans	1	LS	$ 25,000	$ 25,000	QAPP, HASP, etc
Temporary Facilities and Utilities	1	LS	$ 50,000	$ 50,000	fence, roads, signs, trailers, restrooms, etc
Survey - Groundwater	1	LS	$ 15,000	$ 15,000	
SUBTOTAL:				$ 90,000	
Site Work					
Clearing and Grubbing	2.00	ACRE	$ 10,000	$ 20,000	For groundwater component
Construction of gravel roadways - fill material	540	CY	$ 14	$ 7,600	For groundwater component
Construction of gravel roadways - labor and equipment	540	SY	$ 4	$ 2,200	For groundwater component
Wetland Replication - GW	0.5	ACRE	$ 50,000	$ 25,000	For groundwater component
SUBTOTAL:				$ 54,800	
LF Containment					
low permeability cover - Northern Lobe	1	LS	$ 7,345,000	$ 7,345,000	Refer to landfill final cover system cost back-up
low permeability cover - Southern Lobe	1	LS	$ 2,816,000	$ 2,816,000	
SUBTOTAL:				$ 10,161,000	
Sediment Excavation/ Brook Restoration					
Erosion Controls	6,000	LF	$ 9	$ 54,000	
Site Clearing	7	ACRE	$ 10,000	$ 70,000	assumes 50 ft clearing on both sides of brook
Tree Clearing/ Chipping/on-site disposal	7	ACRE	$ 20,000	$ 140,000	
Wetland mats	12	MONTH	$ 20,000	$ 240,000	
Excavation - existing brook	300	CY	$ 18	$ 5,400	
Excavation - new brook	8,600	CY	$ 36	$ 309,600	
On-site Disposal	8,900	CY	$ 25	$ 222,500	
Waste Characterization	27	EACH	$ 2,500	$ 67,500	
Confirmatory Sediment Sampling and Analysis	1	LS	$ 186,000	$ 186,000	
Sediment dewatering (capital costs)	1	LS	$ 100,000	$ 100,000	
Staging and dewatering saturated material	8,900	CY	$ 15	$ 133,500	
Temporary Shoring - existing brook	9,000	SQ FT	$ 25	$ 225,000	
Temporary Shoring - new brook	87,000	SQ FT	$ 25	$ 2,175,000	Drive and Salvage
Backfill - existing brook	4,800	CY	$ 30	$ 144,000	
Backfill - new brook restoration	2,100	CY	$ 30	$ 63,000	
Temporary re-route/pipe brook - existing brook	300	LF	$ 100	$ 30,000	
Temporary re-route/pipe brook - new brook	2,900	LF	$ 100	$ 290,000	
Bank stabilization - new brook	5,800	LF	$ 150	$ 870,000	
Restoration/planting	7	ACRE	$ 50,000	$ 350,000	
Construct new culvert and reconstruct existing	1	LS	$ 250,000	$ 250,000	
SUBTOTAL:				$ 5,925,500	
Groundwater Containment					
Sheet Piling	45,000	SQ FT	$ 35	$ 1,575,000	Drive and leave in place
SUBTOTAL:				$ 1,575,000	
In-situ groundwater treatment - MNA					
Installation of additional monioring wells	1	LS	$ 51,000	$ 51,000	
SUBTOTAL:				$ 51,000	
Groundwater extraction and ex-situ treatment					
Extraction wells with development	1	EACH	$ 25,000	$ 25,000	
Treatment system - bldg	2,400	SQ FT	$ 70	$ 168,000	60' LX 40' W X 20' H
Treatment system - equipment	1	LS	$ 482,000	$ 482,000	
Electrical lines to site - utility pole installation	30	EACH	$ 7,500	$ 225,000	assumes 1 pole per 100 feet
Electrical lines to site - run lines from South Street to treatment	3,000	LF	$ 50	$ 150,000	
Installation - electrical	20%	(of equip total)	$ 96,400	$ 96,400	
Installation - controls/ instrumentation	20%	(of equip total)	$ 96,400	$ 96,400	includes material and labor
Installation - piping	30%	(of equip total)	$ 144,600	$ 144,600	includes material and labor
Installation - equipment	30%	(of equip total)	$ 144,600	$ 144,600	includes material and labor
System start-up	1	LS	$ 50,000	$ 50,000	
SUBTOTAL:				$ 1,582,000	
Institutional Controls	1	LS	$ 50,000	$ 50,000	
SUBTOTAL:				$ 50,000	
SUBTOTAL - CONSTRUCTION ACTIVITIES				$ 19,589,300	
Contingency (10%)				$ 1,959,000	
TOTAL CONSTRUCTION ACTIVITIES				$ 21,548,300	
Profesional/ Technical Services					
Project Management	5%			$ 1,077,500	per USACE and USEPA, 2000
Remedial Design	6%			$ 1,292,900	
Construction Management	6%			$ 1,292,900	
Health and Safety	1.5%			$ 323,300	
Permitting/ Legal	1.5%			$ 323,300	
TOTAL PROFESSIONAL/ TECHNICAL SERVICES				$ 4,309,900	
TOTAL - CAPITAL COSTS				**$ 25,858,200**	

APPENDIX D
ATTACHMENT D4
FEASIBILITY STUDY COST ESTIMATE SUMMARY - SOURCE AREA LANDFILL LOBES

LF-4: Containment of waste, vent landfill gas, re-routing of the brook, excavation of impacted sediment hot spots, partial containment of groundwater (vertical barrier) with groundwater remediation

OPERATION AND MAINTENANCE COSTS

	QTY	UNIT	UNIT COST	TOTAL	NOTES
MONITORING - 3 YEARS, GROUNDWATER EXTRACTION, TREATMENT AND MONITORING - 27 YEARS					
Performance Monitoring and Reporting					
Landfill Gas Monitoring	1	LS	$ 42,000	$ 42,000	
Surface Water Monitoring	1	LS	$ 27,000	$ 27,000	
Monitoring	1	LS	$ 125,000	$ 125,000	
Annual site-wide inspection				$ -	
Inspection	1	LS	$ 5,000	$ 5,000	
SUBTOTAL:				$ 199,000	
Contingency (10%)				$ 19,900	
TOTAL MONITORING (ANNUAL)				**$ 218,900**	
TOTAL MONITORING - PRESENT VALUE - 3 YEARS				**$ 574,000**	3 years of MNA and monitoring
Performance Monitoring and Reporting					
Landfill Gas Monitoring	1	LS	$ 42,000	$ 42,000	
Surface Water Monitoring	1	LS	$ 27,000	$ 27,000	
Groundwater - treatment system	1	LS	$ 73,800	$ 73,800	
Groundwater - area wide	1	LS	$ 38,800	$ 38,800	
SUBTOTAL:				$ 181,600	
Groundwater Treatment - OM&M					
Operations Labor	1	LS	$ 100,000	$ 100,000	full time operator with maintenance assistance
Equipment Repair/replacement	3%	EQUIP	$ 14,500	$ 14,500	
Utilities (metals treatment and lighting/HVAC)	1	EST	$ 25,000	$ 25,000	
O&M - Chemicals, UV Ox utilities, misc.	1	EST	$ 72,900	$ 72,900	
SUBTOTAL:				$ 212,400	
Annual site-wide inspection					
Inspection	1	LS	$ 5,000	$ 5,000	
SUBTOTAL:				$ 5,000	
Discharge to POTW					
Discharge fees	7,900	1000/gal	$ 5.60	$ 45,000	
SUBTOTAL:				$ 45,000	
O&M SUBTOTAL:				$ 444,000	
Contingency (10%)				$ 44,400	
TOTAL - O&M COSTS (ANNUAL) - TO POTW				**$ 488,400**	
TOTAL - PRESENT VALUE - O&M COSTS - TO POTW				**$ 4,779,000**	27 years of system operation
TOTAL - SCENARIO 2 - PRESENT VALUE - O&M COSTS - TO POTW				**$ 5,353,000**	

APPENDIX D
ATTACHMENT D4
FEASIBILITY STUDY COST ESTIMATE SUMMARY - SOURCE AREA LANDFILL LOBES

LF-4: Containment of waste, vent landfill gas, re-routing of the brook, excavation of impacted sediment hot spots, partial containment of groundwater (vertical barrier) with groundwater remediation

PERIODIC COSTS

	YEAR	QTY	UNIT	UNIT COST	TOTAL	PRESENT VALUE (7%)	NOTES
Five Year Site Reviews	5, 10, 15, 20, 25, 30	6	LS	$ 20,000	$ 120,000	$ 43,000	$60K/ 3 alternatives (LF, FDDA, DGGW)
Groundwater Performance and Optimization Study	15	1	LS	$ 30,000	$ 30,000	$ 11,000	
Remedial Action Report	5	1	LS	$ 30,000	$ 30,000	$ 21,000	
Demobilization of on-site treatment system	30	1	LS	$ 150,000	$ 150,000	$ 20,000	
Well Abandonment	30	1	LS	$ 100,000	$ 100,000	$ 13,000	
Update Institutional Controls Plan	30	1	LS	$ 50,000	$ 50,000	$ 7,000	
TOTAL - PRESENT WORTH - O&M COSTS (PV 7%, 30 YRS)					**$480,000**	**$115,000**	

WOODARD & CURRAN
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PROJECT Sutton Brook Disposal Area Superfund Site
DESIGNED BY Ron St. Michel DATE 1/9/2007
CHECKED BY John Borgesi DATE 1/12/2007 rev 5/24/2007
PROJECT NO. 210517.00 SHEET NO. 1 OF 1

:onceptual Construction Costs
.ow Permeability Cover System

Northern Landfill Lobe

Item No.	Item Description	Units	Unit Cost	Quantity	Extended Amount
1	Mobilization/Demobilization	lump sum	$150,000.00	1	$150,000.00
2	Erosion Control Barriers	lin. ft.	$10.00	6,270	$62,700.00
3	Ledge & Rock Excavation	cu. yd.	$75.00	100	$7,500.00
4	Test Pit Excavations	hours	$150.00	40	$6,000.00
5	Site Preparation	lump sum	$300,000.00	1	$300,000.00
6	LF Gas Vent Level C or D	vert. ft.	$100.00	975	$97,500.00
7	LF Gas Vent Level B	vert. ft.	$150.00	325	$48,750.00
8	Waste Excavation & Relocation	cu. yd.	$25.00	2,100	$52,500.00
12	6-in Gas Venting Layer ($1x10^{-3}$ cm/s)	sq. yd.	$5.00	145,200	$726,000.00
14	60-mil textured HDPE Geomembrane	sq. yd.	$7.50	145,200	$1,089,000.00
15	Drainage Geocomposite	sq. yd.	$8.75	145,200	$1,270,500.00
16	18-in Vegetative Support Soil Layer	sq. yd.	$11.00	145,200	$1,597,200.00
17	6-in Topsoil Layer	sq. yd.	$8.00	145,200	$1,161,600.00
18	Gabion Wall	lin. ft.	$75.00	2,000	$150,000.00
19	8-ft Rip Rap Toe-of-Slope Protection	sq. yds.	$55.00	3,600	$198,000.00
20	Mid-Slope Grass Swale	lin. ft.	$12.00	3,500	$42,000.00
21	Mid-Slope Rip Rap Swale	lin. ft.	$20.00	3,500	$70,000.00
22	Detention Pond #1	each	$20,000.00	1	$20,000.00
23	Detention Pond #2	each	$20,000.00	1	$20,000.00
24	Detention Pond #3	each	$35,000.00	1	$35,000.00
25	Wetlands Replication	lump sum	$75,000.00	1	$75,000.00
26	12-ft Wide Gravel Access Road	lin. ft.	$20.00	2,750	$55,000.00
27	Post Closure Maintenance	lump sum	$30,000.00	1	$30,000.00
28	Remaining Lump Sum Items	lump sum	$80,000.00	1	$80,000.00
	Totals				**$7,344,250.00**
					$244,808.33 per acre

Southern Landfill Lobe

Item No.	Item Description	Units	Unit Cost	Quantity	Extended Amount
1	Mobilization/Demobilization	lump sum	$100,000.00	1	$100,000.00
2	Erosion Control Barriers	lin. ft.	$10.00	4,500	$45,000.00
3	Ledge & Rock Excavation	cu. yd.	$75.00	100	$7,500.00
4	Test Pit Excavations	hours	$150.00	24	$3,600.00
5	Site Preparation	lump sum	$175,000.00	1	$175,000.00
6	LF Gas Vent Level C or D	vert. ft.	$100.00	125	$12,500.00
7	LF Gas Vent Level B	vert. ft.	$150.00	125	$18,750.00
8	Waste Excavation & Relocation	cu. yd.	$25.00	3,700	$92,500.00
12	6-in Gas Venting Layer ($1x10^{-3}$ cm/s)	sq. yd.	$5.00	48,400	$242,000.00
14	60-mil textured HDPE Geomembrane	sq. yd.	$7.50	48,400	$363,000.00
15	Drainage Geocomposite	sq. yd.	$8.75	48,400	$423,500.00
16	18-in Vegetative Support Soil Layer	sq. yd.	$11.00	48,400	$532,400.00
17	6-in Topsoil Layer	sq. yd.	$8.00	48,400	$387,200.00
18	8-ft Rip Rap Toe-of-Slope Protection	sq. yds.	$55.00	3,200	$176,000.00
19	Mid-Slope Grass Swale	lin. ft.	$12.00	1,300	$15,600.00
20	Mid-Slope Rip Rap Swale	lin. ft.	$20.00	800	$16,000.00
21	Detention Pond #4	each	$35,000.00	1	$35,000.00
22	Wetlands Replication	lump sum	$40,000.00	1	$40,000.00
23	12-ft Wide Gravel Access Road	lin. ft.	$20.00	3,500	$70,000.00
25	Post Closure Maintenance	lump sum	$10,000.00	1	$10,000.00
26	Remaining Lump Sum Items	lump sum	$50,000.00	1	$50,000.00
	Totals				**$2,815,550.00**
					$281,555.00 per acre

APPENDIX D
ATTACHMENT D5
FEASIBILITY STUDY COST ESTIMATE SUMMARY -FORMER DRUM DISPOSAL AREA
FDDA-1: No Action

CAPITAL COSTS		
Construction Activities		
Mobilization/Demobilization	$	-
Pre-implementation Monitoring, Sampling, Testing and Analysis	$	-
Pilot Test	$	-
Site Work	$	-
Soil Excavation	$	-
Off-site Disposal	$	-
Sediment Excavation	$	-
Institutional Controls	$	-
SUBTOTAL - CONSTRUCTION ACTIVITIES	$	-
Contingency (10%)	$	-
TOTAL CONSTRUCTION ACTIVITIES	**$**	**-**
Profesional/ Technical Services		
Project Management	$	-
Remedial Design	$	-
Construction Management	$	-
Health and Safety	$	-
Permitting/ Legal	$	-
TOTAL PROFESSIONAL/ TECHNICAL SERVICES	$	-
TOTAL CAPITAL COSTS	$	-

ANNUAL OPERATION, MAINTENANCE AND MONITORING COSTS		
Performance Monitoring	$	-
Groundwater Treatment	$	-
Annual site-wide inspection	$	3,000
O&M SUBTOTAL:	$	3,000
Contingency (10%)	$	300
TOTAL - O&M COSTS (ANNUAL)	$	3,300
TOTAL - PRESENT WORTH - O&M COSTS	$	41,000

PERIODIC COSTS - PRESENT VALUE (7%)		
Five Year Site Reviews	$	43,000
Groundwater Performance and Optimization Study	$	-
Remedial Action Report	$	-
Demobilization of on-site treatment system	$	-
Well Abandonment	$	-
Update Instiutional Controls Plan	$	-
TOTAL PRESENT VALUE PERIODIC COSTS	$	43,000

TOTAL PRESENT VALUE (30 YEARS)	**$**	**84,000**

APPENDIX D
ATTACHMENT D5
FEASIBILITY STUDY COST ESTIMATE BACK-UP
FORMER DRUM DISPOSAL AREA

FDDA-1: No Action

OPERATION AND MAINTENANCE COSTS

	QTY	UNIT	UNIT COST	TOTAL	NOTES
Performance Monitoring					
Groundwater - treatment system				$ -	
Groundwater - site wide				$ -	
SUBTOTAL:				$ -	
Groundwater Treatment					
Operations Labor				$ -	
Maintenance Labor				$ -	
Equipment Repair/replacement				$ -	
Utilities				$ -	
				$ -	
SUBTOTAL:				$ -	
Annual site-wide inspection					
Inspection	1	LS	$ 3,000	$ 3,000	
SUBTOTAL:				$ 3,000	
O&M SUBTOTAL:				$ 3,000	
Contingency (10%)				$ 300	
TOTAL - O&M COSTS (ANNUAL)				**$ 3,300**	
TOTAL - PRESENT WORTH - O&M COSTS				$ 41,000	

APPENDIX D
ATTACHMENT D5
FEASIBILITY STUDY COST ESTIMATE BACK-UP
FORMER DRUM DISPOSAL AREA

FDDA-1: No Action

PERIODIC COSTS

	YEAR	QTY	UNIT	UNIT COST	TOTAL	PRESENT VALUE (7%)	NOTES
Five Year Site Reviews	30	6	LS	$ 20,000	$ 120,000	$ 43,000	$60K/ 3 alternatives (LF, FDDA, DGGW)
Groundwater Performance and Optimization Study			LS		$ -		Not applicable for this alternative
Remedial Action Report			LS		$ -		Not applicable for this alternative
Demobilization of on-site treatment system			LS		$ -		Not applicable for this alternative
Well Abandonment			LS		$ -		Not applicable for this alternative
Update Instiutional Controls Plan			LS		$ -		Not included in this alternative
TOTAL - PRESENT WORTH - O&M COSTS					**$ 120,000**	**$ 43,000**	

APPENDIX D
ATTACHMENT D6
FEASIBILITY STUDY COST ESTIMATE SUMMARY - FORMER DRUM DISPOSAL AREA

FDDA-2: Containment of soil (with cap) and groundwater (through extraction and ex-situ treatment)

30 years system operation and groundwater monitoring

CAPITAL COSTS

Construction Activities		
Pilot and Pump Test	$	100,000
Site Prep	$	52,500
Site Work	$	23,400
Soil Containment	$	343,000
Groundwater Containment Extraction and Treatment System	$	1,796,300
Institutional Controls	$	20,000
SUBTOTAL - CONSTRUCTION ACTIVITIES	$	2,335,200
Contingency (10%)	$	234,000
TOTAL CONSTRUCTION ACTIVITIES	**$**	**2,569,200**
Profesional/ Technical Services		
Project Management	$	128,500
Remedial Design	$	205,600
Construction Management	$	154,200
Health and Safety	$	38,600
Permitting/ Legal	$	38,600
TOTAL PROFESSIONAL/ TECHNICAL SERVICES	**$**	**565,500**
TOTAL CAPITAL COSTS	**$**	**3,134,700**

ANNUAL OPERATION, MAINTENANCE AND MONITORING COSTS

TOTAL - PRESENT WORTH - O&MM COSTS - TO SURFACE WATER	$ 4,341,000	--		
		--		
TOTAL - PRESENT VALUE - O&M COSTS - DISCHARGE TO POTW		--	$	5,147,000
		--		
TOTAL - PRESENT VALUE - O&M COSTS	**$ 4,341,000**	--	**$**	**5,147,000**

PERIODIC COSTS - PRESENT VALUE (7%)

Five Year Site Reviews	$	43,000
Groundwater Performance and Optimization Study	$	23,000
Remedial Action Report	$	24,000
Demobilization of on-site treatment system	$	20,000
Well Abandonment	$	13,000
Update Institutional Controls Plan	$	3,000
TOTAL PRESENT VALUE PERIODIC COSTS	$	126,000

TOTAL PRESENT VALUE	**$ 7,601,700**	--	**$**	**8,407,700**

APPENDIX D
ATTACHMENT D6
FEASIBILITY STUDY COST ESTIMATE BACK-UP
FORMER DRUM DISPOSAL AREA

FDDA-2: Containment of soil (with cap) and groundwater (through extraction and ex-situ treatment)

CAPITAL COSTS

Assumptions:

No. Recovery Wells	4		
Total flow rate	20	gpm	20000
Area of soil containment	45,000	sq ft	
Area of access roadways to well heads	4,800	sq ft	
Depth of fill material for roadway	3	ft	
Wetland impacts requiring replication	0	sq ft	

	QTY	UNIT	UNIT COST	TOTAL	NOTES
Construction Activities					
Pilot and Pump Test					
Perform groundwater pump test, data analysis	1	LS	$ 50,000	$ 50,000	
Perform groundwater treatment pilot test, data analysis	1	LS	$ 50,000	$ 50,000	
SUBTOTAL:				$ 100,000	
Site Prep					
Submittals/Implementation Plans	1	LS	$ 20,000	$ 20,000	QAPP, HASP, etc
Temporary Facilities and Utilities	1	LS	$ 25,000	$ 25,000	fence, roads, signs, trailers, restrooms, etc
Survey	1	LS	$ 7,500	$ 7,500	
SUBTOTAL:				$ 52,500	
Site Work					
Clearing and Grubbing	2.00	ACRE	$ 6,300	$ 12,600	
Construction of gravel roadways - fill material	600	CY	$ 14	$ 8,400	
Construction of gravel roadways - labor and equipment	600	SY	$ 4	$ 2,400	
Wetland Replication	0	ACRE	$ 50,000	$ -	
SUBTOTAL:				$ 23,400	
Soil Containment					
Pre-design soil sampling	1	LS	$ 28,000	$ 28,000	
Low permeability cap (with geomembrane)	45,000	SQ FT	$ 7	$ 315,000	Low perm/ geomembrane required since area to be
SUBTOTAL:				$ 343,000	used for stormwater basin
Groundwater Containment Extraction and Treatment System					
Extraction wells with development	4	EACH	$ 25,000	$ 100,000	
Treatment system - bldg	2400	SQ FT	$ 70	$ 168,000	60' LX 40' W X 20' H
Treatment system - equipment	1	LS	$ 587,200	$ 587,200	
Electrical lines to site - utility pole installation	29	EACH	$ 7,500	$ 217,500	1 pole per 100 feet
Electrical lines to site - run lines from South Street to treatmen	2,900	LF	$ 50	$ 145,000	
Installation - electrical	15%	(of equip total)	$ 88,100	$ 88,100	
Installation - controls/ instrumentation	15%	(of equip total)	$ 88,100	$ 88,100	
Installation - piping	30%	(of equip total)	$ 176,200	$ 176,200	includes electrical conduit, extraction and discharge piping
Installation - equipment	30%	(of equip total)	$ 176,200	$ 176,200	includes electrical conduit, extraction and discharge piping
System start-up	100%	LS	$ 50,000	$ 50,000	
SUBTOTAL:				$ 1,796,300	
Institutional Controls	1	LS	$ 20,000	$ 20,000	
SUBTOTAL:				$ 20,000	
SUBTOTAL - CONSTRUCTION ACTIVITIES				$ 2,335,200	
Contingency (10%)				$ 234,000	
TOTAL CONSTRUCTION ACTIVITIES				$ 2,569,200	
Profesional/ Technical Services					
Project Management	5%			$ 128,500	per USACE and USEPA, 2000
Remedial Design	8%			$ 205,600	
Construction Management	6%			$ 154,200	
Health and Safety	1.5%			$ 38,600	
Permitting/ Legal	1.5%			$ 38,600	
TOTAL PROFESSIONAL/ TECHNICAL SERVICES				$ 565,500	
TOTAL - CAPITAL COSTS				**$ 3,134,700**	

APPENDIX D
ATTACHMENT D6
FEASIBILITY STUDY COST ESTIMATE BACK-UP
FORMER DRUM DISPOSAL AREA

FDDA-2: Containment of soil (with cap) and groundwater (through extraction and ex-situ treatment)

OPERATION AND MAINTENANCE COSTS

	QTY	UNIT	UNIT COST	TOTAL	NOTES
Performance Monitoring and Reporting					
Groundwater - treatment system	1	LS	$ 74,000	$ 74,000	
Groundwater - area wide	1	LS	$ 30,000	$ 30,000	
SUBTOTAL:				$ 104,000	
Groundwater Treatment - OM&M					
Operations Labor	1	LS	$ 100,000	$ 100,000	full time operator with maintenance assistance
Equipment Repair/replacement	3%	EQUIP	$ 18,000	$ 18,000	
Utilities	1	EST	$ 25,000	$ 25,000	
Chemicals	1	EST	$ 66,000	$ 66,000	
SUBTOTAL:				$ 209,000	
Annual site-wide inspection					
Inspection - includes cap and area-wide	1	LS	$ 5,000	$ 5,000	
SUBTOTAL:				$ 5,000	
O&M SUBTOTAL:				$ 318,000	
Contingency (10%)				$ 31,800	
TOTAL - O&MM COSTS (ANNUAL) - TO SURFACE WATER				**$ 349,800**	
TOTAL - PRESENT WORTH - O&MM COSTS - TO SURFACE WATER				**$ 4,341,000**	
Discharge to POTW					
Discharge fees	10,512	1000/gal	$ 5.60	$ 59,000	
SUBTOTAL:				$ 59,000	
O&M SUBTOTAL:				$ 377,000	
Contingency (10%)				$ 37,700	
TOTAL - O&M COSTS (ANNUAL) - DISCHARGE TO POTW				**$ 414,700**	
TOTAL - PRESENT VALUE - O&M COSTS - DISCHARGE TO POTW				**$ 5,147,000**	

APPENDIX D
ATTACHMENT D6
FEASIBILITY STUDY COST ESTIMATE BACK-UP
FORMER DRUM DISPOSAL AREA

FDDA-2: Containment of soil (with cap) and groundwater (through extraction and ex-situ treatment)

PERIODIC COSTS

	YEAR	QTY	UNIT	UNIT COST	TOTAL	PRESENT VALUE (7%)	NOTES
Five Year Site Reviews	5, 10, 15, 20, 25, 30	6	LS	$ 20,000	$ 120,000	$ 43,000	$60K/ 3 alternatives (LF, FDDA, DGGW)
Groundwater Performance and Optimization Study	10 and 20	2	LS	$ 30,000	$ 60,000	$ 23,000	
Remedial Action Report	3	1	LS	$ 30,000	$ 30,000	$ 24,000	
Demobilization of on-site treatment system	30	1	LS	$ 150,000	$ 150,000	$ 20,000	
Well Abandonment	30	1	LS	$ 100,000	$ 100,000	$ 13,000	
Update Institutional Controls Plan	30	1	LS	$ 20,000	$ 20,000	$ 3,000	
TOTAL - PRESENT WORTH - O&M COSTS					**$ 480,000**	**$ 126,000**	

APPENDIX D
ATTACHMENT D7
FEASIBILITY STUDY COST ESTIMATE SUMMARY - FORMER DRUM DISPOSAL AREA

FDDA-3: Excavation, treatment and/or disposal of soil with hydraulic containment of groundwater (through extraction and ex-situ treatment)

(Assumes 25 years of system operation, 30 years of groundwater monitoring)

CAPITAL COSTS

Construction Activities		
Pilot and Pump Test	$	100,000
Site Prep	$	52,500
Site Work	$	17,100
Soil Excavation	$	333,300
On-site Disposal	$	222,500
Groundwater Containment Extraction and Treatment System	$	1,796,300
Institutional Controls	$	20,000
SUBTOTAL - CONSTRUCTION ACTIVITIES	$	2,541,700
Contingency (10%)	$	254,200
TOTAL CONSTRUCTION ACTIVITIES	**$**	**2,795,900**
Profesional/ Technical Services		
Project Management	$	139,800
Remedial Design	$	223,700
Construction Management	$	167,800
Health and Safety	$	42,000
Permitting/ Legal	$	42,000
TOTAL PROFESSIONAL/ TECHNICAL SERVICES	**$**	**615,300**
TOTAL CAPITAL COSTS	**$**	**3,411,200**

ANNUAL OPERATION, MAINTENANCE AND MONITORING COSTS

TOTAL - PRESENT VALUE - O&M COSTS - TO SURFACE WATER	$	3,701,200	--		
TOTAL - PRESENT VALUE - MONITORING COSTS - TO SURFACE WATER	$	423,000	--		
TOTAL - PRESENT VALUE - O&M COSTS - DISCHARGE TO POTW				$	5,319,000
TOTAL - PRESENT VALUE - MONITORING COSTS - TO POTW				$	423,000
TOTAL - PRESENT VALUE - O&M COSTS	**$**	**4,124,200**	**--**	**$**	**5,742,000**

Range includes 25 years of system operation, 30 years of groundwater monitoring - Low: discharge to surface water, High: discharge to POTW

PERIODIC COSTS - PRESENT VALUE (7%)

Five Year Site Reviews	$	43,000
Groundwater Performance and Optimization Study	$	15,000
Remedial Action Report	$	24,000
Demobilization of on-site treatment system	$	20,000
Well Abandonment	$	13,000
Update Institutional Controls Plan	$	3,000
TOTAL PRESENT VALUE PERIODIC COSTS	$	118,000

TOTAL PRESENT VALUE	**$**	**7,653,000**	**--**	**$**	**9,271,000**

APPENDIX D
ATTACHMENT D7
FEASIBILITY STUDY COST ESTIMATE BACK-UP
FORMER DRUM DISPOSAL AREA

FDDA-3: Excavation, treatment and/or disposal of soil with hydraulic containment of groundwater (through extraction and ex-situ treatment)

CAPITAL COSTS

Assumptions:

- No treatment of soil is required prior to on-site disposal.

No. Recovery Wells	4		20000
Total flow rate	24	gpm	
Area of excavation	38,300	sq ft	
Depth of excavation	varying	ft	
Volume of soil excavated	8,900	cy	
Perimeter of Excavation	1,000	ft	
Area of access roadways to well heads	4,800	sq ft	
Depth of fill material for roadway	3	ft	
Wetland impacts requiring replication	0	sq ft	

	QTY	UNIT	UNIT COST	TOTAL	NOTES
Construction Activities					
Pilot and Pump Test					
Perform groundwater pump test, data analysis	1	LS	$ 50,000	$ 50,000	
Perform groundwater treatment pilot test, data analysis	1	LS	$ 50,000	$ 50,000	
SUBTOTAL:				$ 100,000	
Site Prep					
Submittals/Implementation Plans	1	LS	$ 20,000	$ 20,000	QAPP, HASP, etc
Temporary Facilities and Utilities	1	LS	$ 25,000	$ 25,000	fence, roads, signs, trailers, restrooms, etc
Survey	1	LS	$ 7,500	$ 7,500	
SUBTOTAL:				$ 52,500	
Site Work					
Clearing and Grubbing	1.00	ACRE	$ 6,300	$ 6,300	
Construction of gravel roadways - fill material	600	CY	$ 14	$ 8,400	
Construction of gravel roadways - labor and equipment	600	SY	$ 4	$ 2,400	
Wetland Replication	0	ACRE	$ 50,000	$ -	
SUBTOTAL:				$ 17,100	
Soil Excavation					
Pre-design soil sampling	1	LS	$ 28,500	$ 28,500	
Erosion Controls	1000	LF	$ 9	$ 9,000	
Excavation	8,900	CY	$ 5	$ 44,500	
Waste Characterization	27	EACH	$ 2,500	$ 67,500	1 sample/500 ton
Confirmatory Soil Sampling and Analysis	1	LS	$ 44,000	$ 44,000	
Backfill - sand/gravel	8,100	CY	$ 14	$ 113,400	
Backfill - topsoil	800	CY	$ 33	$ 26,400	
SUBTOTAL:				$ 333,300	
On-site Disposal					
On-site Transport and Disposal	8,900	CY	$ 25	$ 222,500	
SUBTOTAL:				$ 222,500	
Groundwater Containment Extraction and Treatment System					
Extraction wells with development	4	EACH	$ 25,000	$ 100,000	
Treatment system - bldg	2,400	SQ FT	$ 70	$ 168,000	60' LX 40' W X 20' H
Treatment system - equipment	1	LS	$ 587,200	$ 587,200	
Electrical lines to site - utility pole installation	29	EACH	$ 7,500	$ 217,500	1 pole per 100 feet
Electrical lines to site - run lines from South Street to trea	2,900	LF	$ 50	$ 145,000	
Installation - electrical	15%	(of equip total)	$ 88,100	$ 88,100	
Installation - controls/ instrumentation	15%	(of equip total)	$ 88,100	$ 88,100	
Installation - piping	30%	(of equip total)	$ 176,200	$ 176,200	includes electrical conduit, extraction and discharge piping
Installation - labor	30%	(of equip total)	$ 176,200	$ 176,200	includes electrical conduit, extraction and discharge piping
System start-up	1	LS	$ 50,000	$ 50,000	
SUBTOTAL:				$ 1,796,300	
Institutional Controls	1	LS	$ 20,000	$ 20,000	
SUBTOTAL:				$ 20,000	

APPENDIX D
ATTACHMENT D7
FEASIBILITY STUDY COST ESTIMATE BACK-UP
FORMER DRUM DISPOSAL AREA

CAPITAL COSTS

SUBTOTAL - CONSTRUCTION ACTIVITIES		$	2,541,700	
Contingency (10%)		$	254,200	
TOTAL CONSTRUCTION ACTIVITIES - ON-SITE DISPOSAL		$	2,795,900	
Profesional/ Technical Services - ON-SITE DISPOSAL				
Project Management	5%	$	139,800	per USACE and USEPA, 2000
Remedial Design	8%	$	223,700	
Construction Management	6%	$	167,800	
Health and Safety	1.5%	$	42,000	
Permitting/ Legal	1.5%	$	42,000	
TOTAL PROFESSIONAL/ TECHNICAL SERVICES - ON-SITE DISPOSAL		$	615,300	
TOTAL - CAPITAL COSTS		**$**	**3,411,200**	

APPENDIX D
ATTACHMENT D7
FEASIBILITY STUDY COST ESTIMATE BACK-UP
FORMER DRUM DISPOSAL AREA

FDDA-3: Excavation, treatment and/or disposal of soil with hydraulic containment of groundwater (through extraction and ex-situ treatment)

OPERATION AND MAINTENANCE COSTS

	QTY	UNIT	UNIT COST	TOTAL	NOTES
Performance Monitoring and Reporting					
Groundwater - treatment system	1	LS	$ 74,000	$ 74,000	
Groundwater - area wide	1	LS	$ 30,000	$ 30,000	
SUBTOTAL:				$ 104,000	
Groundwater Treatment - OM&M					
Operations Labor	1	LS	$ 100,000	$ 100,000	full time operator with maintenance assistance
Equipment Repair/replacement	3%	EQUIP	$ 17,700	$ 17,700	
Utilities	1	EST	$ 25,000	$ 25,000	
Chemicals	1	EST	$ 72,000	$ 72,000	
SUBTOTAL:				$ 214,700	
Annual site-wide inspection					
Inspection	1	LS	$ 3,000	$ 3,000	
SUBTOTAL:				$ 3,000	
O&M SUBTOTAL:				$ 288,700	
Contingency (10%)				$ 28,900	
Monitoring SUBTOTAL				$ 33,000	
Contingency (10%)				$ 3,300	
TOTAL - O&M COSTS (ANNUAL) - TO SURFACE WATER				**$ 317,600**	
TOTAL - MONITORING COSTS (ANNUAL) - TO SURFACE WATER				**$ 36,300**	
TOTAL - PRESENT VALUE - O&M COSTS - TO SURFACE WATER				**$ 3,701,200**	
TOTAL - PRESENT VALUE - MONITORING COSTS - TO SURFACE WATER				**$ 423,000**	
Discharge to POTW					
Discharge fees	12,700	1000/gal	$ 5.60	$ 72,000	
SUBTOTAL:				$ 72,000	
O&M SUBTOTAL:				$ 389,600	
Contingency (10%)				$ 39,000	
Monitoring SUBTOTAL				$ 33,000	
Contingency (10%)				$ 3,300	
TOTAL - O&M COSTS (ANNUAL) - DISCHARGE TO POTW				**$ 428,600**	
TOTAL - MONITORING COSTS (ANNUAL) - TO POTW				**$ 36,300**	
TOTAL - PRESENT VALUE - O&M COSTS - DISCHARGE TO POTW				**$ 5,319,000**	
TOTAL - PRESENT VALUE - MONITORING COSTS - TO POTW				**$ 423,000**	

APPENDIX D
ATTACHMENT D7
FEASIBILITY STUDY COST ESTIMATE BACK-UP
FORMER DRUM DISPOSAL AREA

FDDA-3: Excavation, treatment and/or disposal of soil with hydraulic containment of groundwater (through extraction and ex-situ treatment)

PERIODIC COSTS

	YEAR	QTY	UNIT	UNIT COST	TOTAL	PRESENT VALUE (7%)	NOTES
Five Year Site Reviews	5, 10, 15, 20, 25, 30	6	LS	$ 20,000	$ 120,000	$ 43,000	$60K/ 3 alternatives (LF, FDDA, DGGW)
Groundwater Performance and Optimization Study	10	1	LS	$ 30,000	$ 30,000	$ 15,000	
Remedial Action Report	3	1	LS	$ 30,000	$ 30,000	$ 24,000	
Demobilization of on-site treatment system	30	1	LS	$ 150,000	$ 150,000	$ 20,000	
Well Abandonment	30	1	LS	$ 100,000	$ 100,000	$ 13,000	
Update Institutional Controls Plan	30	1	LS	$ 20,000	$ 20,000	$ 3,000	
TOTAL - PRESENT WORTH - O&M COSTS (PV 7%, 30 YRS)					**$ 450,000**	**$ 118,000**	

APPENDIX D
ATTACHMENT D8
FEASIBILITY STUDY COST ESTIMATE SUMMARY - FORMER DRUM DISPOSAL AREA

FDDA-4: Excavation, treatment and/or disposal of soil with groundwater remediation (focused mass reduction)

CAPITAL COSTS

Construction Activities					
Perform groundwater pilot test, data analysis	$	50,000	--		
Site Prep	$	52,500	--		
Site Work	$	6,300	--		
Soil Excavation	$	333,300	--		
In-situ groundwater treatment - MNA	$	38,000			
On-site Disposal	$	222,500	--		
Groundwater Containment Extraction and Treatment System	$	-	--		
Institutional Controls	$	20,000	--		
SUBTOTAL - CONSTRUCTION ACTIVITIES	$	722,600	--		
Contingency (10%)	$	72,300	--		
TOTAL CONSTRUCTION ACTIVITIES	**$**	**794,900**	--		
Profesional/ Technical Services					
Project Management	$	47,700	--	$	-
Remedial Design	$	95,400	--	$	-
Construction Management	$	63,600	--	$	-
Health and Safety	$	23,900	--	$	-
Permitting/ Legal	$	23,900	--	$	-
TOTAL PROFESSIONAL/ TECHNICAL SERVICES	**$**	**254,500**	--	**$**	-
TOTAL CAPITAL COSTS	**$**	**1,049,400**	--	**$**	-

ANNUAL OPERATION, MAINTENANCE AND MONITORING COSTS

MNA - 30 YEARS	$	1,706,000			
TOTAL - PRESENT VALUE - MNA COSTS	$	1,706,000	--	$	-
TOTAL - PRESENT VALUE - O&M COSTS	**$**	**1,706,000**	--	**$**	-

PERIODIC COSTS - PRESENT VALUE (7%)

Five Year Site Reviews	$	43,000
Groundwater Performance and Optimization Study	$	11,000
Remedial Action Report	$	21,000
Demobilization of on-site treatment system	$	20,000
Well Abandonment	$	13,000
Update Institutional Controls Plan	$	3,000
TOTAL PRESENT VALUE PERIODIC COSTS	$	111,000

TOTAL PRESENT VALUE $ 2,866,400

APPENDIX D
ATTACHMENT D8
FEASIBILITY STUDY COST ESTIMATE BACK-UP
FORMER DRUM DISPOSAL AREA

FDDA-4: Excavation, treatment and/or disposal of soil with groundwater remediation (focused mass reduction)

CAPITAL COSTS

Assumptions:

- No treatment of soil is required prior to on-site disposal.

MNA for groundwater		
Area of excavation	38,300	sq ft
Depth of excavation	varying	ft
Volume of soil excavated	8,900	cy
Perimeter of Excavation	1,000	lft
Area of access roadways to well heads		sq ft
Depth of fill material for roadway		ft
Wetland impacts requiring replication	0	sq ft

	QTY	UNIT	UNIT COST	TOTAL	NOTES
Construction Activities					
Pilot and Pump Test					
Perform groundwater pilot test, data analysis	1	LS	$ 50,000	$ 50,000	
SUBTOTAL:				$ 50,000	
Site Prep					
Submittals/Implementation Plans	1	LS	$ 20,000	$ 20,000	QAPP, HASP, etc
Temporary Facilities and Utilities	1	LS	$ 25,000	$ 25,000	fence, roads, signs, trailers, restrooms, etc
Survey	1	LS	$ 7,500	$ 7,500	
SUBTOTAL:				$ 52,500	
Site Work					
Clearing and Grubbing	1.00	ACRE	$ 6,300	$ 6,300	
Construction of gravel roadways - fill material	0	CY	$ 14	$ -	
Construction of gravel roadways - labor and equipment	0	SY	$ 4	$ -	
Wetland Replication	0	ACRE	$ 50,000	$ -	
SUBTOTAL:				$ 6,300	
Soil Excavation					
Pre-design soil sampling	1	LS	$ 28,500	$ 28,500	
Erosion Controls	1000	LF	$ 9	$ 9,000	
Excavation	8,900	CY	$ 5	$ 44,500	
Waste Characterization	27	EACH	$ 2,500	$ 67,500	1 sample/500 ton
Confirmatory Soil Sampling and Analysis	1	LS	$ 44,000	$ 44,000	
Backfill - sand/gravel	8,100	CY	$ 14	$ 113,400	
Backfill - topsoil	800	CY	$ 33	$ 26,400	
SUBTOTAL:				$ 333,300	
In-situ groundwater treatment - MNA					
Installation of additional monioring wells	1	LS	$ 38,000	$ 38,000	See back-up worksheet for details
SUBTOTAL:				$ 38,000	
On-site Disposal					
On-site Transport and Disposal	8,900	CY	$ 25	$ 222,500	
SUBTOTAL:				$ 222,500	
Groundwater Containment Extraction and Treatment System					
Extraction wells with development	0	EACH	$ 25,000	$ -	
Treatment system - bldg	0	SQ FT	$ 70	$ -	60' LX 40' W X 20' H
Treatment system - equipment	0	LS	$ 570,900	$ -	
Electrical lines to site - utility pole installation	0	EACH	$ 7,500	$ -	1 pole per 100 feet
Electrical lines to site - run lines from South Street to treat	0	LF	$ 50	$ -	
Installation - electrical	0%	(of equip total)	$ -	$ -	
Installation - controls/ instrumentation	0%	(of equip total)	$ -	$ -	
Installation - piping	0%	(of equip total)	$ -	$ -	includes electrical conduit, extraction and discharge piping
Installation - labor	0%	(of equip total)	$ -	$ -	includes electrical conduit, extraction and discharge piping
System start-up	0%	LS	$ -	$ -	
SUBTOTAL:				$ -	
Institutional Controls	1	LS	$ 20,000	$ 20,000	
SUBTOTAL:				$ 20,000	
SUBTOTAL - CONSTRUCTION ACTIVITIES - MNA				$ 722,600	
Contingency (10%)				$ 72,300	
TOTAL CONSTRUCTION ACTIVITIES - MNA				$ 794,900	
Profesional/ Technical Services - MNA					
Project Management	6%			$ 47,700	per USACE and USEPA, 2000
Remedial Design	12%			$ 95,400	
Construction Management	8%			$ 63,600	
Health and Safety	3%			$ 23,900	
Permitting/ Legal	3%			$ 23,900	
TOTAL PROFESSIONAL/ TECHNICAL SERVICES - MNA				$ 254,500	
TOTAL - CAPITAL COSTS - MNA				**$ 1,049,400**	

APPENDIX D
ATTACHMENT D8
FEASIBILITY STUDY COST ESTIMATE BACK-UP
FORMER DRUM DISPOSAL AREA

FDDA-4: Excavation, treatment and/or disposal of soil with groundwater remediation (focused mass reduction)

OPERATION AND MAINTENANCE COSTS

	QTY	UNIT	UNIT COST	TOTAL	NOTES
MNA - 30 YEARS					
Performance Monitoring and Reporting					
MNA Implementation	1	LS	$ 122,000	$ 122,000	
SUBTOTAL:				$ 122,000	
Annual site-wide inspection					
Inspection	1	LS	$ 3,000	$ 3,000	
SUBTOTAL:				$ 3,000	
O&M SUBTOTAL:				$ 125,000	
Contingency (10%)				$ 12,500	
TOTAL - MNA COSTS (ANNUAL)				**$ 137,500**	
TOTAL - PRESENT VALUE - MNA COSTS				**$ 1,706,000**	**30 years**

APPENDIX D
ATTACHMENT D8
FEASIBILITY STUDY COST ESTIMATE BACK-UP
FORMER DRUM DISPOSAL AREA

FDDA-4: Excavation, treatment and/or disposal of soil with groundwater remediation (focused mass reduction)

PERIODIC COSTS

	YEAR	QTY	UNIT	UNIT COST	TOTAL	PRESENT VALUE (7%)	NOTES
Five Year Site Reviews	5, 10, 15, 20, 25, 30	6	LS	$ 20,000	$ 120,000	$ 43,000	$60K/ 3 alternatives (LF, FDDA, DGGW)
Groundwater Performance and Optimization Study	15	1	LS	$ 30,000	$ 30,000	$ 11,000	
Remedial Action Report	5	1	LS	$ 30,000	$ 30,000	$ 21,000	
Demobilization of on-site treatment system	30	1	LS	$ 150,000	$ 150,000	$ 20,000	
Well Abandonment	30	1	LS	$ 100,000	$ 100,000	$ 13,000	
Update Institutional Controls Plan	30	1	LS	$ 20,000	$ 20,000	$ 3,000	
TOTAL - PRESENT WORTH - O&M COSTS (PV 7%, 30 YRS)					**$ 450,000**	**$ 111,000**	

APPENDIX D
ATTACHMENT D9
FEASIBILITY STUDY COST ESTIMATE SUMMARY - FORMER DRUM DISPOSAL AREA

FDDA-5: Excavation, treatment and/or disposal of soil with groundwater extraction and ex-situ treatment for area-wide contaminant reduction

(Assumes 25 years of system operation, 30 years of groundwater monitoring)

CAPITAL COSTS

Construction Activities		
Pilot and Pump Test	$	100,000
Site Prep	$	52,500
Site Work	$	17,100
Soil Excavation	$	333,300
On-site Disposal	$	222,500
Groundwater Containment Extraction and Treatment System	$	2,644,200
Institutional Controls	$	20,000
SUBTOTAL - CONSTRUCTION ACTIVITIES	$	3,389,600
Contingency 10%)	$	339,000
TOTAL CONSTRUCTION ACTIVITIES	**$**	**3,728,600**
Profesional/ Technical Services		
Project Management	$	186,500
Remedial Design	$	298,300
Construction Management	$	223,800
Health and Safety	$	56,000
Permitting/ Legal	$	56,000
TOTAL PROFESSIONAL/ TECHNICAL SERVICES	**$**	**820,600**
TOTAL CAPITAL COSTS	**$**	**4,549,200**

ANNUAL OPERATION, MAINTENANCE AND MONITORING COSTS

TOTAL - PRESENT VALUE - O&M COSTS - TO SURFACE WATER	$	4,842,100	--		
TOTAL - PRESENT VALUE - MONITORING COSTS - TO SURFACE WATER	$	450,400	--		
TOTAL - PRESENT VALUE - O&M COSTS - DISCHARGE TO POTW	$	-	--	$	7,225,000
TOTAL - PRESENT VALUE - MONITORING COSTS - TO POTW			--	$	450,400
			--		
			--		
TOTAL - PRESENT VALUE - O&M COSTS	**$**	**5,292,500**	--	**$**	**7,675,400**

Range includes 25 years of system operation, 30 years of groundwater monitoring - Low: discharge to surface water, High: discharge to POTW

PERIODIC COSTS - PRESENT VALUE (7%)

Five Year Site Reviews	$	41,000
Groundwater Performance and Optimization Study	$	15,000
Remedial Action Report	$	24,000
Demobilization of on-site treatment system	$	28,000
Well Abandonment	$	18,000
Update Institutional Controls Plan	$	4,000
TOTAL PRESENT VALUE PERIODIC COSTS	$	130,000

TOTAL PRESENT VALUE	**$**	**9,972,000**	--	**$**	**12,355,000**

APPENDIX D
ATTACHMENT D9
FEASIBILITY STUDY COST ESTIMATE BACK-UP
FORMER DRUM DISPOSAL AREA

FDDA-5: Excavation, treatment and/or disposal of soil with groundwater extraction and ex-situ treatment for area-wide contaminant reduction

CAPITAL COSTS

Assumptions:

- No treatment of soil is required prior to on-site disposal.

No. Recovery Wells	5	
Total flow rate	50	gpm
Area of excavation	38,300	sq ft
Depth of excavation	varying	ft
Volume of soil excavated	8,900	cy
Perimeter of Excavation	1,000	ft
Area of access roadways to well heads	4,800	sq ft
Depth of fill material for roadway	3	ft
Wetland impacts requiring replication	0	sq ft

	QTY	UNIT	UNIT COST	TOTAL	NOTES
Construction Activities					
Pilot and Pump Test					
Perform groundwater pump test, data analysis	1	LS	$ 50,000	$ 50,000	
Perform groundwater treatment pilot test, data analysis	1	LS	$ 50,000	$ 50,000	
SUBTOTAL:				$ 100,000	
Site Prep					
Submittals/Implementation Plans	1	LS	$ 20,000	$ 20,000	QAPP, HASP, etc
Temporary Facilities and Utilities	1	LS	$ 25,000	$ 25,000	fence, roads, signs, trailers, restrooms, etc
Survey	1	LS	$ 7,500	$ 7,500	
SUBTOTAL:				$ 52,500	
Site Work					
Clearing and Grubbing	1.00	ACRE	$ 6,300	$ 6,300	
Construction of gravel roadways - fill material	600	CY	$ 14	$ 8,400	
Construction of gravel roadways - labor and equipment	600	SY	$ 4	$ 2,400	
Wetland Replication	0	ACRE	$ 50,000	$ -	
SUBTOTAL:				$ 17,100	
Soil Excavation					
Pre-design soil sampling	1	LS	$ 28,500	$ 28,500	
Erosion Controls	1000	LF	$ 9	$ 9,000	
Excavation	8,900	CY	$ 5	$ 44,500	
Waste Characterization	27	EACH	$ 2,500	$ 67,500	1 sample/500 ton
Confirmatory Soil Sampling and Analysis	1	LS	$ 44,000	$ 44,000	
Backfill - sand/gravel	8,100	CY	$ 14	$ 113,400	
Backfill - topsoil	800	CY	$ 33	$ 26,400	
SUBTOTAL:				$ 333,300	
On-site Disposal					
On-site Transport and Disposal	8,900	CY	$ 25	$ 222,500	
SUBTOTAL:				$ 222,500	
Groundwater Containment Extraction and Treatment System					
Extraction wells with development	5	EACH	$ 25,000	$ 125,000	
Treatment system - bldg	2,400	SQ FT	$ 70	$ 168,000	60' LX 40' W X 20' H
Treatment system - equipment	1	LS	$ 1,020,300	$ 1,020,300	
Electrical lines to site - utility pole installation	29	EACH	$ 7,500	$ 217,500	1 pole per 100 feet
Electrical lines to site - run lines from South Street to trea	2,900	LF	$ 50	$ 145,000	
Installation - electrical	15%	(of equip total)	$ 153,100	$ 153,100	
Installation - controls/ instrumentation	15%	(of equip total)	$ 153,100	$ 153,100	
Installation - piping	30%	(of equip total)	$ 306,100	$ 306,100	includes electrical conduit, extraction and discharge piping
Installation - labor	30%	(of equip total)	$ 306,100	$ 306,100	includes electrical conduit, extraction and discharge piping
System start-up	100%	LS	$ 50,000	$ 50,000	
SUBTOTAL:				$ 2,644,200	
Institutional Controls	1	LS	$ 20,000	$ 20,000	
SUBTOTAL:				$ 20,000	

APPENDIX D
ATTACHMENT D9
FEASIBILITY STUDY COST ESTIMATE BACK-UP
FORMER DRUM DISPOSAL AREA

FDDA-5: Excavation, treatment and/or disposal of soil with groundwater extraction and ex-situ treatment for area-wide contaminant reduction

CAPITAL COSTS

SUBTOTAL - CONSTRUCTION ACTIVITIES - ON-SITE DISPOSAL AND GW CONTAINMENT		$	3,389,600	
Contingency 10%)		$	339,000	
TOTAL CONSTRUCTION ACTIVITIES - ON-SITE DISPOSAL		$	3,728,600	
Profesional/ Technical Services - ON-SITE DISPOSAL				
Project Management	5%	$	186,500	per USACE and USEPA, 2000
Remedial Design	8%	$	298,300	
Construction Management	6%	$	223,800	
Health and Safety	1.5%	$	56,000	
Permitting/ Legal	1.5%	$	56,000	
TOTAL PROFESSIONAL/ TECHNICAL SERVICES - ON-SITE DISPOSAL		$	820,600	
TOTAL - CAPITAL COSTS		**$**	**4,549,200**	

APPENDIX D
ATTACHMENT D9
FEASIBILITY STUDY COST ESTIMATE BACK-UP
FORMER DRUM DISPOSAL AREA

FDDA-5: Excavation, treatment and/or disposal of soil with groundwater extraction and ex-situ treatment for area-wide contaminant reduction

OPERATION AND MAINTENANCE COSTS

	QTY	UNIT	UNIT COST	TOTAL	NOTES
Performance Monitoring and Reporting					
Groundwater - treatment system	1	LS	$ 74,000	$ 74,000	
Groundwater - area wide	1	LS	$ 30,000	$ 30,000	
SUBTOTAL:				$ 104,000	
Groundwater Treatment - OM&M					
Operations Labor	1	LS	$ 100,000	$ 100,000	full time operator with maintenance assistance
Equipment Repair/replacement	3%	EQUIP	$ 30,700	$ 30,700	
Utilities	1	EST	$ 50,000	$ 50,000	
Chemicals	1	EST	$ 123,000	$ 123,000	
SUBTOTAL:				$ 303,700	
Annual site-wide inspection					
Inspection	1	LS	$ 3,000	$ 3,000	
SUBTOTAL:				$ 3,000	
O&M SUBTOTAL:				$ 377,700	
Contingency (10%)				$ 37,800	
Monitoring SUBTOTAL				$ 33,000	
Contingency (10%)				$ 3,300	
TOTAL - O&M COSTS (ANNUAL) - TO SURFACE WATER				**$ 415,500**	
TOTAL - MONITORING COSTS (ANNUAL) - TO SURFACE WATER				**$ 36,300**	
TOTAL - PRESENT VALUE - O&M COSTS - TO SURFACE WATER				**$ 4,842,100**	
TOTAL - PRESENT VALUE - MONITORING COSTS - TO SURFACE WATER				**$ 450,400**	
Discharge to POTW					
Discharge fees	26,300	1000/gal	$ 5.60	$ 148,000	
SUBTOTAL:				$ 148,000	
O&M SUBTOTAL:				$ 563,500	
Contingency (10%)				$ 56,400	
Monitoring SUBTOTAL				$ 33,000	
Contingency (10%)				$ 3,300	
TOTAL - O&M COSTS (ANNUAL) - DISCHARGE TO POTW				**$ 619,900**	
TOTAL - MONITORING COSTS (ANNUAL) - TO POTW				**$ 36,300**	
TOTAL - PRESENT VALUE - O&M COSTS - DISCHARGE TO POTW				**$ 7,225,000**	
TOTAL - PRESENT VALUE - MONITORING COSTS - TO POTW				**$ 450,400**	

APPENDIX D
ATTACHMENT D9
FEASIBILITY STUDY COST ESTIMATE BACK-UP
FORMER DRUM DISPOSAL AREA

FDDA-5: Excavation, treatment and/or disposal of soil with groundwater extraction and ex-situ treatment for area-wide contaminant reduction

PERIODIC COSTS

	YEAR	QTY	UNIT	UNIT COST	TOTAL	PRESENT VALUE (7%)	NOTES
Five Year Site Reviews	5, 10, 15, 20, 25	5	LS	$ 20,000	$ 100,000	$ 41,000	$60K/ 3 alternatives (LF, FDDA, DGGW)
Groundwater Performance and Optimization Study	10	1	LS	$ 30,000	$ 30,000	$ 15,000	
Remedial Action Report	3	1	LS	$ 30,000	$ 30,000	$ 24,000	
Demobilization of on-site treatment system	25	1	LS	$ 150,000	$ 150,000	$ 28,000	
Well Abandonment	25	1	LS	$ 100,000	$ 100,000	$ 18,000	
Update Institutional Controls Plan	25	1	LS	$ 20,000	$ 20,000	$ 4,000	
TOTAL - PRESENT WORTH - O&M COSTS (PV 7%, 30 YRS)					**$ 430,000**	**$ 130,000**	

APPENDIX D
ATTACHMENT D10
FEASIBILITY STUDY COST ESTIMATE SUMMARY GARAGE AND STORAGE AREA

GSA-1: NO ACTION

CAPITAL COSTS

Construction Activities		
Pilot Test	$	-
Mobilization/Demobilization	$	-
Monitoring, Sampling, Testing and Analysis	$	-
Access Restrictions	$	-
Site Work	$	-
SUBTOTAL - CONSTRUCTION ACTIVITIES	$	-
Contingency (10%)	$	-
TOTAL CONSTRUCTION ACTIVITIES	**$**	**-**
Profesional/ Technical Services		
Project Management	$	-
Remedial Design	$	-
Construction Management	$	-
Health and Safety	$	-
Permitting/ Legal	$	-
TOTAL PROFESSIONAL/ TECHNICAL SERVICES	**$**	**-**
Institutional Controls		
TOTAL INSTITUTIONAL CONTROLS	**$**	**-**
TOTAL CAPITAL COSTS	**$**	**-**

ANNUAL OPERATION, MAINTENANCE AND MONITORING COSTS

Annual site-wide inspection	$	3,000
OM&M SUBTOTAL:	$	3,000
Contingency (10%)	$	300
TOTAL - O&M COSTS (ANNUAL)	$	3,300
TOTAL - PRESENT VALUE (7%, 30 Years)	**$**	**41,000**

PERIODIC COSTS - PRESENT VALUE (7%)

Five Year Site Reviews	$	11,000
Groundwater Performance and Optimization Study	$	-
Remedial Action Report	$	-
Demobilization of on-site treatment system	$	-
Well Abandonment	$	-
Update Institutional Controls Plan	$	-
TOTAL PRESENT VALUE - PERIODIC COSTS	**$**	**11,000**

TOTAL PRESENT VALUE	**$**	**52,000**

APPENDIX D
ATTACHMENT D10
FEASIBILITY STUDY COST ESTIMATE BACK-UP
GARAGE AND STORAGE AREA

GSA-1: NO ACTION

OPERATION AND MAINTENANCE COSTS

	QTY	UNIT	UNIT COST	TOTAL	NOTES
Annual site-wide inspection					
Inspection	1	LS	$ 3,000	$ 3,000	
SUBTOTAL:				$ 3,000	
OM&M SUBTOTAL:				$ 3,000	
Contingency (10%)				$ 300	
TOTAL - O&M COSTS (ANNUAL)				**$ 3,300**	
TOTAL - PRESENT VALUE (7%, 30 Years)				**$ 41,000**	

APPENDIX D
ATTACHMENT D10
FEASIBILITY STUDY COST ESTIMATE BACK-UP
GARAGE AND STORAGE AREA

GSA-1: NO ACTION

PERIODIC COSTS

	YEAR	QTY	UNIT	UNIT COST	TOTAL	PRESENT VALUE (7%)	NOTES
Five Year Site Reviews	5, 10, 15, 20, 25,30	6	LS	$ 5,000	$ 30,000	$ 11,000	
Groundwater Performance and Optimization Study					$ -	$ -	Not applicable for this alternative
Remedial Action Report					$ -	$ -	Not applicable for this alternative
Demobilization of on-site treatment system					$ -	$ -	Not applicable for this alternative
Well Abandonment					$ -	$ -	Not applicable for this alternative
Update Institutional Controls Plan					$ -	$ -	Not included in this alternative
TOTAL PERIODIC COSTS					**$ 30,000**	**$ 11,000**	

APPENDIX D
ATTACHMENT D11
FEASIBILITY STUDY COST ESTIMATE SUMMARY - GARAGE AND STORAGE AREA

GSA-2: Excavation and on-site disposal of soil

CAPITAL COSTS

Construction Activities		
Pre-implementation Monitoring, Sampling, Testing and Analysis	$	22,400
Mobilization/Demobilization	$	30,000
Site Prep	$	2,600
Soil Excavation	$	52,000
On-site Disposal	$	13,300
Institutional Controls	$	-
SUBTOTAL - CONSTRUCTION ACTIVITIES - ON-SITE DISPOSAL	$	120,300
Contingency (10%)	$	12,100
TOTAL CONSTRUCTION ACTIVITIES	**$**	**132,400**
Profesional/ Technical Services		
Project Management	$	10,600
Remedial Design	$	19,900
Construction Management	$	13,300
Health and Safety	$	4,000
Permitting/ Legal	$	4,000
TOTAL PROFESSIONAL/ TECHNICAL SERVICES	**$**	**51,800**
TOTAL CAPITAL COSTS	**$**	**184,200**

ANNUAL OPERATION AND MAINTENANCE COSTS

Annual site-wide inspection	$	-
O&M SUBTOTAL:	$	-
Contingency (10%)	$	-
TOTAL - O&M COSTS (ANNUAL)	$	-
TOTAL - PRESENT VALUE	$	-

PERIODIC COSTS - PRESENT VALUE (7%)

Five Year Site Reviews	$	-
Groundwater Performance and Optimization Study	$	-
Remedial Action Report	$	16,000
Demobilization of on-site treatment system	$	-
Well Abandonment	$	-
Update Institutional Controls Plan	$	-
	$	-
TOTAL PRESENT VALUE - PERIODIC COSTS	$	16,000

TOTAL PRESENT VALUE $ 200,200

Note: Costs assume no treatment prior to on-site disposal.

APPENDIX D
ATTACHMENT D11
FEASIBILITY STUDY COST ESTIMATE BACKUP
GARAGE AND STORAGE AREA

GSA-2: Excavation and on-site disposal of soil

CAPITAL COSTS

Assumptions:
- No treatment of soil is required prior to on-site disposal.

Depth of excavation	varying	ft		
Area of excavation	8,150	sq ft		
Volume of excavated soil	530	cy	795	ton

	QTY	UNIT	UNIT COST	TOTAL	NOTES
Construction Activities					
Pre-implementation Monitoring, Sampling, Testing and Analysis					
Install additional monitoring wells				$ -	Not applicable for GSA
Pre-excavation soil sampling	1	LS	$ 22,400	$ 22,400	See backup worksheet
Groundwater sampling and analysis				$ -	Not applicable for GSA
SUBTOTAL:				$ 22,400	
Mobilization/Demobilization					
Submittals/Implementation Plans	1	LS	$ 5,000	$ 5,000	HASP, etc
Construction Equipment and Facilities	1	LS	$ 10,000	$ 10,000	excavators, loaders, etc.
Temporary Facilities and Utilities	1	LS	$ 10,000	$ 10,000	fence, roads, signs, trailers, restrooms, etc
Survey - excavation limits	1	LS	$ 5,000	$ 5,000	estimate
SUBTOTAL:				$ 30,000	
Site Prep					
Clearing and Grubbing	0.40	ACRE	$ 6,300	$ 2,600	
SUBTOTAL:				$ 2,600	
Soil Excavation					
Erosion Controls	800	LF	$ 9	$ 7,200	haybales and silt fence
Excavation	530	CY	$ 5	$ 2,700	
Waste Characterization	2	EACH	$ 2,500	$ 5,000	1 sample/500 ton
Confirmatory Soil Sampling and Analysis	1	LS	$ 24,200	$ 24,200	See backup worksheet
Backfill - sand/gravel	340	CY	$ 14	$ 4,800	
Backfill - topsoil	190	CY	$ 33	$ 6,300	topsoil, 6" lifts, off-site
Seeding/fertilizer (for restoration)	0.40	ACRE	$ 4,400	$ 1,800	
SUBTOTAL:				$ 52,000	
On-site Disposal					
On-site Transport and Disposal at Southern Lobe	530	CY	$ 25	$ 13,300	
SUBTOTAL:				$ 13,300	
Institutional Controls	0	LS	$ 20,000	$ -	Not applicable for this alternative
SUBTOTAL:				$ -	
SUBTOTAL - CONSTRUCTION ACTIVITIES - ON-SITE DISPOSAL				$ 120,300	
Contingency (10%)				$ 12,100	
TOTAL CONSTRUCTION ACTIVITIES - ON-SITE DISPOSAL				$ 132,400	
Profesional/ Technical Services - ON-SITE DISPOSAL					
Project Management	8%			$ 10,600	per USACE and USEPA, 2000
Remedial Design	15%			$ 19,900	
Construction Management	10%			$ 13,300	
Health and Safety	3%			$ 4,000	
Permitting/ Legal	3%			$ 4,000	
TOTAL PROFESSIONAL/ TECHNICAL SERVICES - ON-SITE DISPOSAL				$ 51,800	
TOTAL - CAPITAL COSTS				**$ 184,200**	

APPENDIX D
ATTACHMENT D11
FEASIBILITY STUDY COST ESTIMATE BACKUP
GARAGE AND STORAGE AREA

GSA-2: Excavation and on-site disposal of soil

PERIODIC COSTS

	YEAR	QTY	UNIT	UNIT COST	TOTAL	PRESENT VALUE (7%)	NOTES
Five Year Site Reviews					$ -	$ -	Not anticipted due to timing of remedial implementation
Groundwater Performance and Optimization Study					$ -	$ -	Not applicable for this alternative
Remedial Action Report	3	1	LS	$ 20,000	$ 20,000	$ 16,000	
Demobilization of on-site treatment system					$ -	$ -	Not applicable for this alternative
Well Abandonment					$ -	$ -	Not applicable for this alternative
Update Institutional Controls Plan					$ -	$ -	Not applicable for this alternative
TOTAL PERIODIC COSTS					**$ 20,000**	**$ 16,000**	

APPENDIX D
ATTACHMENT D12
COST ESTIMATE SUMMARY
DOWNGRADIENT GROUNDWATER

DGGW-1: No Action

CAPITAL COSTS

Construction Activities		
Mobilization/Demobilization	$	-
Pre-implementation Monitoring, Sampling, Testing and Analysis	$	-
Pilot Test	$	-
Site Work	$	-
Groundwater Treatment or Containment	$	-
SUBTOTAL - CONSTRUCTION ACTIVITIES	$	-
Contingency (10%)	$	-
TOTAL CONSTRUCTION ACTIVITIES	**$**	**-**
Profesional/ Technical Services		
Project Management	$	-
Remedial Design	$	-
Construction Management	$	-
Health and Safety	$	-
Permitting/ Legal	$	-
TOTAL PROFESSIONAL/ TECHNICAL SERVICES	$	-
Institutional Controls	$	-
TOTAL INSTITUTIONAL CONTROLS	**$**	**-**
TOTAL CAPITAL COSTS	$	-

ANNUAL OPERATION, MAINTENANCE AND MONITORING COSTS

Performance Monitoring	$	-
Groundwater Treatment	$	-
Annual site-wide inspection	$	3,000
O&M SUBTOTAL:	$	3,000
Contingency (10%)	$	300
TOTAL - O&M COSTS (ANNUAL)	$	3,300
TOTAL - PRESENT VALUE (7%, 30 Years)	$	40,900

PERIODIC COSTS - PRESENT VALUE (7%)

Five Year Site Reviews	$	43,000
Groundwater Performance and Optimization Study	$	-
Remedial Action Report	$	-
Demobilization of on-site treatment system	$	-
Well Abandonment	$	-
Update Instiutional Controls Plan	$	-
	$	-
TOTAL PRESENT VALUE PERIODIC COSTS	$	43,000

TOTAL PRESENT VALUE (30 YEARS)	**$**	**83,900**

APPENDIX D
ATTACHMENT D12
FEASIBILITY STUDY COST ESTIMATE BACK-UP
DOWNGRADIENT GROUNDWATER

DGGW-1: No Action

OPERATION AND MAINTENANCE COSTS

	QTY	UNIT	UNIT COST	TOTAL	NOTES
Performance Monitoring					
Groundwater - treatment system				$ -	Not applicable for this alternative
Groundwater - site wide				$ -	Not applicable for this alternative
SUBTOTAL:				$ -	
Groundwater Treatment					
Operations Labor				$ -	Not applicable for this alternative
Maintenance Labor				$ -	Not applicable for this alternative
Equipment Repair/replacement				$ -	Not applicable for this alternative
Utilities				$ -	Not applicable for this alternative
				$ -	
SUBTOTAL:				$ -	
Annual site-wide inspection					
Inspection	1	LS	$ 3,000	$ 3,000	
SUBTOTAL:				$ 3,000	
O&M SUBTOTAL:				$ 3,000	
Contingency (10%)				$ 300	
TOTAL - O&M COSTS (ANNUAL)				**$ 3,300**	
TOTAL - PRESENT VALUE (7%, 30 Years)				**$ 40,900**	

APPENDIX D
ATTACHMENT D12
FEASIBILITY STUDY COST ESTIMATE BACK-UP
DOWNGRADIENT GROUNDWATER

DGGW-1: No Action

PERIODIC COSTS

	YEAR	QTY	UNIT	UNIT COST	TOTAL	PRESENT VALUE (7%)	NOTES
Five Year Site Reviews	30	6	LS	$ 20,000	$ 120,000	$ 43,000	$60K/ 3 alternatives (LF, FDDA, DGGW)
Groundwater Performance and Optimization Study					$ -		Not applicable for this alternative
Remedial Action Report					$ -		Not applicable for this alternative
Demobilization of on-site treatment system					$ -		Not applicable for this alternative
Well Abandonment					$ -		Not applicable for this alternative
Update Instiutional Controls Plan					$ -		Not included in this alternative
					$ -		
TOTAL PERIODIC COSTS					**$ 120,000**	**$ 43,000**	

APPENDIX D
ATTACHMENT D13
FEASIBILITY STUDY COST ESTIMATE SUMMARY - DOWNGRADIENT GROUNDWATER

DGGW-2: In-situ Remediation *(Assumes 30 years of MNA)*

CAPITAL COSTS

Construction Activities		
Mobilization/Demobilization	$	42,500
In-situ groundwater treatment - MNA	$	88,500
Institutional Controls	$	20,000
SUBTOTAL - CONSTRUCTION ACTIVITIES	$	151,000
Contingency (10%)	$	15,100
TOTAL CONSTRUCTION ACTIVITIES	**$**	**166,100**
Profesional/ Technical Services		
Project Management	$	12,100
Remedial Design	$	22,700
Construction Management	$	15,100
Health and Safety	$	4,600
Permitting/ Legal	$	4,600
TOTAL PROFESSIONAL/ TECHNICAL SERVICES	**$**	**59,100**
TOTAL CAPITAL COSTS	**$**	**225,200**

ANNUAL OPERATION, MAINTENANCE AND MONITORING COSTS

Groundwater Treatment - MNA	$	98,800
Annual site-wide inspection	$	3,000
O&M SUBTOTAL:	$	101,800
Contingency (10%)	$	10,200
TOTAL - O&M COSTS (ANNUAL)	$	112,000
TOTAL - PRESENT VALUE - 30 YEARS, 7%	**$**	**1,389,900**
		(30 YR)

PERIODIC COSTS - PRESENT VALUE (7%)

Five Year Site Reviews	$	43,000
Groundwater Performance and Optimization Study	$	38,000
Remedial Action Report	$	26,000
Demobilization of on-site treatment system	$	-
Well Abandonment	$	7,000
Update Institutional Controls Plan	$	3,000
TOTAL PRESENT VALUE - PERIODIC COSTS	**$**	**117,000**

TOTAL PRESENT VALUE $ 1,732,100

APPENDIX D
ATTACHMENT D13
FEASIBILITY STUDY COST ESTIMATE BACK-UP
DOWNGRADIENT GROUNDWATER

DGGW-2: In-situ Remediation (Assumes 30 years of MNA)

CAPITAL COSTS

	QTY	UNIT	UNIT COST	TOTAL	NOTES
Construction Activities					
Mobilization/Demobilization				$ 20,000	
Submittals/Implementation Plans	1	LS	$ 15,000	$ 15,000	QAPP, HASP, etc
Temporary Facilities and Utilities				$ -	Not required for this alternative
Survey - new well locations	1	LS	$ 7,500	$ 7,500	
SUBTOTAL:				$ 42,500	
In-situ groundwater treatment - MNA					
Installation of additional monioring wells	1	LS	$ 88,500	$ 88,500	
SUBTOTAL:				$ 88,500	
Institutional Controls	1	LS	$ 20,000	$ 20,000	
SUBTOTAL:				$ 20,000	
SUBTOTAL - CONSTRUCTION ACTIVITIES - MNA				$ 151,000	
Contingency (10%)				$ 15,100	
TOTAL CONSTRUCTION ACTIVITIES				$ 166,100	
Profesional/ Technical Services					
Project Management	8%			$ 12,100	per USACE and USEPA, 2000
Remedial Design	15%			$ 22,700	
Construction Management	10%			$ 15,100	
Health and Safety	3%			$ 4,600	
Permitting/ Legal	3%			$ 4,600	
TOTAL PROFESSIONAL/ TECHNICAL SERVICES				$ 59,100	
TOTAL - CAPITAL COSTS				**$ 225,200**	

APPENDIX D
ATTACHMENT D13
FEASIBILITY STUDY COST ESTIMATE BACK-UP
DOWNGRADIENT GROUNDWATER

DGGW-2: In-situ Remediation (Assumes 30 years of MNA)

OPERATION AND MAINTENANCE COSTS

	QTY	UNIT	UNIT COST	TOTAL	NOTES
Groundwater Treatment - MNA					
Monitored Natural Attenuation	1	LS	$ 98,800	$ 98,800	
SUBTOTAL:				$ 98,800	
Annual site-wide inspection					
Inspection	1	LS	$ 3,000	$ 3,000	
SUBTOTAL:				$ 3,000	
O&M SUBTOTAL:				$ 101,800	
Contingency (10%)				$ 10,200	
TOTAL - O&M COSTS (ANNUAL)				**$ 112,000**	
TOTAL - PRESENT VALUE - 30 YEARS, 7%				**$ 1,389,900**	

APPENDIX D
ATTACHMENT D13
FEASIBILITY STUDY COST ESTIMATE BACK-UP
DOWNGRADIENT GROUNDWATER

DGGW-2: In-situ Remediation (Assumes 30 years of MNA)

PERIODIC COSTS

	YEAR	QTY	UNIT	UNIT COST	TOTAL	PRESENT VALUE (7%)	NOTES
Five Year Site Reviews	5, 10, 15, 20, 25,30	6	LS	$ 20,000	$ 120,000	$ 43,000	
Groundwater Performance and Optimization Study	10 and 20	2	LS	$ 25,000	$ 50,000	$ 38,000	
Remedial Action Report	2	1	LS	$ 30,000	$ 30,000	$ 26,000	
Demobilization of on-site treatment system					$ -	$ -	Not applicable for this alternative.
Well Abandonment	30	1	LS	$ 50,000	$ 50,000	$ 7,000	
Update Institutional Controls Plan	30	1	LS	$ 20,000	$ 20,000	$ 3,000	
TOTAL PERIODIC COSTS					**$ 270,000**	**$ 117,000**	

APPENDIX D
ATTACHMENT D14
FEASIBILITY STUDY COST ESTIMATE SUMMARY
DOWNGRADIENT GROUNDWATER

DGGW-3: Groundwater Containment and Treatment

(Assumes 30 years of groundwater system operation and groundwater monitoring)

CAPITAL COSTS

Construction Activities		
Pilot and Pump Test	$	100,000
Site Prep	$	40,000
Site Work	$	8,100
Groundwater Containment System Installation	$	2,015,900
Institutional Controls	$	20,000
SUBTOTAL - CONSTRUCTION ACTIVITIES	$	2,184,000
Contingency (10%)	$	218,400
TOTAL CONSTRUCTION ACTIVITIES	**$**	**2,402,400**
Profesional/ Technical Services		
Project Management	$	120,200
Remedial Design	$	192,200
Construction Management	$	144,200
Health and Safety	$	36,100
Permitting/ Legal	$	36,100
TOTAL PROFESSIONAL/ TECHNICAL SERVICES	**$**	**528,800**
TOTAL CAPITAL COSTS	**$**	**2,931,200**

ANNUAL OPERATION, MAINTENANCE AND MONITORING COSTS

TOTAL - PRESENT VALUE - O&M COSTS - SURFACE WATER	$	6,806,400	--	
			--	
TOTAL - PRESENT VALUE - O&M COSTS - DISCHARGE TO POTW			$	9,823,000
TOTAL - PRESENT VALUE - O&M COSTS	**$**	**6,806,400**	**--**	**$ 9,823,000**

PERIODIC COSTS - PRESENT VALUE (7%)

Five Year Site Reviews	$	43,000
Groundwater Performance and Optimization Study	$	23,000
Remedial Action Report	$	21,000
Demobilization of on-site treatment system	$	20,000
Well Abandonment	$	20,000
Update Institutional Controls Plan	$	3,000
TOTAL PRESENT VALUE PERIODIC COSTS	$	130,000

TOTAL PRESENT VALUE	**$**	**9,867,600**	**--**	**$ 12,884,200**

APPENDIX D
ATTACHMENT D14
FEASIBILITY STUDY COST ESTIMATE BACK-UP - DOWNGRADIENT GROUNDWATER

DGGW-3: Groundwater Containment and Treatment

CAPITAL COSTS

Assumptions:

No. Recovery Wells	3		20000
Total flow rate	75	gpm	
Area of temporary gravel roadways (and wetland impacts)	5	sq ft	
Depth of fill material for roadway through wetland	4	ft	

	QTY	UNIT	UNIT COST	TOTAL	NOTES
Construction Activities					
Pilot and Pump Test					
Perform groundwater pump test, data analysis	1	LS	$ 50,000	$ 50,000	
Perform groundwater treatment pilot test, data analysis	1	LS	$ 50,000	$ 50,000	
SUBTOTAL:				$ 100,000	
Site Prep					
Submittals/Implementation Plans	1	LS	$ 20,000	$ 20,000	QAPP, HASP, etc
Temporary Facilities and Utilities	1	LS	$ 10,000	$ 10,000	fence, roads, signs, trailers, restrooms, etc
Survey	1	LS	$ 10,000	$ 10,000	
SUBTOTAL:				$ 40,000	
Site Work					
Clearing and Grubbing	1.00	ACRE	$ 6,300	$ 6,300	for access roadways to wells
Construction of gravel roadways - fill material	100	CY	$ 14	$ 1,400	
Construction of gravel roadways - labor and equipment	100	SY	$ 4	$ 400	seeding, vegetative cover
SUBTOTAL:				$ 8,100	
Groundwater Containment System Installation					
Extraction wells with development	3	EACH	$ 25,000	$ 75,000	
Treatment system - bldg	3,200	SQ FT	$ 70	$ 224,000	80' L X 40' W X 20' H
Treatment system - equipment	1	LS	$ 739,900	$ 739,900	
Electrical lines to site - utility pole installation	21	EACH	$ 7,500	$ 157,500	1 pole per 100 feet
Electrical lines to site - run lines from South Street to treat	2,070	LF	$ 50	$ 103,500	
Installation - electrical	15%	(of equip total)	$ 111,000	$ 111,000	
Installation - controls/ instrumentation	15%	(of equip total)	$ 111,000	$ 111,000	
Installation - piping (materials and equipment to install)	30%	(of equip total)	$ 222,000	$ 222,000	includes electrical conduit, extraction and discharge pip
Installation - labor	30%	(of equip total)	$ 222,000	$ 222,000	includes electrical conduit, extraction and discharge pip
System start-up	1	LS	$ 50,000	$ 50,000	
SUBTOTAL:				$ 2,015,900	
Institutional Controls	1	LS	$ 20,000	$ 20,000	
SUBTOTAL:				$ 20,000	
SUBTOTAL - CONSTRUCTION ACTIVITIES				$ 2,184,000	
Contingency (10%)				$ 218,400	
TOTAL CONSTRUCTION ACTIVITIES				$ 2,402,400	
Profesional/ Technical Services					
Project Management	5%			$ 120,200	per USACE and USEPA, 2000
Remedial Design	8%			$ 192,200	
Construction Management	6%			$ 144,200	
Health and Safety	1.5%			$ 36,100	
Permitting/ Legal	1.5%			$ 36,100	
TOTAL PROFESSIONAL/ TECHNICAL SERVICES				$ 528,800	
TOTAL - CAPITAL COSTS				**$ 2,931,200**	

APPENDIX D
ATTACHMENT D14
FEASIBILITY STUDY COST ESTIMATE BACK-UP - DOWNGRADIENT GROUNDWATER

DGGW-3: Groundwater Containment and Treatment

OPERATION AND MAINTENANCE COSTS

	QTY	UNIT	UNIT COST	TOTAL	NOTES
Performance Monitoring and Reporting					
Groundwater - treatment system	1	LS	$ 73,800	$ 73,800	
Groundwater - area wide	5	LS	$ 28,900	$ 144,500	
SUBTOTAL:				$ 218,300	
Groundwater Treatment - OM&M					
Operations Labor	1	LS	$ 100,000	$ 100,000	full time operator with maintenance assistance
Equipment Repair/replacement	1.5%	EQUIP	$ 30,300	$ 30,300	
Utilities (metals treatment and lighting/HVAC)	1	EST	$ 50,000	$ 50,000	
O&M - Chemicals, UV Ox utilities, misc.	1	EST	$ 97,000	$ 97,000	
SUBTOTAL:				$ 277,300	
Annual site-wide inspection					
Inspection	1	LS	$ 3,000	$ 3,000	
SUBTOTAL:				$ 3,000	
O&M SUBTOTAL:				$ 498,600	
Contingency (10%)				$ 49,900	
TOTAL - O&M COSTS (ANNUAL) - DISCHARGE TO SURFACE WATER				**$ 548,500**	
TOTAL - PRESENT VALUE - O&M COSTS - SURFACE WATER				**$ 6,806,400**	
Discharge to POTW					
Discharge fees	39,420	1000/gal	$ 5.60	$ 221,000	
SUBTOTAL:				$ 221,000	
O&M SUBTOTAL:				$ 719,600	
Contingency (10%)				$ 72,000	
TOTAL - O&M COSTS (ANNUAL) - DISCHARGE TO POTW				**$ 791,600**	
TOTAL - PRESENT VALUE - O&M COSTS - DISCHARGE TO POTW				**$ 9,823,000**	

APPENDIX D
ATTACHMENT D14
FEASIBILITY STUDY COST ESTIMATE BACK-UP - DOWNGRADIENT GROUNDWATER

DGGW-3: Groundwater Containment and Treatment

PERIODIC COSTS

	YEAR	QTY	UNIT	UNIT COST	TOTAL	PRESENT VALUE (7%)	NOTES
Five Year Site Reviews	5, 10, 15, 20, 25, 30	6	LS	$ 20,000	$ 120,000	$ 43,000	$60K/ 3 alternatives (LF, FDDA, DGGW)
Groundwater Performance and Optimization Study	10 and 20	1	LS	$ 30,000	$ 30,000	$ 23,000	
Remedial Action Report	5	1	LS	$ 30,000	$ 30,000	$ 21,000	
Demobilization of on-site treatment system	30	1	LS	$ 150,000	$ 150,000	$ 20,000	
Well Abandonment	30	1	LS	$ 150,000	$ 150,000	$ 20,000	
Update Institutional Controls Plan	30	1	LS	$ 20,000	$ 20,000	$ 3,000	
TOTAL PERIODIC COSTS					**$ 500,000**	**$ 130,000**	

APPENDIX D
ATTACHMENT D15
FEASIBILITY STUDY COST ESTIMATE SUMMARY - DOWNGRADIENT GROUNDWATER

DGGW-4: Groundwater extraction and ex-situ treatment for area-wide contaminant reduction

(Assumes 30 years of groundwater system operation and 30 years of groundwater monitoring)

CAPITAL COSTS

Construction Activities		
Pilot and Pump Test	$	100,000
Site Prep	$	45,000
Site Work	$	103,300
Groundwater Containment System Installation	$	3,073,900
Institutional Controls	$	20,000
SUBTOTAL - CONSTRUCTION ACTIVITIES	$	3,342,200
Contingency (10%)	$	334,300
TOTAL CONSTRUCTION ACTIVITIES	**$**	**3,676,500**
Profesional/ Technical Services		
Project Management	$	184,000
Remedial Design	$	295,000
Construction Management	$	221,000
Health and Safety	$	56,000
Permitting/ Legal	$	56,000
TOTAL PROFESSIONAL/ TECHNICAL SERVICES	**$**	**812,000**
TOTAL CAPITAL COSTS	**$**	**4,488,500**

ANNUAL OPERATION, MAINTENANCE AND MONITORING COSTS

TOTAL - PRESENT VALUE - O&M COSTS (7%)				
SURFACE WATER DISCHARGE	$6,528,000	--		
POTW DISCHARGE	$ -	--	$	12,166,000
TOTAL - PRESENT VALUE - O&M COSTS (7%)	**$ 6,528,000**	**--**	**$**	**12,166,000**

O&M Range incorporates: Low - discharge to surface water and High: discharge to POTW

PERIODIC COSTS - PRESENT VALUE (7%)

Five Year Site Reviews	$	43,000
Groundwater Performance and Optimization Study	$	23,000
Remedial Action Report	$	21,000
Demobilization of on-site treatment system	$	20,000
Well Abandonment	$	20,000
Update Institutional Controls Plan	$	3,000
TOTAL PRESENT VALUE PERIODIC COSTS	**$**	**130,000**

TOTAL PRESENT VALUE	**$ 11,146,500**	**--**	**$ 16,784,500**

APPENDIX D
ATTACHMENT D15
FEASIBILITY STUDY COST ESTIMATE BACK-UP
DOWNGRADIENT GROUNDWATER

DGGW-4: Groundwater extraction and ex-situ treatment for area-wide contaminant reduction

CAPITAL COSTS

Assumptions:

No. Recovery Wells	14		
Total flow rate	140	gpm	20000
Area of gravel roadways (and wetland impacts)	38,000	sq ft	
Depth of fill material for roadway through wetland	4	ft	

	QTY	UNIT	UNIT COST	TOTAL	NOTES
Construction Activities					
Pilot and Pump Test					
Perform groundwater pump test, data analysis	1	LS	$ 50,000	$ 50,000	
Perform groundwater treatment pilot test, data analysis	1	LS	$ 50,000	$ 50,000	
SUBTOTAL:				$ 100,000	
Site Prep					
Submittals/Implementation Plans	1	LS	$ 20,000	$ 20,000	QAPP, HASP, etc
Temporary Facilities and Utilities	1	LS	$ 10,000	$ 10,000	fence, roads, signs, trailers, restrooms, etc
Survey	1	LS	$ 15,000	$ 15,000	
SUBTOTAL:				$ 45,000	
Site Work					
Clearing and Grubbing	1.00	ACRE	$ 6,300	$ 6,300	for access roadways to wells
Construction of gravel roadways - fill material	5,700	CY	$ 14	$ 79,800	
Construction of gravel roadways - labor and equipment	4,300	SY	$ 4	$ 17,200	seeding, vegetative cover
SUBTOTAL:				$ 103,300	
Groundwater Containment System Installation					
Extraction wells with development	14	EACH	$ 25,000	$ 350,000	
Treatment system - bldg	3,200	SQ FT	$ 70	$ 224,000	80' L X 40' W X 20' H
Treatment system - equipment	1	LS	$ 1,138,700	$ 1,138,700	
Electrical lines to site - utility pole installation	21	EACH	$ 7,500	$ 157,500	1 pole per 100 feet
Electrical lines to site - run lines from South Street to treatm	2,070	LF	$ 50	$ 103,500	
Installation - electrical	15%	(of equip total)	$ 170,900	$ 170,900	
Installation - controls/ instrumentation	15%	(of equip total)	$ 170,900	$ 170,900	
Installation - piping (materials and equipment to install)	30%	(of equip total)	$ 341,700	$ 341,700	includes electrical conduit, extraction and discharge piping
Installation - labor	30%	(of equip total)	$ 341,700	$ 341,700	includes electrical conduit, extraction and discharge piping
System start-up	1	LS	$ 75,000	$ 75,000	
SUBTOTAL:				$ 3,073,900	
Institutional Controls	1	LS	$ 20,000	$ 20,000	
SUBTOTAL:				$ 20,000	
SUBTOTAL - CONSTRUCTION ACTIVITIES				$ 3,342,200	
Contingency (10%)				$ 334,300	
TOTAL CONSTRUCTION ACTIVITIES				$ 3,676,500	
Profesional/ Technical Services					
Project Management	5%			$ 184,000	per USACE and USEPA, 2000
Remedial Design	8%			$ 295,000	
Construction Management	6%			$ 221,000	
Health and Safety	1.5%			$ 56,000	
Permitting/ Legal	1.5%			$ 56,000	
TOTAL PROFESSIONAL/ TECHNICAL SERVICES				$ 812,000	
TOTAL - CAPITAL COSTS				**$ 4,488,500**	

APPENDIX D
ATTACHMENT D15
FEASIBILITY STUDY COST ESTIMATE BACK-UP
DOWNGRADIENT GROUNDWATER

DGGW-4: Groundwater extraction and ex-situ treatment for area-wide contaminant reduction

OPERATION AND MAINTENANCE COSTS

	QTY	UNIT	UNIT COST	TOTAL	NOTES
Performance Monitoring and Reporting					
Groundwater - treatment system	1	LS	$ 73,800	$ 73,800	
Groundwater - area wide	1	LS	$ 28,900	$ 28,900	
SUBTOTAL:				$ 102,700	
Groundwater Treatment - OM&M					
Operations Labor	1	LS	$ 150,000	$ 150,000	One full time and one part time operator with maintenance assistance
Equipment Repair/replacement	1.5%	EQUIP	$ 50,200	$ 50,200	
Utilities (metals treatment and lighting/HVAC)	1	EST	$ 50,000	$ 50,000	
O&M - Chemicals, UV Ox utilities, misc.	1	EST	$ 122,300	$ 122,300	
SUBTOTAL:				$ 372,500	
Annual site-wide inspection					
Inspection	1	LS	$ 3,000	$ 3,000	
SUBTOTAL:				$ 3,000	
Discharge to POTW					
Discharge fees	73,584	1000/gal	$ 5.60	$ 413,000	
SUBTOTAL:				$ 413,000	
O&M - TREATMENT SYSTEM - SUBTOTAL:		$ 446,300	to	$ 859,300	includes trtmt system performance monitoring and O&M of system
Contingency (10%)		$ 44,700	to	$ 86,000	
GROUNDWATER MONITORING SUBTOTAL:		$ 31,900	to	$ 31,900	includes site inspections and area-wide gw monitoring
Contingency (10%)		$ 3,200	to	$ 3,200	
TOTAL - O&M COSTS - TREATMENT SYSTEM (ANNUAL)		**$ 491,000**	**to**	**$ 945,300**	
TOTAL - GROUNDWATER MONITORING COSTS (ANNUAL)		**$ 35,100**	**to**	**$ 35,100**	
TOTAL - PRESENT VALUE - O&M COSTS (7%)		**$6,528,000**	**to**	**$ 12,166,000**	30 YEARS

Range incorporates: Low - discharge to surface water and High - discharge to POTW

APPENDIX D
ATTACHMENT D15
FEASIBILITY STUDY COST ESTIMATE BACK-UP
DOWNGRADIENT GROUNDWATER

DGGW-4: Groundwater extraction and ex-situ treatment for area-wide contaminant reduction

PERIODIC COSTS

	YEAR	QTY	UNIT	UNIT COST	TOTAL	PRESENT VALUE (7%)	NOTES
Five Year Site Reviews	5, 10, 15, 20, 25, 30	6	LS	$ 20,000	$ 120,000	$ 43,000	$60K/ 3 alternatives (LF, FDDA, DGGW)
Groundwater Performance and Optimization Study	10 and 20	1	LS	$ 30,000	$ 30,000	$ 23,000	
Remedial Action Report	5	1	LS	$ 30,000	$ 30,000	$ 21,000	
Demobilization of on-site treatment system	30	1	LS	$ 150,000	$ 150,000	$ 20,000	
Well Abandonment	30	1	LS	$ 150,000	$ 150,000	$ 20,000	
Update Institutional Controls Plan	30	1	LS	$ 20,000	$ 20,000	$ 3,000	
TOTAL PERIODIC COSTS					**$ 500,000**	**$ 130,000**	

APPENDIX E: REMEDIAL ALTERNATIVE COMPLIANCE WITH ARARS

APPENDIX E
TABLE E-1
ACTIONS TAKEN TO COMPLY WITH ARARs and TBCs - LANDFILL LOBES

	ARAR	Status	LF-1	LF-2	LF-3	LF-4
CHEMICAL SPECIFIC						
GROUNDWATER	**Federal Regulatory Requirements**					
	Federal Safe Drinking Water Act (SDWA) Maximum Contaminant Levels (MCLs) (40 CFR Part 141.11-141.16)	Relevant and appropriate	- This alternative will not meet the PRGs established and therefore not comply with this ARAR.	MCLs were used in determining groundwater preliminary remediation goals (PRGs) for site contaminants where such contaminant levels have been established. Under this alternative, the groundwater approach will over time prevent groundwater exceeding MCLs from migrating beyond the point of compliance.	MCLs were used in determining groundwater preliminary remediation goals (PRGs) for site contaminants where such contaminant levels have been established. Under this alternative, the groundwater approach will over time prevent groundwater exceeding MCLs from migrating beyond the point of compliance.	MCLs were used in determining groundwater preliminary remediation goals (PRGs) for site contaminants where such contaminant levels have been established. Under this alternative, the groundwater approach will over time prevent groundwater exceeding MCLs from migrating beyond the point of compliance.
	SDWA Maximum Contaminant Level Goals (MCLGs) (40 CFR Part 141.50-141.51)	Relevant and appropriate	- This alternative will not meet the PRGs established and therefore not comply with this ARAR.	Non-zero MCLGs were used in determining PRGs when MCLs have not been established for a particular contaminant. Under this alternative, the groundwater approach will over time prevent groundwater exceeding MCLGs from migrating beyond the point of compliance.	Non-zero MCLGs were used in determining PRGs when MCLs have not been established for a particular contaminant. Under this alternative, the groundwater approach will over time prevent groundwater exceeding MCLGs from migrating beyond the point of compliance.	Non-zero MCLGs were used in determining PRGs when MCLs have not been established for a particular contaminant. Under this alternative, the groundwater approach will over time prevent groundwater exceeding MCLGs from migrating beyond the point of compliance.
	EPA Risk Reference Doses (RfDs)	To be considered	- This alternative will not meet the PRGs established and therefore not comply with this TBC	RfDs were used to assess health risks due to exposure to non-carcinogenic chemicals in groundwater, and to develop acceptable groundwater PRG concentrations. Under this alternative, the groundwater approach will over time prevent groundwater exceeding PRGs from migrating beyond the point of compliance.	RfDs were used to assess health risks due to exposure to non-carcinogenic chemicals in groundwater, and to develop acceptable groundwater PRG concentrations. Under this alternative, the groundwater approach will over time prevent groundwater exceeding PRGs from migrating beyond the point of compliance.	RfDs were used to assess health risks due to exposure to non-carcinogenic chemicals in groundwater, and to develop acceptable groundwater PRG concentrations. Under this alternative, the groundwater approach will over time prevent groundwater exceeding PRGs from migrating beyond the point of compliance.
	EPA Human Health Assessment Cancer Slope Factors (CSFs)	To be considered	- This alternative will not meet the PRGs established and therefore not comply with this TBC	CSFs were used to compute the individual cancer risk resulting from exposure to contaminants and in the development of acceptable groundwater PRG concentrations. Under this alternative, the groundwater approach will over time prevent groundwater exceeding PRGs from migrating beyond the point of compliance.	CSFs were used to compute the individual cancer risk resulting from exposure to contaminants and in the development of acceptable groundwater PRG concentrations. Under this alternative, the groundwater approach will over time prevent groundwater exceeding PRGs from migrating beyond the point of compliance.	CSFs were used to compute the individual cancer risk resulting from exposure to contaminants and in the development of acceptable groundwater PRG concentrations. Under this alternative, the groundwater approach will over time prevent groundwater exceeding PRGs from migrating beyond the point of compliance.
	Guidelines for Carcinogen Risk Assessment (EPA/630/P-03/001F, March 2005)	To be considered	- This alternative will not meet the PRGs established and therefore not comply with this TBC	Potential cancer risks identified will be addressed by this alternative.	Potential cancer risks identified will be addressed by this alternative.	Potential cancer risks identified will be addressed by this alternative.
	Supplemental Guidance for Assessing Susceptibility from Early-Life Exposure to Carcinogens (EPA/630/R-03/003F, March 2005)	To be considered	- This alternative will not meet the PRGs established and therefore not comply with this TBC	Potential child cancer risks identified will be addressed by this alternative.	Potential child cancer risks identified will be addressed by this alternative.	Potential child cancer risks identified will be addressed by this alternative.

APPENDIX E
TABLE E-1
ACTIONS TAKEN TO COMPLY WITH ARARs and TBCs - LANDFILL LOBES

	ARAR	Status	LF-1	LF-2	LF-3	LF-4
GROUNDWATER	**State Regulatory Requirements**					
	Massachusetts Groundwater Quality Standards (314 CMR 6.00)	Relevant and appropriate	- This alternative will not meet the PRGs established and therefore not comply with this ARAR.	Groundwater beneath the site is mapped in a potentially productive aquifer with the potential for potable water use. Under this alternative, the groundwater approach will over time prevent groundwater exceeding PRGs from migrating beyond the point of compliance.	Groundwater beneath the site is mapped in a potentially productive aquifer with the potential for potable water use. Under this alternative, the groundwater approach will over time prevent groundwater exceeding PRGs from migrating beyond the point of compliance.	Groundwater beneath the site is mapped in a potentially productive aquifer with the potential for potable water use. Under this alternative, the groundwater approach will over time prevent groundwater exceeding PRGs from migrating beyond the point of compliance.
	Massachusetts Drinking Water Standards (310 CMR 22.00)	Relevant and appropriate	- This alternative will not meet the PRGs established and therefore not comply with this ARAR.	Under this alternative, the groundwater approach will over time prevent groundwater exceeding PRGs from migrating beyond the point of compliance.	Under this alternative, the groundwater approach will over time prevent groundwater exceeding PRGs from migrating beyond the point of compliance.	Under this alternative, the groundwater approach will over time prevent groundwater exceeding PRGs from migrating beyond the point of compliance.
	Massachusetts Contingency Plan (310 CMR 40.0000), Method 1 Standards	Relevant and appropriate	- This alternative will not meet the PRGs established and therefore not comply with this ARAR.	Under this alternative, the groundwater approach will over time prevent groundwater exceeding PRGs from migrating beyond the point of compliance.	Under this alternative, the groundwater approach will over time prevent groundwater exceeding PRGs from migrating beyond the point of compliance.	Under this alternative, the groundwater approach will over time prevent groundwater exceeding PRGs from migrating beyond the point of compliance.
	Massachusetts Office of Research and Standards Guidelines (ORSG)	To be considered	- This alternative will not meet the PRGs established and therefore not comply with this TBC.	Under this alternative, the groundwater approach will over time prevent groundwater exceeding PRGs from migrating beyond the point of compliance.	Under this alternative, the groundwater approach will over time prevent groundwater exceeding PRGs from migrating beyond the point of compliance.	Under this alternative, the groundwater approach will over time prevent groundwater exceeding PRGs from migrating beyond the point of compliance.
SEDIMENT/SOIL	**State Regulatory Requirements**					
	Massachusetts Contingency Plan (310 CMR 40.0000), Method 1 Standards	Relevant and appropriate	- This alternative will not meet the PRGs established and therefore not comply with this ARAR.	- Under this alternative, soils will not be excavated and disposed of due to exceedances of PRGs; therefore this ARAR is not specific to this alternative. Sediments will be excavated to meet site-specific human health and ecological derived PRGs.	- Under this alternative, soils will not be excavated and disposed of due to exceedances of PRGs; therefore this ARAR is not specific to this alternative. Sediments will be excavated to meet site-specific human health and ecological derived PRGs.	- Under this alternative, soils will not be excavated and disposed of due to exceedances of PRGs; therefore this ARAR is not specific to this alternative. Sediments will be excavated to meet site-specific human health and ecological derived PRGs.
SURFACE WATER	**Federal Regulatory Requirements**					
	Clean Water Act (CWA) Ambient Water Quality Criteria (AWQC) (33 USC 1251 *et seq*.)	To be considered	- This alternative will not meet the PRGs established and therefore not comply with this TBC.	- Surface water PRGs will be met over time, and therefore comply with this ARAR. - If groundwater extraction and ex-situ treatment is implemented and discharge of treated groundwater to surface water is the selected discharge method, then this alternative can be designed and implemented to meet these criteria. Surface water monitoring would be performed. These standards would be used to help assess the effectiveness of the groundwater treatment.	- Surface water PRGs will be met over time, and therefore comply with this ARAR. - If groundwater extraction and ex-situ treatment with discharge of treated groundwater to surface water is the selected discharge method, then this alternative can be designed and implemented to meet these criteria. Surface water monitoring would be performed. These standards would be used to help assess the effectiveness of the groundwater treatment.	- Surface water PRGs will be met over time, and therefore comply with this ARAR. - If groundwater extraction and ex-situ treatment with discharge of treated groundwater to surface water is the selected discharge method, then this alternative can be designed and implemented to meet these criteria. Surface water monitoring would be performed. These standards would be used to help assess the effectiveness of the groundwater treatment.

APPENDIX E
TABLE E-1
ACTIONS TAKEN TO COMPLY WITH ARARs and TBCs - LANDFILL LOBES

	ARAR	Status	LF-1	LF-2	LF-3	LF-4
LOCATION SPECIFIC						
SURFACE WATER/ WETLANDS/ FLOODPLAINS	**Federal Regulatory Requirements**					
	Wetlands Executive Order (EO11990), 40 CFR Part 6, Appendix A	Applicable	- This ARAR is not specific to this alternative.	Under this alternative, the installation of the landfill cover would result in the unavoidable destruction of existing wetlands, although during remedial design the effects of remedial activities on the wetlands will be evaluated and minimized. Compensatory wetlands mitigation would be performed as necessary to comply with this ARAR.	Under this alternative, the installation of the landfill cover would result in the unavoidable destruction of existing wetlands, although during remedial design the effects of remedial activities on the wetlands will be evaluated and minimized. Compensatory wetlands mitigation would be performed as necessary to comply with this ARAR.	- This alternative may not meet substantial compliance with this ARAR due to the amount of resource area required to be replicated on-site and dependent on the other alternatives selected. However, should the necessary area for wetland replication be available on-site, this alternative will also need to demonstrate that no other practical alternative exists with less resource area impacts. Both alternatives, LF-2 and LF-3, present viable options that are less damaging to the on-site resource areas. Therefore, it is unlikely that this alternative will comply with this ARAR.
	Clean Water Act Section 404 Dredge and Fill Regulations (40 CFR 230, 33 CFR 320-323)	Applicable	- This ARAR is not specific to this alternative.	Under this alternative, the installation of the landfill cover would result in the unavoidable destruction of existing wetlands, although during remedial design the effects of remedial activities on the wetlands will be evaluated and minimized. Compensatory wetlands mitigation would be performed as necessary to comply with this ARAR. In addition, brook sediment excavation would be unavoidable in order to remediate contaminated sediments. Under this alternative, the brook will be restored with clean sediments.	Under this alternative, the installation of the landfill cover would result in the unavoidable destruction of existing wetlands, although during remedial design the effects of remedial activities on the wetlands will be evaluated and minimized. Compensatory wetlands mitigation would be performed as necessary to comply with this ARAR. In addition, brook sediment excavation would be unavoidable in order to remediate contaminated sediments. Under this alternative, the brook will be restored with clean sediments.	- This alternative may not meet substantial compliance with this ARAR due to the amount of resource area required to be replicated on-site and dependent on the other alternatives selected. However, should the necessary area for wetland replication be available on-site, this alternative will also need to demonstrate that no other practical alternative exists with less resource area impacts. Both alternatives, LF-2 and LF-3, present viable options that are less damaging to the on-site resource areas. Therefore, it is unlikely that this alternative will comply with this ARAR.
	Rivers and Harbors Act Section 10 (33 USC 403, 33 CFR 320-323)	Applicable	- This ARAR is not specific to this alternative.	Under this alternative, the installation of the landfill cover would result in the unavoidable destruction of existing wetlands, although during remedial design the effects of remedial activities on the wetlands will be evaluated and minimized. Compensatory wetlands mitigation would be performed as necessary to comply with this ARAR. In addition, brook sediment excavation would be unavoidable in order to remediate contaminated sediments. Under this alternative, the brook sediments will be restored with clean sediments.	Under this alternative, the installation of the landfill cover would result in the unavoidable destruction of existing wetlands, although during remedial design the effects of remedial activities on the wetlands will be evaluated and minimized. Compensatory wetlands mitigation would be performed as necessary to comply with this ARAR. In addition, brook sediment excavation would be unavoidable in order to remediate contaminated sediments. Under this alternative, the brook will be restored with clean sediments.	- This alternative may not meet substantial compliance with this ARAR due to the amount of resource area required to be replicated on-site and dependent on the other alternatives selected. However, should the necessary area for wetland replication be available on-site, this alternative will also need to demonstrate that no other practical alternative exists with less resource area impacts. Both alternatives, LF-2 and LF-3, present viable options that are less damaging to the on-site resource areas. Therefore, it is unlikely that this alternative will comply with this ARAR.
	Floodplains Executive Order (EO11988), 40 CFR Part 6, Appendix A	Applicable	- This ARAR is not specific to this alternative.	Available practicable means will be used to reduce the risk of flood loss, to minimize the impact of floods and to restore and preserve the floodplains. In areas where the landfill cover will result in the filling in of areas within the 100-year floodplain, there will be a replication of 100-year floodplain space equivalent to the amount loss by the final cover . Stormwater management basins will also be designed to minimize the impact of floods.	Available practicable means will be used to reduce the risk of flood loss, to minimize the impact of floods and to restore and preserve the floodplains. In areas where the landfill cover will result in the filling in of areas within the 100-year floodplain, there will be a replication of 100-year floodplain space equivalent to the amount loss by the final cover . Stormwater management basins will also be designed to minimize the impact of floods.	- Although this alternative may present potential design complications to recreate the flood plain, with the increase in length of the brook it is anticipated that this alternative can be designed and implemented to comply with this ARAR.

APPENDIX E
TABLE E-1
ACTIONS TAKEN TO COMPLY WITH ARARs and TBCs - LANDFILL LOBES

	ARAR	Status	LF-1	LF-2	LF-3	LF-4
SURFACE WATER/ WETLANDS/ FLOODPLAINS	RCRA Floodplain Restrictions for Hazardous Waste Facilities (40 CFR 264.18(b))	Relevant and Appropriate	- This ARAR is not specific to this alternative.	Available practicable means will be used to reduce the risk of flood loss, to minimize the impact of floods and to restore and preserve the floodplains. In areas where the landfill cover will result in the filling in of areas within the 100-year floodplain, there will be a replication of 100-year floodplain space equivalent to the amount loss by the final cover . Stormwater management basins will also be designed to minimize the impact of floods.	Available practicable means will be used to reduce the risk of flood loss, to minimize the impact of floods and to restore and preserve the floodplains. In areas where the landfill cover will result in the filling in of areas within the 100-year floodplain, there will be a replication of 100-year floodplain space equivalent to the amount loss by the final cover . Stormwater management basins will also be designed to minimize the impact of floods.	- Although this alternative may present potential design complications to recreate the flood plain, with the increase in length of the brook it is anticipated that this alternative can be designed and implemented to comply with this ARAR.
	Fish and Wildlife Coordination Act (16 USC 661 et seq, 40 CFR Part 6)	Applicable	- This ARAR is not specific to this alternative.	Since this alternative requires modification of a water body, this consultation requirement will be conducted.	Since this alternative requires modification of a water body, this consultation requirement will be conducted.	Since this alternative requires modification of a water body, this consultation requirement will be conducted.
	State Regulatory Requirements					
	Massachusetts Wetlands Regulations (310 CMR 10.00, MGL c. 131, Section 40: Wetlands Protection Act)	Applicable	- This ARAR is not specific to this alternative.	The installation of the landfill caps and wells will occur in or around wetlands (and their 100 foot buffer zones) and Sutton Brook (and its riverfront area). Sediments in Sutton Brook will be excavated and restored with clean sediments. Because of the contamination in the landfill source areas, there is no practicable alternative to installing an impermeable cap. All practicable means will be used to minimize harm to the wetlands, including erosion and sedimentation controls and stormwater management. Wetlands and sediments disturbed by remedial activities will be mitigated, restored or preserved.	The installation of the landfill caps and wells will occur in or around wetlands (and their 100 foot buffer zones) and Sutton Brook (and its riverfront area). Sediments in Sutton Brook will be excavated and restored with clean sediments. Because of the contamination in the landfill source areas, there is no practicable alternative to installing an impermeable cap. All practicable means will be used to minimize harm to the wetlands, including erosion and sedimentation controls and stormwater management. Wetlands and sediments disturbed by remedial activities will be mitigated, restored or preserved.	- This alternative may not meet substantial compliance with this ARAR due to the amount of resource area required to be replicated on-site and dependent on the other alternatives selected. However, should the necessary area for wetland replication be available on-site, this alternative will also need to demonstrate that no other practical alternative exists with less resource area impacts. Under the Massachusetts Wetlands Protection Act, the project must demonstrate that there is no practicable alternative to the response action being proposed that would be less damaging to the resource areas. Both alternatives, LF-2 and LF-3, present viable options that are less damaging to the on-site resource areas. Therefore, it is unlikely that this alternative will comply with this ARAR.
	Massachusetts Water Quality Certification for Discharge of Dredged or Fill Material, Dredging, and Dredging Material Disposal in Waters of the U.S. within the Commonwealth (314 CMR 9.00)	Applicable	- This ARAR is not specific to this alternative.	The installation of the landfill caps and monitoring wells will occur in or around wetlands. Sediments in Sutton Brook will be excavated and restored with clean sediments. Because of the contamination in the landfill source areas, there is no practicable alternative to installing an impermeable cap. All practicable means will be used to minimize harm to the wetlands, including erosion and sedimentation controls and stormwater management. Wetlands and sediments disturbed by remedial activities will be mitigated, restored or preserved. There would be no substantial long-term adverse impacts to the integrity of surface waters.	The installation of the landfill caps and monitoring wells will occur in or around wetlands. Sediments in Sutton Brook will be excavated and restored with clean sediments. Because of the contamination in the landfill source areas, there is no practicable alternative to installing an impermeable cap. All practicable means will be used to minimize harm to the wetlands, including erosion and sedimentation controls and stormwater management. Wetlands and sediments disturbed by remedial activities will be mitigated, restored or preserved. There would be no substantial long-term adverse impacts to the integrity of surface waters.	The installation of the landfill caps and monitoring wells will occur in or around wetlands. Sediments in Sutton Brook will be excavated and restored with clean sediments. Because of the contamination in the landfill source areas, there is no practicable alternative to installing an impermeable cap. All practicable means will be used to minimize harm to the wetlands, including erosion and sedimentation controls and stormwater management. Wetlands and sediments disturbed by remedial activities will be mitigated, restored or preserved. There would be no substantial long-term adverse impacts to the integrity of surface waters.

APPENDIX E
TABLE E-1
ACTIONS TAKEN TO COMPLY WITH ARARs and TBCs - LANDFILL LOBES

	ARAR	Status	LF-1	LF-2	LF-3	LF-4
SURFACE WATER/ WETLANDS/ FLOODPLAINS	Massachusetts Waterways Regulations (310 CMR 9.00)	Applicable	- This ARAR is not specific to this alternative.	Actions within flowed and filled tidelands and other waterways at the Site will comply with the regulation's environmental standards.	Actions within flowed and filled tidelands and other waterways at the Site will comply with the regulation's environmental standards.	Actions within flowed and filled tidelands and other waterways at the Site will comply with the regulation's environmental standards.
	Massachusetts Hazardous Waste Rules, Facility Location Standards (310 CMR 30.700)	Applicable	- This ARAR is not specific to this alternative.	Any remedial structures, including the landfills, within Land Subject to Flooding and potential public water supply area, will be designed, constructed, operated, and maintained to prevent a release of hazardous waste within the protected resource area.	Any remedial structures, including the landfills, within Land Subject to Flooding and potential public water supply area, will be designed, constructed, operated, and maintained to prevent a release of hazardous waste within the protected resource area.	Any remedial structures, including the landfills, within Land Subject to Flooding and potential public water supply area, will be designed, constructed, operated, and maintained to prevent a release of hazardous waste within the protected resource area.
OTHER NATURAL RESOURCES	**Federal Regulatory Requirements**					
	Endangered Species Act (16 USC 1531 et seq.; 40 CFR 6.302(h); 50 CFR 402)	Applicable if encountered	- This ARAR is not specific to this alternative.	If endangered or threatened species in the site area are identified, remedial activities would avoid actions that would adversely affect threatened or endangered species or habitats.	If endangered or threatened species in the site area are identified, remedial activities would avoid actions that would adversely affect threatened or endangered species or habitats.	If endangered or threatened species in the site area are identified, remedial activities would avoid actions that would adversely affect threatened or endangered species or habitats.
	National Historic Preservation Act (16 USC 470 et seq., 36 CFR 800)	Applicable if encountered	- This ARAR is not specific to this alternative.	Should this alternative impact historic properties, as determined in the remedial design, activities will be coordinated with the Massachusetts Historical Commission (MHC). If it is determined that adverse impacts are unavoidable, then MHC will be consulted to determine ways to minimize and/or mitigate such adverse impacts.	Should this alternative impact historic properties, as determined in the remedial design, activities will be coordinated with the Massachusetts Historical Commission (MHC). If it is determined that adverse impacts are unavoidable, then MHC will be consulted to determine ways to minimize and/or mitigate such adverse impacts.	Should this alternative impact historic properties, as determined in the remedial design, activities will be coordinated with the Massachusetts Historical Commission (MHC). If it is determined that adverse impacts are unavoidable, then MHC will be consulted to determine ways to minimize and/or mitigate such adverse impacts.
	State Regulatory Requirements					
	Antiquities Act and Regulations; Massachusetts Historical Commission; Protection of Properties Included in the State Register of Historic Places (M.G.L. ch. 9, sec. 26-27; 950 CMR 70.00)	Applicable if encountered	- This ARAR is not specific to this alternative.	Should this alternative impact historic or archaeological properties, as determined in the remedial design, activities will be coordinated with the Massachusetts Historical Commission (MHC). If it is determined that adverse impacts cannot be eliminated, then MHC will be consulted to determine ways to minimize and/or mitigate such adverse impacts.	Should this alternative impact historic or archaeological properties, as determined in the remedial design, activities will be coordinated with the Massachusetts Historical Commission (MHC). If it is determined that adverse impacts cannot be eliminated, then MHC will be consulted to determine ways to minimize and/or mitigate such adverse impacts.	Should this alternative impact historic or archaeological properties, as determined in the remedial design, activities will be coordinated with the Massachusetts Historical Commission (MHC). If it is determined that adverse impacts cannot be eliminated, then MHC will be consulted to determine ways to minimize and/or mitigate such adverse impacts.
	Massachusetts Endangered Species Act, 321 CMR 10.00, (MGL c. 131A)	Applicable if encountered	- This ARAR is not specific to this alternative.	If endangered or threatened species in the site area are identified, remedial activities would avoid actions that would adversely affect threatened or endangered species or habitats.	If endangered or threatened species in the site area are identified, remedial activities would avoid actions that would adversely affect threatened or endangered species or habitats.	If endangered or threatened species in the site area are identified, remedial activities would avoid actions that would adversely affect threatened or endangered species or habitats.

APPENDIX E
TABLE E-1
ACTIONS TAKEN TO COMPLY WITH ARARs and TBCs - LANDFILL LOBES

	ARAR	Status	LF-1	LF-2	LF-3	LF-4
ACTION SPECIFIC						
SITE WORK	**State Regulatory Requirements**					
	Massachusetts Air Pollution Control Regulations (310 CMR 7.00)	Applicable	- This ARAR is not specific to this alternative.	Construction activities will be managed to meet the standards for visible emissions (310 CMR 7.06); dust, odor, construction, and demolition (310 CMR 7.09); and noise (310 CMR 7.10).	Construction activities will be managed to meet the standards for visible emissions (310 CMR 7.06); dust, odor, construction, and demolition (310 CMR 7.09); and noise (310 CMR 7.10).	Construction activities will be managed to meet the standards for visible emissions (310 CMR 7.06); dust, odor, construction, and demolition (310 CMR 7.09); and noise (310 CMR 7.10).
	MassDEP Stormwater Management Policy	To be considered	- This policy is not specific to this alternative.	This alternative can be designed and implemented to comply with this requirement.	This alternative can be designed and implemented to comply with this requirement.	This alternative can be designed and implemented to comply with this requirement.
WASTE	**Federal Regulatory Requirements**					
	RCRA Subtitle C - Hazardous Waste Identification and Listing Regulations (40 CFR Parts 260-262 and 40 CFR 264.13)	Applicable	- This alternative does not meet the requirements of this ARAR.	Any media generated as part of monitoring activities and active groundwater treatment will be tested for hazardous waste characteristics. If determined to be hazardous waste, then they will be stored, transported, or disposed of in accordance with 40 CFR Part 264.	Any media generated as part of monitoring activities and active groundwater treatment will be tested for hazardous waste characteristics. If determined to be hazardous waste, then they will be stored, transported, or disposed of in accordance with 40 CFR Part 264.	Any media generated as part of monitoring activities and active groundwater treatment will be tested for hazardous waste characteristics. If determined to be hazardous waste, then they will be stored, transported, or disposed of in accordance with 40 CFR Part 264.
	RCRA Subtitle C - Closure and Post-Closure (40 CFR Subpart G, 264.111 and 264.117)	Applicable	- This alternative does not meet the requirements of this ARAR.	This alternative can be designed and implemented to comply with this ARAR.	This alternative can be designed and implemented to comply with this ARAR.	This alternative can be designed and implemented to comply with this ARAR.
	RCRA Subtitle C - Landfills (40 CFR Subpart N, 264.310)	Applicable	- This alternative does not meet the requirements of this ARAR.	This alternative can be designed and implemented to comply with this ARAR.	This alternative can be designed and implemented to comply with this ARAR.	This alternative can be designed and implemented to comply with this ARAR.
	RCRA 40 CFR 264 Subpart I, Use and Management of Containers	Applicable if containers are used in the remedial action	- This alternative does not meet the requirements of this ARAR.	For this alternative's groundwater remedial action, if containers are used to store hazardous waste, then this alternative can be implemented to comply with this ARAR.	For this alternative's groundwater treatment, if containers are used to store hazardous waste, then this alternative can be implemented to comply with this ARAR.	For this alternative's groundwater treatment, if containers are used to store hazardous waste, then this alternative can be implemented to comply with this ARAR.
	RCRA 40 CFR 264 Subpart J, Tank Systems	Applicable if tank systems are used in the remedial action	- This alternative does not meet the requirements of this ARAR.	For this alternative's groundwater remedial action, if tank systems are used to store or treat hazardous waste, then this alternative can be implemented to comply with this ARAR.	For this alternative's groundwater treatment, if tank systems are used to store or treat hazardous waste, then this alternative can be implemented to comply with this ARAR.	For this alternative's groundwater treatment, if tank systems are used to store or treat hazardous waste, then this alternative can be implemented to comply with this ARAR.
	RCRA 40 CFR 264 Subpart L, Waste Piles	Applicable if waste piles are used in the remedial action	- This alternative does not meet the requirements of this ARAR.	If piles are used to store hazardous waste (potentially such as the excavated sediments prior to consolidation into one of the landfill lobes), then this alternative can be implemented to comply with this ARAR.	If piles are used to store hazardous waste (potentially such as the excavated sediments prior to consolidation into one of the landfill lobes), then this alternative can be implemented to comply with this ARAR.	If piles are used to store hazardous waste (potentially such as the excavated sediments prior to consolidation into one of the landfill lobes), then this alternative can be implemented to comply with this ARAR.
	RCRA 40 CFR 264 Subpart X, Miscellaneous Units	Applicable if miscellaneous units are used in the remedial action	- This alternative does not meet the requirements of this ARAR.	For this alternative's groundwater remedial action, if miscellaneous units are used to treat, store, or dispose of hazardous waste, then this alternative can be implemented to comply with this ARAR.	For this alternative's groundwater remedial action, if miscellaneous units are used to treat, store, or dispose of hazardous waste, then this alternative can be implemented to comply with this ARAR.	For this alternative's groundwater remedial action, if miscellaneous units are used to treat, store, or dispose of hazardous waste, then this alternative can be implemented to comply with this ARAR.
	RCRA 40 CFR 264 Subpart AA, Air Emission Standards for Process Vents	Applicable if thresholds are met	- This alternative does not meet the requirements of this ARAR.	For this alternative's groundwater remedial action, if process vents are used in the remedial action and if applicable thresholds are met, then air emission controls will be implemented during groundwater treatment to comply with this regulation.	For this alternative's groundwater remedial action, if process vents are used in the remedial action and if applicable thresholds are met, then air emission controls will be implemented during groundwater treatment to comply with this regulation.	For this alternative's groundwater remedial action, if process vents are used in the remedial action and if applicable thresholds are met, then air emission controls will be implemented during groundwater treatment to comply with this regulation.

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	ARAR	Status	LF-1	LF-2	LF-3	LF-4
WASTE	RCRA 40 CFR 264 Subpart BB, Air Emission Standards for Equipment Leaks	Applicable if thresholds are met	- This alternative does not meet the requirements of this ARAR.	For this alternative's groundwater remedial action, if equipment covered by this standard is used in the remedial action and handles hazardous wastes at concentrations that meet this rule's threshold, then a leak detection and repair program will be implemented during groundwater treatment to comply with this regulation.	For this alternative's groundwater remedial action, if equipment covered by this standard is used in the remedial action and handles hazardous wastes at concentrations that meet this rule's threshold, then a leak detection and repair program will be implemented during groundwater treatment to comply with this regulation.	For this alternative's groundwater remedial action, if equipment covered by this standard is used in the remedial action and handles hazardous wastes at concentrations that meet this rule's threshold, then a leak detection and repair program will be implemented during groundwater treatment to comply with this regulation.
	RCRA 40 CFR 264 Subpart CC, Air Emission Standards for Tanks, Surface Impoundments and Containers	Applicable if thresholds are met	- This alternative does not meet the requirements of this ARAR.	Any media generated as part of monitoring activities and groundwater treatment will be tested for hazardous waste characteristics. If determined to be hazardous waste, then they will be stored, transported, or disposed of in accordance with 40 CFR Part 264. If tanks or containers are used in the remedial action and if applicable thresholds are met, then air emission controls will be implemented during groundwater treatment to comply with this regulation.	Any media generated as part of monitoring activities and groundwater treatment will be tested for hazardous waste characteristics. If determined to be hazardous waste, then they will be stored, transported, or disposed of in accordance with 40 CFR Part 264. If tanks or containers are used in the remedial action and if applicable thresholds are met, then air emission controls will be implemented during groundwater treatment to comply with this regulation.	Any media generated as part of monitoring activities and groundwater treatment will be tested for hazardous waste characteristics. If determined to be hazardous waste, then they will be stored, transported, or disposed of in accordance with 40 CFR Part 264. If tanks or containers are used in the remedial action and if applicable thresholds are met, then air emission controls will be implemented during groundwater treatment to comply with this regulation.
	RCRA 40 CFR 264 Subpart DD, Containment Buildings	Applicable	- This alternative does not meet the requirements of this ARAR.	For this alternative's groundwater remedial action, if a building is used to house treatment equipment, then the design, operation, closure, and post-closure of the treatment building for this alternative's groundwater remedial action will comply with this regulation.	For this alternative's groundwater remedial action, if a building is used to house treatment equipment, then the design, operation, closure, and post-closure of the treatment building for this alternative's groundwater remedial action will comply with this regulation.	For this alternative's groundwater remedial action, if a building is used to house treatment equipment, then the design, operation, closure, and post-closure of the treatment building for this alternative's groundwater remedial action will comply with this regulation.
	Technical Memorandum RE: Revised Alternative Cap Design Guidance Proposed for Unlined, Hazardous Waste Landfills in EPA Region 1 (February 5, 2001).	To be considered	- This alternative does not meet the requirements of this guidance.	This TBC will be considered in the design of the final cover for the landfill lobes in meeting the RCRA Subtitle C hazardous waste landfill final cover requirements.	This TBC will be considered in the design of the final cover for the landfill lobes in meeting the RCRA Subtitle C hazardous waste landfill final cover requirements.	This TBC will be considered in the design of the final cover for the landfill lobes in meeting the RCRA Subtitle C hazardous waste landfill final cover requirements.
	Presumptive Remedy for CERCLA Municipal Landfill Sites (OSWER Directive No. 9355.0-49F)	To be considered	- This alternative does not meet the requirements of this guidance.	This guidance was followed in the development of the RI/FS, and this alternative can be designed and implemented to comply with this requirement.	This guidance was followed in the development of the RI/FS, and this alternative can be designed and implemented to comply with this requirement.	This guidance was followed in the development of the RI/FS, and this alternative can be designed and implemented to comply with this requirement.
	State Regulatory Requirements					
	Massachusetts Hazardous Waste Management Standards (310 CMR 30.500)	Applicable	- This alternative does not meet the requirements of this ARAR.	This alternative will meet all closure/post-closure standards. Any media generated as part of monitoring activities and groundwater remedial action will be tested for hazardous waste characteristics. If determined to be hazardous waste, then they will be stored, transported, or disposed of in accordance with these rules.	This alternative will meet all closure/post-closure standards. Any media generated as part of monitoring activities and groundwater remedial action will be tested for hazardous waste characteristics. If determined to be hazardous waste, then they will be stored, transported, or disposed of in accordance with these rules.	This alternative will meet all closure/post-closure standards. Any media generated as part of monitoring activities and groundwater remedial action will be tested for hazardous waste characteristics. If determined to be hazardous waste, then they will be stored, transported, or disposed of in accordance with these rules.
	Massachusetts Technical Standards for Hazardous Waste Facilities (310 CMR 30.600, 310 CMR 30.633, 310 CMR 30.640, 310 CMR 30.660, 310 CMR 30.680, 310 CMR 30.690)	Applicable	- This alternative does not meet the requirements of this ARAR.	This alternative's final landfill cover, post-closure care, and groundwater monitoring can be designed and implemented to comply with this ARAR. For this alternative's groundwater remedial action, if containers or tank systems are used to store or treat hazardous waste, then this alternative can be implemented to comply with this ARAR. Also, if piles are used to store hazardous waste (potentially such as the excavated sediments prior to consolidation into one of the landfill lobes), then this alternative can be implemented to comply with this ARAR.	This alternative's final landfill cover, post-closure care, and groundwater monitoring can be designed and implemented to comply with this ARAR. For this alternative's groundwater remedial action, if containers or tank systems are used to store or treat hazardous waste, then this alternative can be implemented to comply with this ARAR. Also, if piles are used to store hazardous waste (potentially such as the excavated sediments prior to consolidation into one of the landfill lobes), then this alternative can be implemented to comply with this ARAR.	This alternative's final landfill cover, post-closure care, and groundwater monitoring can be designed and implemented to comply with this ARAR. For this alternative's groundwater remedial action, if containers or tank systems are used to store or treat hazardous waste, then this alternative can be implemented to comply with this ARAR. Also, if piles are used to store hazardous waste (potentially such as the excavated sediments prior to consolidation into one of the landfill lobes), then this alternative can be implemented to comply with this ARAR.
	MassDEP Landfill Technical Guidance, revised, May 1997	To be considered	- This alternative does not meet the requirements of this guidance.	This guidance will be used in the remedial alternative evaluation and during the landfill closure process.	This guidance will be used in the remedial alternative evaluation and during the landfill closure process.	This guidance will be used in the remedial alternative evaluation and during the landfill closure process.

APPENDIX E
TABLE E-1
ACTIONS TAKEN TO COMPLY WITH ARARs and TBCs - LANDFILL LOBES

	ARAR	Status	LF-1	LF-2	LF-3	LF-4
SURFACE WATER	**Federal Regulatory Requirements**					
	Clean Water Act National Pollutants Discharge Elimination System (NPDES) (40 CFR Part 122-125 and 131)	Applicable	- This ARAR is not specific to this alternative.	On-site discharges to surface waters, including Sutton Brook and adjacent wetlands, shall meet these substantive discharge standards. These discharge limitations shall also be used to develop monitoring standards for surface waters.	On-site discharges to surface waters, including Sutton Brook and adjacent wetlands, shall meet these substantive discharge standards. These discharge limitations shall also be used to develop monitoring standards for surface waters.	On-site discharges to surface waters, including Sutton Brook and adjacent wetlands, shall meet these substantive discharge standards. These discharge limitations shall also be used to develop monitoring standards for surface waters.
	Clean Water Act (CWA) Ambient Water Quality Criteria (AWQC) (33 USC 1251 *et seq*.) (40 CFR 122.44)	Applicable	- This ARAR is not specific to this alternative.	If treated groundwater is discharged to surface water, it would be treated as needed to comply with this ARAR. Surface water monitoring would be performed. These standards would be used to help assess the effectiveness of the groundwater treatment.	If treated groundwater is discharged to surface water, it would be treated as needed to comply with this ARAR. Surface water monitoring would be performed. These standards would be used to help assess the effectiveness of the groundwater treatment.	If treated groundwater is discharged to surface water, it would be treated as needed to comply with this ARAR. Surface water monitoring would be performed. These standards would be used to help assess the effectiveness of the groundwater treatment.
	State Regulatory Requirements					
	Clean Waters Act - MassDEP Surface Water Discharge Permit Program (314 CMR 3.00; MGL c. 21 Sections 26-53)	Applicable	- This ARAR is not specific to this alternative.	Any on-site discharges to surface waters, including Sutton Brook and adjacent wetlands, shall meet these substantive discharge standards. These discharge limitations shall also be used to develop monitoring standards for surface waters.	Any on-site discharges to surface waters, including Sutton Brook and adjacent wetlands, shall meet these substantive discharge standards. These discharge limitations shall also be used to develop monitoring standards for surface waters.	Any on-site discharges to surface waters, including Sutton Brook and adjacent wetlands, shall meet these substantive discharge standards. These discharge limitations shall also be used to develop monitoring standards for surface waters.
	Massachusetts Surface Water Quality Standards (314 CMR 4.00)	Applicable	- This ARAR is not specific to this alternative.	Any on-site discharges to surface waters, including Sutton Brook and adjacent wetlands, shall meet these substantive discharge standards. These discharge limitations shall also be used to develop monitoring standards for surface waters.	Any on-site discharges to surface waters, including Sutton Brook and adjacent wetlands, shall meet these substantive discharge standards. These discharge limitations shall also be used to develop monitoring standards for surface waters.	Any on-site discharges to surface waters, including Sutton Brook and adjacent wetlands, shall meet these substantive discharge standards. These discharge limitations shall also be used to develop monitoring standards for surface waters.
	MassDEP Surface Water Discharge Permit Program (314 CMR 3.00)	Applicable	- This ARAR is not specific to this alternative.	Any on-site discharges to surface waters, including Sutton Brook and adjacent wetlands, shall meet these substantive discharge standards. These discharge limitations shall also be used to develop monitoring standards for surface waters.	Any on-site discharges to surface waters, including Sutton Brook and adjacent wetlands, shall meet these substantive discharge standards. These discharge limitations shall also be used to develop monitoring standards for surface waters.	Any on-site discharges to surface waters, including Sutton Brook and adjacent wetlands, shall meet these substantive discharge standards. These discharge limitations shall also be used to develop monitoring standards for surface waters.
GROUNDWATER	**Federal Regulatory Requirements**					
	RCRA Subtitle C - Releases from Solid Waste Management Units (40 CFR Subpart F, 264.95 and 264.96(a) and (c))	Applicable	- This ARAR is not specific to this alternative.	These regulations will be considered in EPA's selection of the remedy, and, if this alternative is selected, this alternative will be implemented to comply with these requirements.	These regulations will be considered in EPA's selection of the remedy, and, if this alternative is selected, this alternative will be implemented to comply with these requirements.	These regulations will be considered in EPA's selection of the remedy, and, if this alternative is selected, this alternative will be implemented to comply with these requirements.
	Underground Injection (40 CFR Part 144)	Relevant and appropriate	- This ARAR is not specific to this alternative.	If the performance of this alternative chooses underground injection, infiltration gallery or any other system that disposes of treatment water or waste into groundwater as the remediation technology, groundwater would be treated to be non-hazardous prior to subsurface discharge.	If the performance of this alternative chooses underground injection, infiltration gallery or any other system that disposes of treatment water or waste into groundwater as the remediation technology, groundwater would be treated to be non-hazardous prior to subsurface discharge.	If the performance of this alternative chooses underground injection, infiltration gallery or any other system that disposes of treatment water or waste into groundwater as the remediation technology, groundwater would be treated to be non-hazardous prior to subsurface discharge.
	Final OSWER Directive "Use of Monitored Natural Attenuation at Superfund, RCRA Corrective Action, and Underground Storage Tank Sites (OSWER Dir. 9200.4-17P, 4/12/99)	To be considered	- This guidance is not specific to this alternative.	Under this alternative, contaminant levels in the groundwater plume underneath the northern landfill lobe and southern lobe (LF-2a only) will be monitored consistent with this guidance.	Under this alternative, contaminant levels in the groundwater plume underneath the northern landfill lobe will be monitored consistent with this guidance.	Under this alternative, contaminant levels in the groundwater plume underneath the northern landfill lobe will be monitored consistent with this guidance.

APPENDIX E
TABLE E-1
ACTIONS TAKEN TO COMPLY WITH ARARs and TBCs - LANDFILL LOBES

	ARAR	Status	LF-1	LF-2	LF-3	LF-4
GROUNDWATER	**State Regulatory Requirements**					
	MassDEP Underground Injection Control Requirements (310 CMR 27.00)	Applicable	- This ARAR is not specific to this alternative.	If the performance of this alternative chooses underground injection, infiltration gallery or any other system that disposes of treatment water or waste into groundwater as the remediation technology, groundwater would be treated to be non-hazardous prior to subsurface discharge.	If the performance of this alternative chooses underground injection, infiltration gallery or any other system that disposes of treatment water or waste into groundwater as the remediation technology, groundwater would be treated to be non-hazardous prior to subsurface discharge.	If the performance of this alternative chooses underground injection, infiltration gallery or any other system that disposes of treatment water or waste into groundwater as the remediation technology, groundwater would be treated to be non-hazardous prior to subsurface discharge.
	MassDEP Groundwater Discharge Permit Program (314 CMR 5.00)	Applicable	- This ARAR is not specific to this alternative.	If the performance of this alternative chooses underground injection, infiltration gallery or any other system that disposes of treatment water or waste into groundwater as the remediation technology, groundwater would be treated to be non-hazardous prior to subsurface discharge.	If the performance of this alternative chooses underground injection, infiltration gallery or any other system that disposes of treatment water or waste into groundwater as the remediation technology, groundwater would be treated to be non-hazardous prior to subsurface discharge.	If the performance of this alternative chooses underground injection, infiltration gallery or any other system that disposes of treatment water or waste into groundwater as the remediation technology, groundwater would be treated to be non-hazardous prior to subsurface discharge.
	Massachusetts Well Decommissioning Requirements (313 CMR 3.03)	Applicable	- This ARAR is not specific to this alternative.	These regulations will be followed to the extent that the alternative involves decommissioning any wells.	These regulations will be followed to the extent that the alternative involves decommissioning any wells.	These regulations will be followed to the extent that the alternative involves decommissioning any wells.
SOIL/ SEDIMENT	**State Regulatory Requirements**					
	Reuse and Disposal of Contaminated Soils at Massachusetts Landfills (COMM-97-001)	To be considered	- This Policy is not specific to this alternative.	- This alternative can be designed and implemented to comply with this policy.	- This alternative can be designed and implemented to comply with this policy.	- This alternative can be designed and implemented to comply with this policy.
Air	**Federal Regulatory Requirements**					
	Clean Air Act National Emissions Standards for Hazardous Air Pollutants (NESHAPs), 40 CFR Part 61	Applicable	- This ARAR is not specific to this alternative.	For this alternative's groundwater remedial action, if air stripping is used and any of the 189 Hazardous Air pollutants are emitted, then this alternative's groundwater remedial action will comply with this ARAR.	For this alternative's groundwater remedial action, if air stripping is used and any of the 189 Hazardous Air pollutants are emitted, then this alternative's groundwater remedial action will comply with this ARAR.	For this alternative's groundwater remedial action, if air stripping is used and any of the 189 Hazardous Air pollutants are emitted, then this alternative's groundwater remedial action will comply with this ARAR.
	OSWER Directive 9355.0-28, Air Stripper Control Guidance, 7/12/89	To be considered	- This Policy is not specific to this alternative.	For this alternative's groundwater remedial action, if air stripping is used, then this alternative's groundwater remedial action will comply with this policy.	For this alternative's groundwater remedial action, if air stripping is used, then this alternative's groundwater remedial action will comply with this policy.	For this alternative's groundwater remedial action, if air stripping is used, then this alternative's groundwater remedial action will comply with this policy.
	State Regulatory Requirements					
	Massachusetts Ambient Air Quality Standards (310 CMR 6.00)	Applicable	- This ARAR is not specific to this alternative.	For this alternative's groundwater remedial action, if air stripping is used, then this alternative's groundwater remedial action will comply with this ARAR. No air emissions from remedial treatment will cause ambient air quality standards to be exceeded.	For this alternative's groundwater remedial action, if air stripping is used, then this alternative's groundwater remedial action will comply with this ARAR. No air emissions from remedial treatment will cause ambient air quality standards to be exceeded.	For this alternative's groundwater remedial action, if air stripping is used, then this alternative's groundwater remedial action will comply with this ARAR. No air emissions from remedial treatment will cause ambient air quality standards to be exceeded.
	MassDEP Revised Ambient Air Guidelines (December 6, 1995)	To be considered	- This Policy is not specific to this alternative.	- This alternative can be designed and implemented to comply with this policy.	- This alternative can be designed and implemented to comply with this policy.	- This alternative can be designed and implemented to comply with this policy.
	Massachusetts Air Pollution Control Regulations (310 CMR 7.00)	Applicable	- This ARAR is not specific to this alternative.	For this alternative's groundwater remedial action, if air stripping is used, then this alternative's groundwater remedial action will comply with this ARAR. Odor emissions from the groundwater treatment air stripper will be controlled with best available control technology.	For this alternative's groundwater remedial action, if air stripping is used, then this alternative's groundwater remedial action will comply with this ARAR. Odor emissions from the groundwater treatment air stripper will be controlled with best available control technology.	For this alternative's groundwater remedial action, if air stripping is used, then this alternative's groundwater remedial action will comply with this ARAR. Odor emissions from the groundwater treatment air stripper will be controlled with best available control technology.

APPENDIX E
TABLE E-2
ACTIONS TAKEN TO COMPLY WITH ARARs and TBCs - FORMER DRUM DISPOSAL AREA

	ARAR	Status	FDDA-1	FDDA-2	FDDA-3	FDDA-4	FDDA-5
CHEMICAL SPECIFIC							
GROUNDWATER	**Federal Regulatory Requirements**						
	Federal Safe Drinking Water Act (SDWA) Maximum Contaminant Levels (MCLs) (40 CFR Part 141.11-141.16)	Relevant and appropriate	- This alternative will not meet the PRGs established and therefore not comply with this ARAR.	MCLs were used in determining groundwater preliminary remediation goals (PRGs) for site contaminants where such contaminant levels have been established. Under this alternative, the groundwater approach will over time prevent groundwater exceeding MCLs from migrating beyond the point of compliance.	MCLs were used in determining groundwater preliminary remediation goals (PRGs) for site contaminants where such contaminant levels have been established. Under this alternative, the groundwater approach will over time prevent groundwater exceeding MCLs from migrating beyond the point of compliance.	MCLs were used in determining groundwater preliminary remediation goals (PRGs) for site contaminants where such contaminant levels have been established. Under this alternative, the groundwater approach will over time prevent groundwater exceeding MCLs from migrating beyond the point of compliance.	MCLs were used in determining groundwater preliminary remediation goals (PRGs) for site contaminants where such contaminant levels have been established. Under this alternative, the groundwater approach will over time prevent groundwater exceeding MCLs from migrating beyond the point of compliance.
	SDWA Maximum Contaminant Level Goals (MCLGs) (40 CFR Part 141.50-141.51)	Relevant and appropriate	- This alternative will not meet the PRGs established and therefore not comply with this ARAR.	Non-zero MCLGs were used in determining PRGs when MCLs have not been established for a particular contaminant. Under this alternative, the groundwater approach will over time prevent groundwater exceeding MCLGs from migrating beyond the point of compliance.	Non-zero MCLGs were used in determining PRGs when MCLs have not been established for a particular contaminant. Under this alternative, the groundwater approach will over time prevent groundwater exceeding MCLGs from migrating beyond the point of compliance.	Non-zero MCLGs were used in determining PRGs when MCLs have not been established for a particular contaminant. Under this alternative, the groundwater approach will over time prevent groundwater exceeding MCLGs from migrating beyond the point of compliance.	Non-zero MCLGs were used in determining PRGs when MCLs have not been established for a particular contaminant. Under this alternative, the groundwater approach will over time prevent groundwater exceeding MCLGs from migrating beyond the point of compliance.
	EPA Risk Reference Doses (RfDs)	To be considered	- This alternative will not meet the PRGs established and therefore not comply with this TBC.	RfDs were used to assess health risks due to exposure to non-carcinogenic chemicals in groundwater, and to develop acceptable groundwater PRG concentrations. Under this alternative, the groundwater approach will over time prevent groundwater exceeding PRGs from migrating beyond the point of compliance.	RfDs were used to assess health risks due to exposure to non-carcinogenic chemicals in groundwater, and to develop acceptable groundwater PRG concentrations. Under this alternative, the groundwater approach will over time prevent groundwater exceeding PRGs from migrating beyond the point of compliance.	RfDs were used to assess health risks due to exposure to non-carcinogenic chemicals in groundwater, and to develop acceptable groundwater PRG concentrations. Under this alternative, the groundwater approach will over time prevent groundwater exceeding PRGs from migrating beyond the point of compliance.	RfDs were used to assess health risks due to exposure to non-carcinogenic chemicals in groundwater, and to develop acceptable groundwater PRG concentrations. Under this alternative, the groundwater approach will over time prevent groundwater exceeding PRGs from migrating beyond the point of compliance.
	EPA Human Health Assessment Cancer Slope Factors (CSFs)	To be considered	- This alternative will not meet the PRGs established and therefore not comply with this TBC.	CSFs were used to compute the individual cancer risk resulting from exposure to contaminants and in the development of acceptable groundwater PRG concentrations. Under this alternative, the groundwater approach will over time prevent groundwater exceeding PRGs from migrating beyond the point of compliance.	CSFs were used to compute the individual cancer risk resulting from exposure to contaminants and in the development of acceptable groundwater PRG concentrations. Under this alternative, the groundwater approach will over time prevent groundwater exceeding PRGs from migrating beyond the point of compliance.	CSFs were used to compute the individual cancer risk resulting from exposure to contaminants and in the development of acceptable groundwater PRG concentrations. Under this alternative, the groundwater approach will over time prevent groundwater exceeding PRGs from migrating beyond the point of compliance.	CSFs were used to compute the individual cancer risk resulting from exposure to contaminants and in the development of acceptable groundwater PRG concentrations. Under this alternative, the groundwater approach will over time prevent groundwater exceeding PRGs from migrating beyond the point of compliance.
	Guidelines for Carcinogen Risk Assessment (EPA/630/P-03/001F, March 2005)	To be considered	- This alternative will not meet the PRGs established and therefore not comply with this TBC.	Potential cancer risks identified will be addressed by this alternative.	Potential cancer risks identified will be addressed by this alternative.	Potential cancer risks identified will be addressed by this alternative.	Potential cancer risks identified will be addressed by this alternative.
	Supplemental Guidance for Assessing Susceptibility from Early-Life Exposure to Carcinogens (EPA/630/R-03/003F, March 2005)	To be considered	- This alternative will not meet the PRGs established and therefore not comply with this TBC.	Potential child cancer risks identified will be addressed by this alternative.	Potential child cancer risks identified will be addressed by this alternative.	Potential child cancer risks identified will be addressed by this alternative.	Potential child cancer risks identified will be addressed by this alternative.
	State Regulatory Requirements						
	Massachusetts Groundwater Quality Standards (314 CMR 6.00)	Relevant and appropriate	- This alternative will not meet the PRGs established and therefore not comply with this ARAR.	Groundwater beneath the site is mapped in a potentially productive aquifer with the potential for potable water use. Under this alternative, the groundwater approach will over time prevent groundwater exceeding PRGs from migrating beyond the point of compliance.	Groundwater beneath the site is mapped in a potentially productive aquifer with the potential for potable water use. Under this alternative, the groundwater approach will over time prevent groundwater exceeding PRGs from migrating beyond the point of compliance.	Groundwater beneath the site is mapped in a potentially productive aquifer with the potential for potable water use. Under this alternative, the groundwater approach will over time prevent groundwater exceeding PRGs from migrating beyond the point of compliance.	Groundwater beneath the site is mapped in a potentially productive aquifer with the potential for potable water use. Under this alternative, the groundwater approach will over time prevent groundwater exceeding PRGs from migrating beyond the point of compliance.

APPENDIX E
TABLE E-2
ACTIONS TAKEN TO COMPLY WITH ARARs and TBCs - FORMER DRUM DISPOSAL AREA

	ARAR	Status	FDDA-1	FDDA-2	FDDA-3	FDDA-4	FDDA-5
GROUNDWATER	Massachusetts Drinking Water Standards (310 CMR 22.00)	Relevant and appropriate	- This alternative will not meet the PRGs established and therefore not comply with this ARAR.	Under this alternative, the groundwater approach will over time prevent groundwater exceeding PRGs from migrating beyond the point of compliance.	Under this alternative, the groundwater approach will over time prevent groundwater exceeding PRGs from migrating beyond the point of compliance.	Under this alternative, the groundwater approach will over time prevent groundwater exceeding PRGs from migrating beyond the point of compliance.	Under this alternative, the groundwater approach will over time prevent groundwater exceeding PRGs from migrating beyond the point of compliance.
	Massachusetts Contingency Plan (310 CMR 40.0000), Method 1 Standards	Relevant and appropriate	- This alternative will not meet the PRGs established and therefore not comply with this ARAR.	Under this alternative, the groundwater approach will over time prevent groundwater exceeding PRGs from migrating beyond the point of compliance.	Under this alternative, the groundwater approach will over time prevent groundwater exceeding PRGs from migrating beyond the point of compliance.	Under this alternative, the groundwater approach will over time prevent groundwater exceeding PRGs from migrating beyond the point of compliance.	Under this alternative, the groundwater approach will over time prevent groundwater exceeding PRGs from migrating beyond the point of compliance.
	Massachusetts Office of Research and Standards Guidelines (ORSG)	To be considered	- This alternative will not meet the PRGs established and therefore not comply with this TBC.	Under this alternative, the groundwater approach will over time prevent groundwater exceeding PRGs from migrating beyond the point of compliance.	Under this alternative, the groundwater approach will over time prevent groundwater exceeding PRGs from migrating beyond the point of compliance.	Under this alternative, the groundwater approach will over time prevent groundwater exceeding PRGs from migrating beyond the point of compliance.	Under this alternative, the groundwater approach will over time prevent groundwater exceeding PRGs from migrating beyond the point of compliance.
SEDIMENT/SOIL	**State Regulatory Requirements**						
	Massachusetts Contingency Plan (310 CMR 40.0000), Method 1 Standards	Relevant and appropriate	- This alternative will not meet the PRGs established and therefore not comply with this ARAR.	- This alternative will not meet the PRGs established; but exposure to impacted soil will be eliminated with construction of a low permeability containment system.	Under this alternative, soils in excess of PRGs (either based on this ARAR and/or on site-specific human health and ecological derived PRGs) will be excavated and disposed.	Under this alternative, soils in excess of PRGs (either based on this ARAR and/or on site-specific human health and ecological derived PRGs) will be excavated and disposed.	Under this alternative, soils in excess of PRGs (either based on this ARAR and/or on site-specific human health and ecological derived PRGs) will be excavated and disposed.
SURFACE WATER	**Federal Regulatory Requirements**						
	Clean Water Act (CWA) Ambient Water Quality Criteria (AWQC) (33 USC 1251 *et seq*.)	To be considered	- This TBC is not specific to this alternative.	- If discharge of treated groundwater to surface water is the selected discharge method, then this alternative can be designed and implemented to meet these standards.	- If discharge of treated groundwater to surface water is the selected discharge method, then this alternative can be designed and implemented to meet these standards.	- If groundwater extraction and ex-situ treatment is implemented and discharge of treated groundwater to surface water is the selected discharge method, then this alternative can be designed and implemented to meet these criteria.	- If discharge of treated groundwater to surface water is the selected discharge method, then this alternative can be designed and implemented to meet these standards.
LOCATION SPECIFIC							
SURFACE WATER/ WETLANDS/ FLOODPLAINS	**Federal Regulatory Requirements**						
	Wetlands Executive Order (EO11990), 40 CFR Part 6, Appendix A	Applicable	- This ARAR is not specific to this alternative.	Under this alternative, the installation of the liner would result in work areas close to delineated wetland boundaries and potentially may disturb some areas. During remedial design the effects of remedial activities on the wetlands will be evaluated and minimized. Compensatory wetlands mitigation would be performed as necessary to comply with this ARAR.	Under this alternative, the excavation of soils would result in work areas close to delineated wetland boundaries and potentially may disturb some areas. During remedial design the effects of remedial activities on the wetlands will be evaluated and minimized. Compensatory wetlands mitigation would be performed as necessary to comply with this ARAR.	Under this alternative, the excavation of soils would result in work areas close to delineated wetland boundaries and potentially may disturb some areas. During remedial design the effects of remedial activities on the wetlands will be evaluated and minimized. Compensatory wetlands mitigation would be performed as necessary to comply with this ARAR.	Under this alternative, the excavation of soils would result in work areas close to delineated wetland boundaries and potentially may disturb some areas. During remedial design the effects of remedial activities on the wetlands will be evaluated and minimized. Compensatory wetlands mitigation would be performed as necessary to comply with this ARAR.
	Clean Water Act Section 404 Dredge and Fill Regulations (40 CFR 230, 33 CFR 320-323)	Applicable	- This ARAR is not specific to this alternative.	Under this alternative, the installation of the liner would result in work areas close to delineated wetland boundaries and potentially may disturb some areas. During remedial design the effects of remedial activities on the wetlands will be evaluated and minimized. Compensatory wetlands mitigation would be performed as necessary to comply with this ARAR.	Under this alternative, the excavation of soils would result in work areas close to delineated wetland boundaries and potentially may disturb some areas. During remedial design the effects of remedial activities on the wetlands will be evaluated and minimized. Compensatory wetlands mitigation would be performed as necessary to comply with this ARAR.	Under this alternative, the excavation of soils would result in work areas close to delineated wetland boundaries and potentially may disturb some areas. During remedial design the effects of remedial activities on the wetlands will be evaluated and minimized. Compensatory wetlands mitigation would be performed as necessary to comply with this ARAR.	Under this alternative, the excavation of soils would result in work areas close to delineated wetland boundaries and potentially may disturb some areas. During remedial design the effects of remedial activities on the wetlands will be evaluated and minimized. Compensatory wetlands mitigation would be performed as necessary to comply with this ARAR.

APPENDIX E
TABLE E-2
ACTIONS TAKEN TO COMPLY WITH ARARs and TBCs - FORMER DRUM DISPOSAL AREA

	ARAR	Status	FDDA-1	FDDA-2	FDDA-3	FDDA-4	FDDA-5
SURFACE WATER/ WETLANDS/ FLOODPLAINS	Rivers and Harbors Act Section 10 (33 USC 403, 33 CFR 320-323)	Applicable	- This ARAR is not specific to this alternative.	Under this alternative, the installation of the liner would result in work areas close to delineated wetland boundaries and potentially may disturb some areas. During remedial design the effects of remedial activities on the wetlands will be evaluated and minimized. Compensatory wetlands mitigation would be performed as necessary to comply with this ARAR.	Under this alternative, the excavation of soils would result in work areas close to delineated wetland boundaries and potentially may disturb some areas. During remedial design the effects of remedial activities on the wetlands will be evaluated and minimized. Compensatory wetlands mitigation would be performed as necessary to comply with this ARAR.	Under this alternative, the excavation of soils would result in work areas close to delineated wetland boundaries and potentially may disturb some areas. During remedial design the effects of remedial activities on the wetlands will be evaluated and minimized. Compensatory wetlands mitigation would be performed as necessary to comply with this ARAR.	Under this alternative, the excavation of soils would result in work areas close to delineated wetland boundaries and potentially may disturb some areas. During remedial design the effects of remedial activities on the wetlands will be evaluated and minimized. Compensatory wetlands mitigation would be performed as necessary to comply with this ARAR.
	Floodplains Executive Order (EO11988), 40 CFR Part 6, Appendix A	Applicable	- This ARAR is not specific to this alternative.	Available practicable means will be used to reduce the risk of flood loss, to minimize the impact of floods and to restore and preserve the floodplains.	Available practicable means will be used to reduce the risk of flood loss, to minimize the impact of floods and to restore and preserve the floodplains.	Available practicable means will be used to reduce the risk of flood loss, to minimize the impact of floods and to restore and preserve the floodplains.	Available practicable means will be used to reduce the risk of flood loss, to minimize the impact of floods and to restore and preserve the floodplains.
	RCRA Floodplain Restrictions for Hazardous Waste Facilities (40 CFR 264.18(b))	Relevant and Appropriate	- This ARAR is not specific to this alternative.	- This ARAR is not specific to this alternative.	- This ARAR is not specific to this alternative.	- This ARAR is not specific to this alternative.	- This ARAR is not specific to this alternative.
	Fish and Wildlife Coordination Act (16 USC 661 et seq, 40 CFR Part 6)	Applicable	- This ARAR is not specific to this alternative.	- This ARAR is not specific to this alternative.	- This ARAR is not specific to this alternative.	- This ARAR is not specific to this alternative.	- This ARAR is not specific to this alternative.
	State Regulatory Requirements						
	Massachusetts Wetlands Regulations (310 CMR 10.00, MGL c. 131, Section 40: Wetlands Protection Act)	Applicable	- This ARAR is not specific to this alternative.	Under this alternative, the installation of the liner would result in work areas close to delineated wetland boundaries and potentially may disturb some areas. During remedial design the effects of remedial activities on the wetlands will be evaluated and minimized. Compensatory wetlands mitigation would be performed as necessary to comply with this ARAR.	Under this alternative, the excavation of soils would result in work areas close to delineated wetland boundaries and potentially may disturb some areas. During remedial design the effects of remedial activities on the wetlands will be evaluated and minimized. Compensatory wetlands mitigation would be performed as necessary to comply with this ARAR.	Under this alternative, the excavation of soils would result in work areas close to delineated wetland boundaries and potentially may disturb some areas. During remedial design the effects of remedial activities on the wetlands will be evaluated and minimized. Compensatory wetlands mitigation would be performed as necessary to comply with this ARAR.	Under this alternative, the excavation of soils would result in work areas close to delineated wetland boundaries and potentially may disturb some areas. During remedial design the effects of remedial activities on the wetlands will be evaluated and minimized. Compensatory wetlands mitigation would be performed as necessary to comply with this ARAR.
	Massachusetts Water Quality Certification for Discharge of Dredged or Fill Material, Dredging, and Dredging Material Disposal in Waters of the U.S. within the Commonwealth (314 CMR 9.00)	Applicable	- This ARAR is not specific to this alternative.	Under this alternative, the installation of the liner would result in work areas close to delineated wetland boundaries and potentially may disturb some areas. During remedial design the effects of remedial activities on the wetlands will be evaluated and minimized. Compensatory wetlands mitigation would be performed as necessary to comply with this ARAR.	Under this alternative, the excavation of soils would result in work areas close to delineated wetland boundaries and potentially may disturb some areas. During remedial design the effects of remedial activities on the wetlands will be evaluated and minimized. Compensatory wetlands mitigation would be performed as necessary to comply with this ARAR.	Under this alternative, the excavation of soils would result in work areas close to delineated wetland boundaries and potentially may disturb some areas. During remedial design the effects of remedial activities on the wetlands will be evaluated and minimized. Compensatory wetlands mitigation would be performed as necessary to comply with this ARAR.	Under this alternative, the excavation of soils would result in work areas close to delineated wetland boundaries and potentially may disturb some areas. During remedial design the effects of remedial activities on the wetlands will be evaluated and minimized. Compensatory wetlands mitigation would be performed as necessary to comply with this ARAR.
	Massachusetts Waterways Regulations (310 CMR 9.00)	Applicable	- This ARAR is not specific to this alternative.	Under this alternative, the installation of the liner would result in work areas close to delineated wetland boundaries and potentially may disturb some areas. During remedial design the effects of remedial activities on the wetlands will be evaluated and minimized. Compensatory wetlands mitigation would be performed as necessary to comply with this ARAR.	Under this alternative, the excavation of soils would result in work areas close to delineated wetland boundaries and potentially may disturb some areas. During remedial design the effects of remedial activities on the wetlands will be evaluated and minimized. Compensatory wetlands mitigation would be performed as necessary to comply with this ARAR.	Under this alternative, the excavation of soils would result in work areas close to delineated wetland boundaries and potentially may disturb some areas. During remedial design the effects of remedial activities on the wetlands will be evaluated and minimized. Compensatory wetlands mitigation would be performed as necessary to comply with this ARAR.	Under this alternative, the excavation of soils would result in work areas close to delineated wetland boundaries and potentially may disturb some areas. During remedial design the effects of remedial activities on the wetlands will be evaluated and minimized. Compensatory wetlands mitigation would be performed as necessary to comply with this ARAR.

APPENDIX E
TABLE E-2
ACTIONS TAKEN TO COMPLY WITH ARARs and TBCs - FORMER DRUM DISPOSAL AREA

	ARAR	Status	FDDA-1	FDDA-2	FDDA-3	FDDA-4	FDDA-5
SURFACE WATER/ WETLANDS/ FLOODPLAINS	Massachusetts Hazardous Waste Rules, Facility Location Standards (310 CMR 30.700)	Applicable	- This ARAR is not specific to this alternative.	Any remedial structures within Land Subject to Flooding and potential public water supply area, will be designed, constructed, operated, and maintained to prevent a release of hazardous waste within the protected resource area.	Any remedial structures within Land Subject to Flooding and potential public water supply area, will be designed, constructed, operated, and maintained to prevent a release of hazardous waste within the protected resource area.	Any remedial structures within Land Subject to Flooding and potential public water supply area, will be designed, constructed, operated, and maintained to prevent a release of hazardous waste within the protected resource area.	Any remedial structures within Land Subject to Flooding and potential public water supply area, will be designed, constructed, operated, and maintained to prevent a release of hazardous waste within the protected resource area.
OTHER NATURAL RESOURCES	**Federal Regulatory Requirements**						
	Endangered Species Act (16 USC 1531 et seq.; 40 CFR 6.302(h); 50 CFR 402)	Applicable if encountered	- This ARAR is not specific to this alternative.	If endangered or threatened species in the site area are identified, remedial activities would avoid actions that would adversely affect threatened or endangered species or habitats.	If endangered or threatened species in the site area are identified, remedial activities would avoid actions that would adversely affect threatened or endangered species or habitats.	If endangered or threatened species in the site area are identified, remedial activities would avoid actions that would adversely affect threatened or endangered species or habitats.	If endangered or threatened species in the site area are identified, remedial activities would avoid actions that would adversely affect threatened or endangered species or habitats.
	National Historic Preservation Act (16 USC 470 et seq., 36 CFR 800)	Applicable if encountered	- This ARAR is not specific to this alternative.	Should this alternative impact historic properties, as determined in the remedial design, activities will be coordinated with the Massachusetts Historical Commission (MHC). If it is determined that adverse impacts are unavoidable, then MHC will be consulted to determine ways to minimize and/or mitigate such adverse impacts.	Should this alternative impact historic properties, as determined in the remedial design, activities will be coordinated with the Massachusetts Historical Commission (MHC). If it is determined that adverse impacts are unavoidable, then MHC will be consulted to determine ways to minimize and/or mitigate such adverse impacts.	Should this alternative impact historic properties, as determined in the remedial design, activities will be coordinated with the Massachusetts Historical Commission (MHC). If it is determined that adverse impacts are unavoidable, then MHC will be consulted to determine ways to minimize and/or mitigate such adverse impacts.	Should this alternative impact historic properties, as determined in the remedial design, activities will be coordinated with the Massachusetts Historical Commission (MHC). If it is determined that adverse impacts are unavoidable, then MHC will be consulted to determine ways to minimize and/or mitigate such adverse impacts.
	State Regulatory Requirements						
	Antiquities Act and Regulations; Massachusetts Historical Commission; Protection of Properties Included in the State Register of Historic Places (M.G.L. ch. 9, sec. 26-27; 950 CMR 70.00)	Applicable if encountered	- This ARAR is not specific to this alternative.	Should this alternative impact historic or archaeological properties, as determined in the remedial design, activities will be coordinated with the Massachusetts Historical Commission (MHC). If it is determined that adverse impacts cannot be eliminated, then MHC will be consulted to determine ways to minimize and/or mitigate such adverse impacts.	Should this alternative impact historic or archaeological properties, as determined in the remedial design, activities will be coordinated with the Massachusetts Historical Commission (MHC). If it is determined that adverse impacts cannot be eliminated, then MHC will be consulted to determine ways to minimize and/or mitigate such adverse impacts.	Should this alternative impact historic or archaeological properties, as determined in the remedial design, activities will be coordinated with the Massachusetts Historical Commission (MHC). If it is determined that adverse impacts cannot be eliminated, then MHC will be consulted to determine ways to minimize and/or mitigate such adverse impacts.	Should this alternative impact historic or archaeological properties, as determined in the remedial design, activities will be coordinated with the Massachusetts Historical Commission (MHC). If it is determined that adverse impacts cannot be eliminated, then MHC will be consulted to determine ways to minimize and/or mitigate such adverse impacts.
	Massachusetts Endangered Species Act, 321 CMR 10.00, (MGL c. 131A)	Applicable if encountered	- This ARAR is not specific to this alternative.	If endangered or threatened species in the site area are identified, remedial activities would avoid actions that would adversely affect threatened or endangered species or habitats.	If endangered or threatened species in the site area are identified, remedial activities would avoid actions that would adversely affect threatened or endangered species or habitats.	If endangered or threatened species in the site area are identified, remedial activities would avoid actions that would adversely affect threatened or endangered species or habitats.	If endangered or threatened species in the site area are identified, remedial activities would avoid actions that would adversely affect threatened or endangered species or habitats.
ACTION SPECIFIC							
SITE WORK	**State Regulatory Requirements**						
	Massachusetts Air Pollution Control Regulations (310 CMR 7.00)	Applicable	- This ARAR is not specific to this alternative.	Construction activities will be managed to meet the standards for visible emissions (310 CMR 7.06); dust, odor, construction, and demolition (310 CMR 7.09); and noise (310 CMR 7.10).	Construction activities will be managed to meet the standards for visible emissions (310 CMR 7.06); dust, odor, construction, and demolition (310 CMR 7.09); and noise (310 CMR 7.10).	Construction activities will be managed to meet the standards for visible emissions (310 CMR 7.06); dust, odor, construction, and demolition (310 CMR 7.09); and noise (310 CMR 7.10).	Construction activities will be managed to meet the standards for visible emissions (310 CMR 7.06); dust, odor, construction, and demolition (310 CMR 7.09); and noise (310 CMR 7.10).
	MassDEP Stormwater Management Policy	To be considered	- This policy is not specific to this alternative.	This alternative can be designed and implemented to comply with this requirement.	This alternative can be designed and implemented to comply with this requirement.	This alternative can be designed and implemented to comply with this requirement.	This alternative can be designed and implemented to comply with this requirement.

APPENDIX E
TABLE E-2
ACTIONS TAKEN TO COMPLY WITH ARARs and TBCs - FORMER DRUM DISPOSAL AREA

	ARAR	Status	FDDA-1	FDDA-2	FDDA-3	FDDA-4	FDDA-5
WASTE	RCRA Subtitle C - Hazardous Waste Identification and Listing Regulations (40 CFR Parts 260-262 and 40 CFR 264.13)	Applicable	- This alternative does not meet the requirements of this ARAR.	Any media generated as part of monitoring activities and active groundwater treatment will be tested for hazardous waste characteristics. If determined to be hazardous waste, then they will be stored, transported, or disposed of in accordance with 40 CFR Part 264.	Any media generated as part of monitoring activities and active groundwater treatment will be tested for hazardous waste characteristics. If determined to be hazardous waste, then they will be stored, transported, or disposed of in accordance with 40 CFR Part 264.	Any media generated as part of monitoring activities and active groundwater treatment will be tested for hazardous waste characteristics. If determined to be hazardous waste, then they will be stored, transported, or disposed of in accordance with 40 CFR Part 264.	Any media generated as part of monitoring activities and active groundwater treatment will be tested for hazardous waste characteristics. If determined to be hazardous waste, then they will be stored, transported, or disposed of in accordance with 40 CFR Part 264.
	RCRA 40 CFR 264 Subpart I, Use and Management of Containers	Applicable if containers are used in the remedial action	- This alternative does not meet the requirements of this ARAR.	For this alternative's groundwater remedial action, if containers are used to store hazardous waste, then this alternative can be implemented to comply with this ARAR.	For this alternative's groundwater treatment, if containers are used to store hazardous waste, then this alternative can be implemented to comply with this ARAR.	For this alternative's groundwater treatment, if containers are used to store hazardous waste, then this alternative can be implemented to comply with this ARAR.	For this alternative's groundwater treatment, if containers are used to store hazardous waste, then this alternative can be implemented to comply with this ARAR.
	RCRA 40 CFR 264 Subpart J, Tank Systems	Applicable if tank systems are used in the remedial action	- This alternative does not meet the requirements of this ARAR.	For this alternative's groundwater remedial action, if tank systems are used to store or treat hazardous waste, then this alternative can be implemented to comply with this ARAR.	For this alternative's groundwater treatment, if tank systems are used to store or treat hazardous waste, then this alternative can be implemented to comply with this ARAR.	For this alternative's groundwater treatment, if tank systems are used to store or treat hazardous waste, then this alternative can be implemented to comply with this ARAR.	For this alternative's groundwater treatment, if tank systems are used to store or treat hazardous waste, then this alternative can be implemented to comply with this ARAR.
	RCRA 40 CFR 264 Subpart L, Waste Piles	Applicable if waste piles are used in the remedial action	- This alternative does not meet the requirements of this ARAR.	If piles are used to store hazardous waste (potentially such as the excavated soils prior to consolidation into one of the landfill lobes), then this alternative can be implemented to comply with this ARAR.	If piles are used to store hazardous waste (potentially such as the excavated soils prior to consolidation into one of the landfill lobes), then this alternative can be implemented to comply with this ARAR.	If piles are used to store hazardous waste (potentially such as the excavated soils prior to consolidation into one of the landfill lobes), then this alternative can be implemented to comply with this ARAR.	If piles are used to store hazardous waste (potentially such as the excavated soils prior to consolidation into one of the landfill lobes), then this alternative can be implemented to comply with this ARAR.
	RCRA 40 CFR 264 Subpart X, Miscellaneous Units	Applicable if miscellaneous units are used in the remedial action	- This alternative does not meet the requirements of this ARAR.	For this alternative's groundwater remedial action, if miscellaneous units are used to treat, store, or dispose of hazardous waste, then this alternative can be implemented to comply with this ARAR.	For this alternative's groundwater remedial action, if miscellaneous units are used to treat, store, or dispose of hazardous waste, then this alternative can be implemented to comply with this ARAR.	For this alternative's groundwater remedial action, if miscellaneous units are used to treat, store, or dispose of hazardous waste, then this alternative can be implemented to comply with this ARAR.	For this alternative's groundwater remedial action, if miscellaneous units are used to treat, store, or dispose of hazardous waste, then this alternative can be implemented to comply with this ARAR.
	RCRA 40 CFR 264 Subpart AA, Air Emission Standards for Process Vents	Applicable if thresholds are met	- This alternative does not meet the requirements of this ARAR.	For this alternative's groundwater remedial action, if process vents are used in the remedial action and if applicable thresholds are met, then air emission controls will be implemented during groundwater treatment to comply with this regulation.	For this alternative's groundwater remedial action, if process vents are used in the remedial action and if applicable thresholds are met, then air emission controls will be implemented during groundwater treatment to comply with this regulation.	For this alternative's groundwater remedial action, if process vents are used in the remedial action and if applicable thresholds are met, then air emission controls will be implemented during groundwater treatment to comply with this regulation.	For this alternative's groundwater remedial action, if process vents are used in the remedial action and if applicable thresholds are met, then air emission controls will be implemented during groundwater treatment to comply with this regulation.
	RCRA 40 CFR 264 Subpart BB, Air Emission Standards for Equipment Leaks	Applicable if thresholds are met	- This alternative does not meet the requirements of this ARAR.	For this alternative's groundwater remedial action, if equipment covered by this standard is used in the remedial action and handles hazardous wastes at concentrations that meet this rule's threshold, then a leak detection and repair program will be implemented during groundwater treatment to comply with this regulation.	For this alternative's groundwater remedial action, if equipment covered by this standard is used in the remedial action and handles hazardous wastes at concentrations that meet this rule's threshold, then a leak detection and repair program will be implemented during groundwater treatment to comply with this regulation.	For this alternative's groundwater remedial action, if equipment covered by this standard is used in the remedial action and handles hazardous wastes at concentrations that meet this rule's threshold, then a leak detection and repair program will be implemented during groundwater treatment to comply with this regulation.	For this alternative's groundwater remedial action, if equipment covered by this standard is used in the remedial action and handles hazardous wastes at concentrations that meet this rule's threshold, then a leak detection and repair program will be implemented during groundwater treatment to comply with this regulation.
	RCRA 40 CFR 264 Subpart CC, Air Emission Standards for Tanks, Surface Impoundments and Containers	Applicable if thresholds are met	- This alternative does not meet the requirements of this ARAR.	Any media generated as part of monitoring activities and groundwater treatment will be tested for hazardous waste characteristics. If determined to be hazardous waste, then they will be stored, transported, or disposed of in accordance with 40 CFR Part 264. If tanks or containers are used in the remedial action and if applicable thresholds are met, then air emission controls will be implemented during groundwater treatment to comply with this regulation.	Any media generated as part of monitoring activities and groundwater treatment will be tested for hazardous waste characteristics. If determined to be hazardous waste, then they will be stored, transported, or disposed of in accordance with 40 CFR Part 264. If tanks or containers are used in the remedial action and if applicable thresholds are met, then air emission controls will be implemented during groundwater treatment to comply with this regulation.	Any media generated as part of monitoring activities and groundwater treatment will be tested for hazardous waste characteristics. If determined to be hazardous waste, then they will be stored, transported, or disposed of in accordance with 40 CFR Part 264. If tanks or containers are used in the remedial action and if applicable thresholds are met, then air emission controls will be implemented during groundwater treatment to comply with this regulation.	Any media generated as part of monitoring activities and groundwater treatment will be tested for hazardous waste characteristics. If determined to be hazardous waste, then they will be stored, transported, or disposed of in accordance with 40 CFR Part 264. If tanks or containers are used in the remedial action and if applicable thresholds are met, then air emission controls will be implemented during groundwater treatment to comply with this regulation.
	RCRA 40 CFR 264 Subpart DD, Containment Buildings	Applicable	- This alternative does not meet the requirements of this ARAR.	For this alternative's groundwater remedial action, if a building is used to house treatment equipment, then the design, operation, closure, and post-closure of the treatment building for this alternative's groundwater remedial action will comply with this regulation.	For this alternative's groundwater remedial action, if a building is used to house treatment equipment, then the design, operation, closure, and post-closure of the treatment building for this alternative's groundwater remedial action will comply with this regulation.	For this alternative's groundwater remedial action, if a building is used to house treatment equipment, then the design, operation, closure, and post-closure of the treatment building for this alternative's groundwater remedial action will comply with this regulation.	For this alternative's groundwater remedial action, if a building is used to house treatment equipment, then the design, operation, closure, and post-closure of the treatment building for this alternative's groundwater remedial action will comply with this regulation.

APPENDIX E
TABLE E-2
ACTIONS TAKEN TO COMPLY WITH ARARs and TBCs - FORMER DRUM DISPOSAL AREA

	ARAR	Status	FDDA-1	FDDA-2	FDDA-3	FDDA-4	FDDA-5
SURFACE WATER	**Federal Regulatory Requirements**						
	Clean Water Act National Pollutants Discharge Elimination System (NPDES) (40 CFR Part 122-125 and 131)	Applicable	- This ARAR is not specific to this alternative.	On-site discharges to surface waters, including Sutton Brook and adjacent wetlands, shall meet these substantive discharge standards.	On-site discharges to surface waters, including Sutton Brook and adjacent wetlands, shall meet these substantive discharge standards.	On-site discharges to surface waters, including Sutton Brook and adjacent wetlands, shall meet these substantive discharge standards.	On-site discharges to surface waters, including Sutton Brook and adjacent wetlands, shall meet these substantive discharge standards.
	Clean Water Act (CWA) Ambient Water Quality Criteria (AWQC) (33 USC 1251 *et seq*.) (40 CFR 122.44)	Applicable	- This ARAR is not specific to this alternative.	If treated groundwater is discharged to surface water, it would be treated as needed to comply with this ARAR.	If treated groundwater is discharged to surface water, it would be treated as needed to comply with this ARAR.	If treated groundwater is discharged to surface water, it would be treated as needed to comply with this ARAR.	If treated groundwater is discharged to surface water, it would be treated as needed to comply with this ARAR.
	State Regulatory Requirements						
	Clean Waters Act - MassDEP Surface Water Discharge Permit Program (314 CMR 3.00; MGL c. 21 Sections 26-53)	Applicable	- This ARAR is not specific to this alternative.	Any on-site discharges to surface waters, including Sutton Brook and adjacent wetlands, shall meet these substantive discharge standards.	Any on-site discharges to surface waters, including Sutton Brook and adjacent wetlands, shall meet these substantive discharge standards.	Any on-site discharges to surface waters, including Sutton Brook and adjacent wetlands, shall meet these substantive discharge standards.	Any on-site discharges to surface waters, including Sutton Brook and adjacent wetlands, shall meet these substantive discharge standards.
	Massachusetts Surface Water Quality Standards (314 CMR 4.00)	Applicable	- This ARAR is not specific to this alternative.	Any on-site discharges to surface waters, including Sutton Brook and adjacent wetlands, shall meet these substantive discharge standards.	Any on-site discharges to surface waters, including Sutton Brook and adjacent wetlands, shall meet these substantive discharge standards.	Any on-site discharges to surface waters, including Sutton Brook and adjacent wetlands, shall meet these substantive discharge standards.	Any on-site discharges to surface waters, including Sutton Brook and adjacent wetlands, shall meet these substantive discharge standards.
	MassDEP Surface Water Discharge Permit Program (314 CMR 3.00)	Applicable	- This ARAR is not specific to this alternative.	Any on-site discharges to surface waters, including Sutton Brook and adjacent wetlands, shall meet these substantive discharge standards.	Any on-site discharges to surface waters, including Sutton Brook and adjacent wetlands, shall meet these substantive discharge standards.	Any on-site discharges to surface waters, including Sutton Brook and adjacent wetlands, shall meet these substantive discharge standards.	Any on-site discharges to surface waters, including Sutton Brook and adjacent wetlands, shall meet these substantive discharge standards.
GROUNDWATER	**Federal Regulatory Requirements**						
	RCRA Subtitle C - Releases from Solid Waste Management Units (40 CFR Subpart F, 264.95 and 264.96(a) and (c))	Applicable	- This ARAR is not specific to this alternative.	This alternative's monitoring program can be designed and implemented to comply with this ARAR.	This alternative's monitoring program can be designed and implemented to comply with this ARAR.	This alternative's monitoring program can be designed and implemented to comply with this ARAR.	This alternative's monitoring program can be designed and implemented to comply with this ARAR.
	Underground Injection (40 CFR Part 144)	Relevant and appropriate	- This ARAR is not specific to this alternative.	If the performance of this alternative chooses underground injection, infiltration gallery or any other system that disposes of treatment water or waste into groundwater as the remediation technology, groundwater would be treated to be non-hazardous prior to subsurface discharge.	If the performance of this alternative chooses underground injection, infiltration gallery or any other system that disposes of treatment water or waste into groundwater as the remediation technology, groundwater would be treated to be non-hazardous prior to subsurface discharge.	If the performance of this alternative chooses underground injection, infiltration gallery or any other system that disposes of treatment water or waste into groundwater as the remediation technology, groundwater would be treated to be non-hazardous prior to subsurface discharge.	If the performance of this alternative chooses underground injection, infiltration gallery or any other system that disposes of treatment water or waste into groundwater as the remediation technology, groundwater would be treated to be non-hazardous prior to subsurface discharge.
	Final OSWER Directive "Use of Monitored Natural Attenuation at Superfund, RCRA Corrective Action, and Underground Storage Tank Sites (OSWER Dir. 9200.4-17P, 4/12/99)	To be considered	This policy is not specific to this alternative.	This policy is not specific to this alternative.	This policy is not specific to this alternative.	Under this alternative, contaminant levels in the groundwater plume will be monitored consistent with this guidance.	This policy is not specific to this alternative.
	State Regulatory Requirements						
	MassDEP Underground Injection Control Requirements (310 CMR 27.00)	Applicable	- This ARAR is not specific to this alternative.	If the performance of this alternative chooses underground injection, infiltration gallery or any other system that disposes of treatment water or waste into groundwater as the remediation technology, groundwater would be treated to be non-hazardous prior to subsurface discharge.	If the performance of this alternative chooses underground injection, infiltration gallery or any other system that disposes of treatment water or waste into groundwater as the remediation technology, groundwater would be treated to be non-hazardous prior to subsurface discharge.	If the performance of this alternative chooses underground injection, infiltration gallery or any other system that disposes of treatment water or waste into groundwater as the remediation technology, groundwater would be treated to be non-hazardous prior to subsurface discharge.	If the performance of this alternative chooses underground injection, infiltration gallery or any other system that disposes of treatment water or waste into groundwater as the remediation technology, groundwater would be treated to be non-hazardous prior to subsurface discharge.

APPENDIX E
TABLE E-2
ACTIONS TAKEN TO COMPLY WITH ARARs and TBCs - FORMER DRUM DISPOSAL AREA

	ARAR	Status	FDDA-1	FDDA-2	FDDA-3	FDDA-4	FDDA-5
GROUNDWATER	MassDEP Groundwater Discharge Permit Program (314 CMR 5.00)	Applicable	- This ARAR is not specific to this alternative.	If the performance of this alternative chooses underground injection, infiltration gallery or any other system that disposes of treatment water or waste into groundwater as the remediation technology, groundwater would be treated to be non-hazardous prior to subsurface discharge.	If the performance of this alternative chooses underground injection, infiltration gallery or any other system that disposes of treatment water or waste into groundwater as the remediation technology, groundwater would be treated to be non-hazardous prior to subsurface discharge.	If the performance of this alternative chooses underground injection, infiltration gallery or any other system that disposes of treatment water or waste into groundwater as the remediation technology, groundwater would be treated to be non-hazardous prior to subsurface discharge.	If the performance of this alternative chooses underground injection, infiltration gallery or any other system that disposes of treatment water or waste into groundwater as the remediation technology, groundwater would be treated to be non-hazardous prior to subsurface discharge.
	Massachusetts Well Decommissioning Requirements (313 CMR 3.03)	Applicable	- This ARAR is not specific to this alternative.	These regulations will be followed to the extent that the alternative involves decommissioning any wells.	These regulations will be followed to the extent that the alternative involves decommissioning any wells.	These regulations will be followed to the extent that the alternative involves decommissioning any wells.	These regulations will be followed to the extent that the alternative involves decommissioning any wells.
SOIL/ SEDIMENT	**State Regulatory Requirements**						
	Reuse and Disposal of Contaminated Soils at Massachusetts Landfills (COMM-97-001)	To be considered	This policy is not specific to this alternative.	This policy is not specific to this alternative.	- This alternative can be designed and implemented to comply with this policy.	- This alternative can be designed and implemented to comply with this policy.	- This alternative can be designed and implemented to comply with this policy.
Air	**Federal Regulatory Requirements**						
	Clean Air Act National Emissions Standards for Hazardous Air Pollutants (NESHAPs), 40 CFR Part 61	Applicable	- This ARAR is not specific to this alternative.	For this alternative's groundwater remedial action, if air stripping is used and any of the 189 Hazardous Air pollutants are emitted, then this alternative's groundwater remedial action will comply with this ARAR.	For this alternative's groundwater remedial action, if air stripping is used and any of the 189 Hazardous Air pollutants are emitted, then this alternative's groundwater remedial action will comply with this ARAR.	For this alternative's groundwater remedial action, if air stripping is used and any of the 189 Hazardous Air pollutants are emitted, then this alternative's groundwater remedial action will comply with this ARAR.	For this alternative's groundwater remedial action, if air stripping is used and any of the 189 Hazardous Air pollutants are emitted, then this alternative's groundwater remedial action will comply with this ARAR.
	OSWER Directive 9355.0-28, Air Stripper Control Guidance, 7/12/89	To be considered	This policy is not specific to this alternative.	For this alternative's groundwater remedial action, if air stripping is used, then this alternative's groundwater remedial action will comply with this policy.	For this alternative's groundwater remedial action, if air stripping is used, then this alternative's groundwater remedial action will comply with this policy.	For this alternative's groundwater remedial action, if air stripping is used, then this alternative's groundwater remedial action will comply with this policy.	For this alternative's groundwater remedial action, if air stripping is used, then this alternative's groundwater remedial action will comply with this policy.
	State Regulatory Requirements						
	Massachusetts Ambient Air Quality Standards (310 CMR 6.00)	Applicable	- This ARAR is not specific to this alternative.	For this alternative's groundwater remedial action, if air stripping is used, then this alternative's groundwater remedial action will comply with this ARAR. No air emissions from remedial treatment will cause ambient air quality standards to be exceeded.	For this alternative's groundwater remedial action, if air stripping is used, then this alternative's groundwater remedial action will comply with this ARAR. No air emissions from remedial treatment will cause ambient air quality standards to be exceeded.	For this alternative's groundwater remedial action, if air stripping is used, then this alternative's groundwater remedial action will comply with this ARAR. No air emissions from remedial treatment will cause ambient air quality standards to be exceeded.	For this alternative's groundwater remedial action, if air stripping is used, then this alternative's groundwater remedial action will comply with this ARAR. No air emissions from remedial treatment will cause ambient air quality standards to be exceeded.
	MassDEP Revised Ambient Air Guidelines (December 6, 1995)	To be considered	This policy is not specific to this alternative.	- This alternative can be designed and implemented to comply with this policy.	- This alternative can be designed and implemented to comply with this policy.	- This alternative can be designed and implemented to comply with this policy.	- This alternative can be designed and implemented to comply with this policy.
	Massachusetts Air Pollution Control Regulations (310 CMR 7.00)	Applicable	- This ARAR is not specific to this alternative.	For this alternative's groundwater remedial action, if air stripping is used, then this alternative's groundwater remedial action will comply with this ARAR. Odor emissions from the groundwater treatment air stripper will be controlled with best available control technology.	For this alternative's groundwater remedial action, if air stripping is used, then this alternative's groundwater remedial action will comply with this ARAR. Odor emissions from the groundwater treatment air stripper will be controlled with best available control technology.	For this alternative's groundwater remedial action, if air stripping is used, then this alternative's groundwater remedial action will comply with this ARAR. Odor emissions from the groundwater treatment air stripper will be controlled with best available control technology.	For this alternative's groundwater remedial action, if air stripping is used, then this alternative's groundwater remedial action will comply with this ARAR. Odor emissions from the groundwater treatment air stripper will be controlled with best available control technology.

APPENDIX E
TABLE E-3
ACTIONS TAKEN TO COMPLY WITH ARARs - GARAGE AND STORAGE AREA

	ARAR	Status	GSA-1	GSA-2
CHEMICAL SPECIFIC				
SEDIMENT/SOIL	**State Regulatory Requirements**			
	Massachusetts Contingency Plan (310 CMR 40.0000), Method 1 Standards	Relevant and Appropriate	- This alternative will not meet the PRGs established and therefore not comply with this ARAR.	Under this alternative, soils in excess of PRGs (either based on this ARAR and/or on site-specific human health and ecological derived PRGs) will be excavated and disposed.
LOCATION SPECIFIC				
SURFACE WATER/ WETLANDS/ FLOODPLAINS	**Federal Regulatory Requirements and Guidance**			
	Wetlands Executive Order (EO11990), 40 CFR Part 6, Appendix A	Applicable	- This ARAR is not specific to this alternative.	Under this alternative, the excavation of soils would result in work areas near but outside of delineated wetland boundaries. During remedial design the effects of remedial activities on the wetlands will be evaluated and minimized. Compensatory wetlands mitigation would be performed as necessary to comply with this ARAR.
	Clean Water Act Section 404 Dredge and Fill Regulations (40 CFR 230, 33 CFR 320-323)	Applicable	- This ARAR is not specific to this alternative.	Under this alternative, the excavation of soils would result in work areas near but outside of delineated wetland boundaries. During remedial design the effects of remedial activities on the wetlands will be evaluated and minimized. Compensatory wetlands mitigation would be performed as necessary to comply with this ARAR.
	Rivers and Harbors Act Section 10 (33 USC 403, 33 CFR 320-323)	Applicable	- This ARAR is not specific to this alternative.	Under this alternative, the excavation of soils would result in work areas near but outside of delineated wetland boundaries. During remedial design the effects of remedial activities on the wetlands will be evaluated and minimized. Compensatory wetlands mitigation would be performed as necessary to comply with this ARAR.
	Floodplains Executive Order (EO11988), 40 CFR Part 6, Appendix A	Applicable	- This ARAR is not specific to this alternative.	Available practicable means will be used to reduce the risk of flood loss, to minimize the impact of floods and to restore and preserve the floodplains.
	RCRA Floodplain Restrictions for Hazardous Waste Facilities (40 CFR 264.18(b))	Relevant and Appropriate	- This ARAR is not specific to this alternative.	- This ARAR is not specific to the Garage and Storage area
	Fish and Wildlife Coordination Act (16 USC 661 et seq, 40 CFR Part 6)	Applicable	- This ARAR is not specific to this alternative.	- This ARAR is not specific to the Garage and Storage area

APPENDIX E
TABLE E-3
ACTIONS TAKEN TO COMPLY WITH ARARs - GARAGE AND STORAGE AREA

	ARAR	Status	GSA-1	GSA-2
SURFACE WATER/ WETLANDS/ FLOODPLAINS	**State Regulatory Requirements**			
	Massachusetts Wetlands Regulations (310 CMR 10.00, MGL c. 131, Section 40: Wetlands Protection Act)	Applicable	- This ARAR is not specific to this alternative.	Under this alternative, the excavation of soils would result in work areas near but outside of delineated wetland boundaries. During remedial design the effects of remedial activities on the wetlands will be evaluated and minimized. Compensatory wetlands mitigation would be performed as necessary to comply with this ARAR.
	Massachusetts Water Quality Certification for Discharge of Dredged or Fill Material, Dredging, and Dredging Material Disposal in Waters of the U.S. within the Commonwealth (314 CMR 9.00)	Applicable	- This ARAR is not specific to this alternative.	- This ARAR is not specific to the Garage and Storage area
	Massachusetts Waterways Regulations (310 CMR 9.00)	Applicable	- This ARAR is not specific to this alternative.	Under this alternative, the excavation of soils would result in work areas near but outside of delineated wetland boundaries. During remedial design the effects of remedial activities on the wetlands will be evaluated and minimized. Compensatory wetlands mitigation would be performed as necessary to comply with this ARAR.
	Massachusetts Hazardous Waste Rules, Facility Location Standards (310 CMR 30.700)	Applicable	- This ARAR is not specific to this alternative.	- This ARAR is not specific to the Garage and Storage area
OTHER NATURAL RESOURCES	**Federal Regulatory Requirements**			
	Endangered Species Act (16 USC 1531 et seq.; 40 CFR 6.302(h); 50 CFR 402)	Applicable if encountered	- This ARAR is not specific to this alternative.	If endangered or threatened species in the site area are identified, remedial activities would avoid actions that would adversely affect threatened or endangered species or habitats.
	National Historic Preservation Act (16 USC 470 et seq., 36 CFR 800)	Applicable if encountered	- This ARAR is not specific to this alternative.	Should this alternative impact historic properties, as determined in the remedial design, activities will be coordinated with the Massachusetts Historical Commission (MHC). If it is determined that adverse impacts are unavoidable, then MHC will be consulted to determine ways to minimize and/or mitigate such adverse impacts.
	State Regulatory Requirements			
	Antiquities Act and Regulations; Massachusetts Historical Commission; Protection of Properties Included in the State Register of Historic Places (M.G.L. ch. 9, sec. 26-27; 950 CMR 70.00)	Applicable if encountered	- This ARAR is not specific to this alternative.	Should this alternative impact historic or archaeological properties, as determined in the remedial design, activities will be coordinated with the Massachusetts Historical Commission (MHC). If it is determined that adverse impacts cannot be eliminated, then MHC will be consulted to determine ways to minimize and/or mitigate such adverse impacts.
	Massachusetts Endangered Species Act, 321 CMR 10.00, (MGL c. 131A)	Applicable if encountered	- This ARAR is not specific to this alternative.	If endangered or threatened species in the site area are identified, remedial activities would avoid actions that would adversely affect threatened or endangered species or habitats.

APPENDIX E
TABLE E-3
ACTIONS TAKEN TO COMPLY WITH ARARs - GARAGE AND STORAGE AREA

	ARAR	Status	GSA-1	GSA-2
ACTION SPECIFIC				
SITE WORK	**State Regulatory Requirements**			
	Massachusetts Air Pollution Control Regulations (310 CMR 7.00)	Applicable	- This ARAR is not specific to this alternative.	Construction activities will be managed to meet the standards for visible emissions (310 CMR 7.06); dust, odor, construction, and demolition (310 CMR 7.09); and noise (310 CMR 7.10).
	MassDEP Stormwater Management Policy	To be considered	- This policy is not specific to this alternative.	This alternative can be designed and implemented to comply with this requirement.
SOIL	**State Regulatory Requirements**			
	Reuse and Disposal of Contaminated Soils at Massachusetts Landfills (COMM-97-001)	To be considered	- This policy is not specific to this alternative.	- This alternative can be designed and implemented to comply with this policy.

APPENDIX E
TABLE E-4
ACTIONS TAKEN TO COMPLY WITH ARARs and TBCs - DOWNGRADIENT GROUNDWATER

	ARAR	Status	DGGW-1	DGGW-2	DGGW-3	DGGW-4
CHEMICAL SPECIFIC						
GROUNDWATER	**Federal Regulatory Requirements**					
	Federal Safe Drinking Water Act (SDWA) Maximum Contaminant Levels (MCLs) (40 CFR Part 141.11-141.16)	Relevant and appropriate	- This alternative will not meet the PRGs established and therefore not comply with this ARAR.	MCLs were used in determining groundwater preliminary remediation goals (PRGs) for site contaminants where such contaminant levels have been established. Under this alternative, the groundwater approach will over time prevent groundwater exceeding MCLs from migrating beyond the point of compliance.	MCLs were used in determining groundwater preliminary remediation goals (PRGs) for site contaminants where such contaminant levels have been established. Under this alternative, the groundwater approach will over time prevent groundwater exceeding MCLs from migrating beyond the point of compliance.	MCLs were used in determining groundwater preliminary remediation goals (PRGs) for site contaminants where such contaminant levels have been established. Under this alternative, the groundwater approach will over time prevent groundwater exceeding MCLs from migrating beyond the point of compliance.
	SDWA Maximum Contaminant Level Goals (MCLGs) (40 CFR Part 141.50-141.51)	Relevant and appropriate	- This alternative will not meet the PRGs established and therefore not comply with this ARAR.	Non-zero MCLGs were used in determining PRGs when MCLs have not been established for a particular contaminant. Under this alternative, the groundwater approach will over time prevent groundwater exceeding MCLGs from migrating beyond the point of compliance.	Non-zero MCLGs were used in determining PRGs when MCLs have not been established for a particular contaminant. Under this alternative, the groundwater approach will over time prevent groundwater exceeding MCLGs from migrating beyond the point of compliance.	Non-zero MCLGs were used in determining PRGs when MCLs have not been established for a particular contaminant. Under this alternative, the groundwater approach will over time prevent groundwater exceeding MCLGs from migrating beyond the point of compliance.
	EPA Risk Reference Doses (RfDs)	To be considered	- This alternative will not meet the PRGs established and therefore not comply with this TBC	RfDs were used to assess health risks due to exposure to non-carcinogenic chemicals in groundwater, and to develop acceptable groundwater PRG concentrations. Under this alternative, the groundwater approach will over time prevent groundwater exceeding PRGs from migrating beyond the point of compliance.	RfDs were used to assess health risks due to exposure to non-carcinogenic chemicals in groundwater, and to develop acceptable groundwater PRG concentrations. Under this alternative, the groundwater approach will over time prevent groundwater exceeding PRGs from migrating beyond the point of compliance.	RfDs were used to assess health risks due to exposure to non-carcinogenic chemicals in groundwater, and to develop acceptable groundwater PRG concentrations. Under this alternative, the groundwater approach will over time prevent groundwater exceeding PRGs from migrating beyond the point of compliance.
	EPA Human Health Assessment Cancer Slope Factors (CSFs)	To be considered	- This alternative will not meet the PRGs established and therefore not comply with this TBC	CSFs were used to compute the individual cancer risk resulting from exposure to contaminants and in the development of acceptable groundwater PRG concentrations. Under this alternative, the groundwater approach will over time prevent groundwater exceeding PRGs from migrating beyond the point of compliance.	CSFs were used to compute the individual cancer risk resulting from exposure to contaminants and in the development of acceptable groundwater PRG concentrations. Under this alternative, the groundwater approach will over time prevent groundwater exceeding PRGs from migrating beyond the point of compliance.	CSFs were used to compute the individual cancer risk resulting from exposure to contaminants and in the development of acceptable groundwater PRG concentrations. Under this alternative, the groundwater approach will over time prevent groundwater exceeding PRGs from migrating beyond the point of compliance.
	Guidelines for Carcinogen Risk Assessment (EPA/630/P-03/001F, March 2005)	To be considered	- This alternative will not meet the PRGs established and therefore not comply with this TBC	Potential cancer risks identified will be addressed by this alternative.	Potential cancer risks identified will be addressed by this alternative.	Potential cancer risks identified will be addressed by this alternative.
	Supplemental Guidance for Assessing Susceptibility from Early-Life Exposure to Carcinogens (EPA/630/R-03/003F, March 2005)	To be considered	- This alternative will not meet the PRGs established and therefore not comply with this TBC	Potential child cancer risks identified will be addressed by this alternative.	Potential child cancer risks identified will be addressed by this alternative.	Potential child cancer risks identified will be addressed by this alternative.
	State Regulatory Requirements					
	Massachusetts Groundwater Quality Standards (314 CMR 6.00)	Relevant and appropriate	- This alternative will not meet the PRGs established and therefore not comply with this ARAR.	Groundwater beneath the site is mapped in a potentially productive aquifer with the potential for potable water use. Under this alternative, the groundwater approach will over time prevent groundwater exceeding PRGs from migrating beyond the point of compliance.	Groundwater beneath the site is mapped in a potentially productive aquifer with the potential for potable water use. Under this alternative, the groundwater approach will over time prevent groundwater exceeding PRGs from migrating beyond the point of compliance.	Groundwater beneath the site is mapped in a potentially productive aquifer with the potential for potable water use. Under this alternative, the groundwater approach will over time prevent groundwater exceeding PRGs from migrating beyond the point of compliance.
	Massachusetts Drinking Water Standards (310 CMR 22.00)	Relevant and appropriate	- This alternative will not meet the PRGs established and therefore not comply with this ARAR.	Under this alternative, the groundwater approach will over time prevent groundwater exceeding PRGs from migrating beyond the point of compliance.	Under this alternative, the groundwater approach will over time prevent groundwater exceeding PRGs from migrating beyond the point of compliance.	Under this alternative, the groundwater approach will over time prevent groundwater exceeding PRGs from migrating beyond the point of compliance.
	Massachusetts Contingency Plan (310 CMR 40.0000), Method 1 Standards	Relevant and appropriate	- This alternative will not meet the PRGs established and therefore not comply with this ARAR.	Under this alternative, the groundwater approach will over time prevent groundwater exceeding PRGs from migrating beyond the point of compliance.	Under this alternative, the groundwater approach will over time prevent groundwater exceeding PRGs from migrating beyond the point of compliance.	Under this alternative, the groundwater approach will over time prevent groundwater exceeding PRGs from migrating beyond the point of compliance.
	Massachusetts Office of Research and Standards Guidelines (ORSG)	To be considered	- This alternative will not meet the PRGs established and therefore not comply with this TBC.	Under this alternative, the groundwater approach will over time prevent groundwater exceeding PRGs from migrating beyond the point of compliance.	Under this alternative, the groundwater approach will over time prevent groundwater exceeding PRGs from migrating beyond the point of compliance.	Under this alternative, the groundwater approach will over time prevent groundwater exceeding PRGs from migrating beyond the point of compliance.

APPENDIX E
TABLE E-4
ACTIONS TAKEN TO COMPLY WITH ARARs and TBCs - DOWNGRADIENT GROUNDWATER

	ARAR	Status	DGGW-1	DGGW-2	DGGW-3	DGGW-4
SURFACE WATER	**Federal Regulatory Requirements**					
	Clean Water Act (CWA) Ambient Water Quality Criteria (AWQC) (33 USC 1251 *et seq*.)	To be considered	- This TBC is not specific to this alternative.	- If groundwater extraction and ex-situ treatment is implemented and discharge of treated groundwater to surface water is the selected discharge method, then this alternative can be designed and implemented to meet these criteria.	- If discharge of treated groundwater to surface water is the selected discharge method, then this alternative can be designed and implemented to meet these criteria.	- If discharge of treated groundwater to surface water is the selected discharge method, then this alternative can be designed and implemented to meet these criteria.
LOCATION SPECIFIC						
SURFACE WATER/ WETLANDS/ FLOODPLAINS	**Federal Regulatory Requirements**					
	Wetlands Executive Order (EO11990), 40 CFR Part 6, Appendix A	Applicable	- This ARAR is not specific to this alternative.	- This alternative can be designed and implemented to meet these requirements.	Under this alternative, the installation of wells and utilities would result in the unavoidable destruction of wetlands. During remedial design the effects of remedial activities on the wetlands will be evaluated and minimized. Compensatory wetlands mitigation would be performed as necessary to comply with this ARAR.	Under this alternative, the installation of wells and utilities would result in the unavoidable destruction of wetlands. During remedial design the effects of remedial activities on the wetlands will be evaluated and minimized. Compensatory wetlands mitigation would be performed as necessary to comply with this ARAR.
	Clean Water Act Section 404 Dredge and Fill Regulations (40 CFR 230, 33 CFR 320-323)	Applicable	- This ARAR is not specific to this alternative.	- This alternative can be designed and implemented to meet these requirements.	Under this alternative, the installation of wells and utilities would result in the unavoidable destruction of wetlands. During remedial design the effects of remedial activities on the wetlands will be evaluated and minimized. Compensatory wetlands mitigation would be performed as necessary to comply with this ARAR.	Under this alternative, the installation of wells and utilities would result in the unavoidable destruction of wetlands. During remedial design the effects of remedial activities on the wetlands will be evaluated and minimized. Compensatory wetlands mitigation would be performed as necessary to comply with this ARAR.
	Rivers and Harbors Act Section 10 (33 USC 403, 33 CFR 320-323)	Applicable	- This ARAR is not specific to this alternative.	- This ARAR is not specific to the Downgradient Groundwater area.	- This ARAR is not specific to the Downgradient Groundwater area.	- This ARAR is not specific to the Downgradient Groundwater area.
	Floodplains Executive Order (EO11988), 40 CFR Part 6, Appendix A	Applicable	- This ARAR is not specific to this alternative.	- This alternative can be designed and implemented to meet these requirements.	Available practicable means will be used to reduce the risk of flood loss, to minimize the impact of floods and to restore and preserve the floodplains. In areas where the work will result in the filling in of areas within the 100-year floodplain, there will be a replication of 100-year floodplain space equivalent to the amount loss by this work.	Available practicable means will be used to reduce the risk of flood loss, to minimize the impact of floods and to restore and preserve the floodplains. In areas where the work will result in the filling in of areas within the 100-year floodplain, there will be a replication of 100-year floodplain space equivalent to the amount loss by this work.
	RCRA Floodplain Restrictions for Hazardous Waste Facilities (40 CFR 264.18(b))	Relevant and Appropriate	- This ARAR is not specific to this alternative.	- This ARAR is not specific to the Downgradient Groundwater area.	- This ARAR is not specific to the Downgradient Groundwater area.	- This ARAR is not specific to the Downgradient Groundwater area.
	Fish and Wildlife Coordination Act (16 USC 661 et seq, 40 CFR Part 6)	Applicable	- This ARAR is not specific to this alternative.	- This ARAR is not specific to the Downgradient Groundwater area.	- This ARAR is not specific to the Downgradient Groundwater area.	- This ARAR is not specific to the Downgradient Groundwater area.
	State Regulatory Requirements					
	Massachusetts Wetlands Regulations (310 CMR 10.00, MGL c. 131, Section 40: Wetlands Protection Act)	Applicable	- This ARAR is not specific to this alternative.	- This alternative can be designed and implemented to meet these requirements.	Under this alternative, the installation of wells and utilities would result in the unavoidable destruction of wetlands. During remedial design the effects of remedial activities on the wetlands will be evaluated and minimized. Compensatory wetlands mitigation would be performed as necessary to comply with this ARAR.	Under this alternative, the installation of wells and utilities would result in the unavoidable destruction of wetlands. During remedial design the effects of remedial activities on the wetlands will be evaluated and minimized. Compensatory wetlands mitigation would be performed as necessary to comply with this ARAR.

APPENDIX E
TABLE E-4
ACTIONS TAKEN TO COMPLY WITH ARARs and TBCs - DOWNGRADIENT GROUNDWATER

	ARAR	Status	DGGW-1	DGGW-2	DGGW-3	DGGW-4
SURFACE WATER/ WETLANDS/ FLOODPLAINS	Massachusetts Water Quality Certification for Discharge of Dredged or Fill Material, Dredging, and Dredging Material Disposal in Waters of the U.S. within the Commonwealth (314 CMR 9.00)	Applicable	- This ARAR is not specific to this alternative.	- This alternative can be designed and implemented to meet these requirements.	Under this alternative, the installation of wells and utilities would result in the unavoidable destruction of wetlands. During remedial design the effects of remedial activities on the wetlands will be evaluated and minimized. Compensatory wetlands mitigation would be performed as necessary to comply with this ARAR.	Under this alternative, the installation of wells and utilities would result in the unavoidable destruction of wetlands. During remedial design the effects of remedial activities on the wetlands will be evaluated and minimized. Compensatory wetlands mitigation would be performed as necessary to comply with this ARAR.
	Massachusetts Waterways Regulations (310 CMR 9.00)	Applicable	- This ARAR is not specific to this alternative.	- This alternative can be designed and implemented to meet these requirements.	Under this alternative, the installation of wells and utilities would result in the unavoidable destruction of wetlands. During remedial design the effects of remedial activities on the wetlands will be evaluated and minimized. Compensatory wetlands mitigation would be performed as necessary to comply with this ARAR.	Under this alternative, the installation of wells and utilities would result in the unavoidable destruction of wetlands. During remedial design the effects of remedial activities on the wetlands will be evaluated and minimized. Compensatory wetlands mitigation would be performed as necessary to comply with this ARAR.
	Massachusetts Hazardous Waste Rules, Facility Location Standards (310 CMR 30.700)	Applicable	- This ARAR is not specific to this alternative.	Any remedial structures within Land Subject to Flooding and potential public water supply area, will be designed, constructed, operated, and maintained to prevent a release of hazardous waste within the protected resource area.	Any remedial structures within Land Subject to Flooding and potential public water supply area, will be designed, constructed, operated, and maintained to prevent a release of hazardous waste within the protected resource area.	Any remedial structures within Land Subject to Flooding and potential public water supply area, will be designed, constructed, operated, and maintained to prevent a release of hazardous waste within the protected resource area.
OTHER NATURAL RESOURCES	**Federal Regulatory Requirements**					
	Endangered Species Act (16 USC 1531 et seq.; 40 CFR 6.302(h); 50 CFR 402)	Applicable if encountered	- This ARAR is not specific to this alternative.	If endangered or threatened species in the site area are identified, remedial activities would avoid actions that would adversely affect threatened or endangered species or habitats.	If endangered or threatened species in the site area are identified, remedial activities would avoid actions that would adversely affect threatened or endangered species or habitats.	If endangered or threatened species in the site area are identified, remedial activities would avoid actions that would adversely affect threatened or endangered species or habitats.
	National Historic Preservation Act (16 USC 470 et seq., 36 CFR 800)	Applicable if encountered	- This ARAR is not specific to this alternative.	Should this alternative impact historic properties, as determined in the remedial design, activities will be coordinated with the Massachusetts Historical Commission (MHC). If it is determined that adverse impacts are unavoidable, then MHC will be consulted to determine ways to minimize and/or mitigate such adverse impacts.	Should this alternative impact historic properties, as determined in the remedial design, activities will be coordinated with the Massachusetts Historical Commission (MHC). If it is determined that adverse impacts are unavoidable, then MHC will be consulted to determine ways to minimize and/or mitigate such adverse impacts.	Should this alternative impact historic properties, as determined in the remedial design, activities will be coordinated with the Massachusetts Historical Commission (MHC). If it is determined that adverse impacts are unavoidable, then MHC will be consulted to determine ways to minimize and/or mitigate such adverse impacts.
	State Regulatory Requirements					
	Antiquities Act and Regulations; Massachusetts Historical Commission; Protection of Properties Included in the State Register of Historic Places (M.G.L. ch. 9, sec. 26-27; 950 CMR 70.00)	Applicable if encountered	- This ARAR is not specific to this alternative.	Should this alternative impact historic or archaeological properties, as determined in the remedial design, activities will be coordinated with the Massachusetts Historical Commission (MHC). If it is determined that adverse impacts cannot be eliminated, then MHC will be consulted to determine ways to minimize and/or mitigate such adverse impacts.	Should this alternative impact historic or archaeological properties, as determined in the remedial design, activities will be coordinated with the Massachusetts Historical Commission (MHC). If it is determined that adverse impacts cannot be eliminated, then MHC will be consulted to determine ways to minimize and/or mitigate such adverse impacts.	Should this alternative impact historic or archaeological properties, as determined in the remedial design, activities will be coordinated with the Massachusetts Historical Commission (MHC). If it is determined that adverse impacts cannot be eliminated, then MHC will be consulted to determine ways to minimize and/or mitigate such adverse impacts.
	Massachusetts Endangered Species Act, 321 CMR 10.00, (MGL c. 131A)	Applicable if encountered	- This ARAR is not specific to this alternative.	If endangered or threatened species in the site area are identified, remedial activities would avoid actions that would adversely affect threatened or endangered species or habitats.	If endangered or threatened species in the site area are identified, remedial activities would avoid actions that would adversely affect threatened or endangered species or habitats.	If endangered or threatened species in the site area are identified, remedial activities would avoid actions that would adversely affect threatened or endangered species or habitats.
ACTION SPECIFIC						
SITE WORK	**State Regulatory Requirements**					
	Massachusetts Air Pollution Control Regulations (310 CMR 7.00)	Applicable	- This ARAR is not specific to this alternative.	This alternative can be designed and implemented to comply with this requirement.	Construction activities will be managed to meet the standards for visible emissions (310 CMR 7.06); dust, odor, construction, and demolition (310 CMR 7.09); and noise (310 CMR 7.10).	Construction activities will be managed to meet the standards for visible emissions (310 CMR 7.06); dust, odor, construction, and demolition (310 CMR 7.09); and noise (310 CMR 7.10).
	MassDEP Stormwater Management Policy	To be considered	This policy is not specific to this alternative.	This alternative can be designed and implemented to comply with this requirement.	This alternative can be designed and implemented to comply with this requirement.	This alternative can be designed and implemented to comply with this requirement.

APPENDIX E
TABLE E-4
ACTIONS TAKEN TO COMPLY WITH ARARs and TBCs - DOWNGRADIENT GROUNDWATER

	ARAR	Status	DGGW-1	DGGW-2	DGGW-3	DGGW-4
WASTE	**Federal Regulatory Requirements**					
	RCRA Subtitle C - Hazardous Waste Identification and Listing Regulations (40 CFR Parts 260-262 and 40 CFR 264.13)	Applicable	- This alternative does not meet the requirements of this ARAR.	Any media generated as part of monitoring activities and active groundwater treatment will be tested for hazardous waste characteristics. If determined to be hazardous waste, then they will be stored, transported, or disposed of in accordance with 40 CFR Part 264.	Any media generated as part of monitoring activities and active groundwater treatment will be tested for hazardous waste characteristics. If determined to be hazardous waste, then they will be stored, transported, or disposed of in accordance with 40 CFR Part 264.	Any media generated as part of monitoring activities and active groundwater treatment will be tested for hazardous waste characteristics. If determined to be hazardous waste, then they will be stored, transported, or disposed of in accordance with 40 CFR Part 264.
	RCRA 40 CFR 264 Subpart I, Use and Management of Containers	Applicable if containers are used in the remedial action	- This alternative does not meet the requirements of this ARAR.	For this alternative's groundwater remedial action, if containers are used to store hazardous waste, then this alternative can be implemented to comply with this ARAR.	For this alternative's groundwater treatment, if containers are used to store hazardous waste, then this alternative can be implemented to comply with this ARAR.	For this alternative's groundwater treatment, if containers are used to store hazardous waste, then this alternative can be implemented to comply with this ARAR.
	RCRA 40 CFR 264 Subpart J, Tank Systems	Applicable if tank systems are used in the remedial action	- This alternative does not meet the requirements of this ARAR.	For this alternative's groundwater remedial action, if tank systems are used to store or treat hazardous waste, then this alternative can be implemented to comply with this ARAR.	For this alternative's groundwater treatment, if tank systems are used to store or treat hazardous waste, then this alternative can be implemented to comply with this ARAR.	For this alternative's groundwater treatment, if tank systems are used to store or treat hazardous waste, then this alternative can be implemented to comply with this ARAR.
	RCRA 40 CFR 264 Subpart X, Miscellaneous Units	Applicable if miscellaneous units are used in the remedial action	- This alternative does not meet the requirements of this ARAR.	For this alternative's groundwater remedial action, if miscellaneous units are used to treat, store, or dispose of hazardous waste, then this alternative can be implemented to comply with this ARAR.	For this alternative's groundwater remedial action, if miscellaneous units are used to treat, store, or dispose of hazardous waste, then this alternative can be implemented to comply with this ARAR.	For this alternative's groundwater remedial action, if miscellaneous units are used to treat, store, or dispose of hazardous waste, then this alternative can be implemented to comply with this ARAR.
	RCRA 40 CFR 264 Subpart AA, Air Emission Standards for Process Vents	Applicable if thresholds are met	- This alternative does not meet the requirements of this ARAR.	For this alternative's groundwater remedial action, if process vents are used in the remedial action and if applicable thresholds are met, then air emission controls will be implemented during groundwater treatment to comply with this regulation.	For this alternative's groundwater remedial action, if process vents are used in the remedial action and if applicable thresholds are met, then air emission controls will be implemented during groundwater treatment to comply with this regulation.	For this alternative's groundwater remedial action, if process vents are used in the remedial action and if applicable thresholds are met, then air emission controls will be implemented during groundwater treatment to comply with this regulation.
	RCRA 40 CFR 264 Subpart BB, Air Emission Standards for Equipment Leaks	Applicable if thresholds are met	- This alternative does not meet the requirements of this ARAR.	For this alternative's groundwater remedial action, if equipment covered by this standard is used in the remedial action and handles hazardous wastes at concentrations that meet this rule's threshold, then a leak detection and repair program will be implemented during groundwater treatment to comply with this regulation.	For this alternative's groundwater remedial action, if equipment covered by this standard is used in the remedial action and handles hazardous wastes at concentrations that meet this rule's threshold, then a leak detection and repair program will be implemented during groundwater treatment to comply with this regulation.	For this alternative's groundwater remedial action, if equipment covered by this standard is used in the remedial action and handles hazardous wastes at concentrations that meet this rule's threshold, then a leak detection and repair program will be implemented during groundwater treatment to comply with this regulation.
	RCRA 40 CFR 264 Subpart CC, Air Emission Standards for Tanks, Surface Impoundments and Containers	Applicable if thresholds are met	- This alternative does not meet the requirements of this ARAR.	Any media generated as part of monitoring activities and groundwater treatment will be tested for hazardous waste characteristics. If determined to be hazardous waste, then they will be stored, transported, or disposed of in accordance with 40 CFR Part 264. If tanks or containers are used in the remedial action and if applicable thresholds are met, then air emission controls will be implemented during groundwater treatment to comply with this regulation.	Any media generated as part of monitoring activities and groundwater treatment will be tested for hazardous waste characteristics. If determined to be hazardous waste, then they will be stored, transported, or disposed of in accordance with 40 CFR Part 264. If tanks or containers are used in the remedial action and if applicable thresholds are met, then air emission controls will be implemented during groundwater treatment to comply with this regulation.	Any media generated as part of monitoring activities and groundwater treatment will be tested for hazardous waste characteristics. If determined to be hazardous waste, then they will be stored, transported, or disposed of in accordance with 40 CFR Part 264. If tanks or containers are used in the remedial action and if applicable thresholds are met, then air emission controls will be implemented during groundwater treatment to comply with this regulation.
	RCRA 40 CFR 264 Subpart DD, Containment Buildings	Applicable	- This alternative does not meet the requirements of this ARAR.	For this alternative's groundwater remedial action, if a building is used to house treatment equipment, then the design, operation, closure, and post-closure of the treatment building for this alternative's groundwater remedial action will comply with this regulation.	For this alternative's groundwater remedial action, if a building is used to house treatment equipment, then the design, operation, closure, and post-closure of the treatment building for this alternative's groundwater remedial action will comply with this regulation.	For this alternative's groundwater remedial action, if a building is used to house treatment equipment, then the design, operation, closure, and post-closure of the treatment building for this alternative's groundwater remedial action will comply with this regulation.
SURFACE WATER	**Federal Regulatory Requirements**					
	Clean Water Act National Pollutants Discharge Elimination System (NPDES) (40 CFR Part 122-125 and 131)	Applicable	- This ARAR is not specific to this alternative.	On-site discharges to surface waters, including Sutton Brook and adjacent wetlands, shall meet these substantive discharge standards.	On-site discharges to surface waters, including Sutton Brook and adjacent wetlands, shall meet these substantive discharge standards.	On-site discharges to surface waters, including Sutton Brook and adjacent wetlands, shall meet these substantive discharge standards.
	Clean Water Act (CWA) Ambient Water Quality Criteria (AWQC) (33 USC 1251 *et seq*.) (40 CFR 122.44)	Applicable	- This ARAR is not specific to this alternative.	If treated groundwater is discharged to surface water, it would be treated as needed to comply with this ARAR.	If treated groundwater is discharged to surface water, it would be treated as needed to comply with this ARAR.	If treated groundwater is discharged to surface water, it would be treated as needed to comply with this ARAR.

APPENDIX E
TABLE E-4
ACTIONS TAKEN TO COMPLY WITH ARARs and TBCs - DOWNGRADIENT GROUNDWATER

	ARAR	Status	DGGW-1	DGGW-2	DGGW-3	DGGW-4
SURFACE WATER	**State Regulatory Requirements**					
	Clean Waters Act - MassDEP Surface Water Discharge Permit Program (314 CMR 3.00; MGL c. 21 Sections 26-53)	Applicable	- This ARAR is not specific to this alternative.	Any on-site discharges to surface waters, including Sutton Brook and adjacent wetlands, shall meet these substantive discharge standards.	Any on-site discharges to surface waters, including Sutton Brook and adjacent wetlands, shall meet these substantive discharge standards.	Any on-site discharges to surface waters, including Sutton Brook and adjacent wetlands, shall meet these substantive discharge standards.
	Massachusetts Surface Water Quality Standards (314 CMR 4.00)	Applicable	- This ARAR is not specific to this alternative.	Any on-site discharges to surface waters, including Sutton Brook and adjacent wetlands, shall meet these substantive discharge standards.	Any on-site discharges to surface waters, including Sutton Brook and adjacent wetlands, shall meet these substantive discharge standards.	Any on-site discharges to surface waters, including Sutton Brook and adjacent wetlands, shall meet these substantive discharge standards.
	MassDEP Surface Water Discharge Permit Program (314 CMR 3.00)	Applicable	- This ARAR is not specific to this alternative.	Any on-site discharges to surface waters, including Sutton Brook and adjacent wetlands, shall meet these substantive discharge standards.	Any on-site discharges to surface waters, including Sutton Brook and adjacent wetlands, shall meet these substantive discharge standards.	Any on-site discharges to surface waters, including Sutton Brook and adjacent wetlands, shall meet these substantive discharge standards.
GROUNDWATER	**Federal Regulatory Requirements**					
	RCRA Subtitle C - Releases from Solid Waste Management Units (40 CFR Subpart F, 264.95 and 264.96(a) and (c))	Applicable	- This ARAR is not specific to this alternative.	This alternative's monitoring program can be designed and implemented to comply with this ARAR.	This alternative's monitoring program can be designed and implemented to comply with this ARAR.	This alternative's monitoring program can be designed and implemented to comply with this ARAR.
	Underground Injection (40 CFR Part 144)	Relevant and appropriate	- This ARAR is not specific to this alternative.	If the performance of this alternative chooses underground injection, infiltration gallery or any other system that disposes of treatment water or waste into groundwater as the remediation technology, groundwater would be treated to be non-hazardous prior to subsurface discharge.	If the performance of this alternative chooses underground injection, infiltration gallery or any other system that disposes of treatment water or waste into groundwater as the remediation technology, groundwater would be treated to be non-hazardous prior to subsurface discharge.	If the performance of this alternative chooses underground injection, infiltration gallery or any other system that disposes of treatment water or waste into groundwater as the remediation technology, groundwater would be treated to be non-hazardous prior to subsurface discharge.
	Final OSWER Directive "Use of Monitored Natural Attenuation at Superfund, RCRA Corrective Action, and Underground Storage Tank Sites (OSWER Dir. 9200.4-17P, 4/12/99)	To be considered	This policy is not specific to this alternative.	Under this alternative, contaminant levels in the groundwater plume will be monitored consistent with this guidance.	- This policy is not specific to this alternative.	- This policy is not specific to this alternative.
	State Regulatory Requirements					
	MassDEP Underground Injection Control Requirements (310 CMR 27.00)	Applicable	- This ARAR is not specific to this alternative.	If the performance of this alternative chooses underground injection, infiltration gallery or any other system that disposes of treatment water or waste into groundwater as the remediation technology, groundwater would be treated to be non-hazardous prior to subsurface discharge.	If the performance of this alternative chooses underground injection, infiltration gallery or any other system that disposes of treatment water or waste into groundwater as the remediation technology, groundwater would be treated to be non-hazardous prior to subsurface discharge.	If the performance of this alternative chooses underground injection, infiltration gallery or any other system that disposes of treatment water or waste into groundwater as the remediation technology, groundwater would be treated to be non-hazardous prior to subsurface discharge.
	MassDEP Groundwater Discharge Permit Program (314 CMR 5.00)	Applicable	- This ARAR is not specific to this alternative.	If the performance of this alternative chooses underground injection, infiltration gallery or any other system that disposes of treatment water or waste into groundwater as the remediation technology, groundwater would be treated to be non-hazardous prior to subsurface discharge.	If the performance of this alternative chooses underground injection, infiltration gallery or any other system that disposes of treatment water or waste into groundwater as the remediation technology, groundwater would be treated to be non-hazardous prior to subsurface discharge.	If the performance of this alternative chooses underground injection, infiltration gallery or any other system that disposes of treatment water or waste into groundwater as the remediation technology, groundwater would be treated to be non-hazardous prior to subsurface discharge.
	Massachusetts Well Decommissioning Requirements (313 CMR 3.03)	Applicable	- This ARAR is not specific to this alternative.	These regulations will be followed to the extent that the alternative involves decommissioning any wells.	These regulations will be followed to the extent that the alternative involves decommissioning any wells.	These regulations will be followed to the extent that the alternative involves decommissioning any wells.
AIR	**Federal Regulatory Requirements**					
	Clean Air Act National Emissions Standards for Hazardous Air Pollutants (NESHAPs), 40 CFR Part 61	Applicable	- This ARAR is not specific to this alternative.	For this alternative's groundwater remedial action, if air stripping is used and any of the 189 Hazardous Air pollutants are emitted, then this alternative's groundwater remedial action will comply with this ARAR.	For this alternative's groundwater remedial action, if air stripping is used and any of the 189 Hazardous Air pollutants are emitted, then this alternative's groundwater remedial action will comply with this ARAR.	For this alternative's groundwater remedial action, if air stripping is used and any of the 189 Hazardous Air pollutants are emitted, then this alternative's groundwater remedial action will comply with this ARAR.
	OSWER Directive 9355.0-28, Air Stripper Control Guidance, 7/12/89	To be considered	This policy is not specific to this alternative.	For this alternative's groundwater remedial action, if air stripping is used, then this alternative's groundwater remedial action will comply with this policy.	For this alternative's groundwater remedial action, if air stripping is used, then this alternative's groundwater remedial action will comply with this policy.	For this alternative's groundwater remedial action, if air stripping is used, then this alternative's groundwater remedial action will comply with this policy.

APPENDIX E
TABLE E-4
ACTIONS TAKEN TO COMPLY WITH ARARs and TBCs - DOWNGRADIENT GROUNDWATER

	ARAR	Status	DGGW-1	DGGW-2	DGGW-3	DGGW-4
AIR	**State Regulatory Requirements**					
	Massachusetts Ambient Air Quality Standards (310 CMR 6.00)	Applicable	- This ARAR is not specific to this alternative.	For this alternative's groundwater remedial action, if air stripping is used, then this alternative's groundwater remedial action will comply with this ARAR. No air emissions from remedial treatment will cause ambient air quality standards to be exceeded.	For this alternative's groundwater remedial action, if air stripping is used, then this alternative's groundwater remedial action will comply with this ARAR. No air emissions from remedial treatment will cause ambient air quality standards to be exceeded.	For this alternative's groundwater remedial action, if air stripping is used, then this alternative's groundwater remedial action will comply with this ARAR. No air emissions from remedial treatment will cause ambient air quality standards to be exceeded.
	MassDEP Revised Ambient Air Guidelines (December 6, 1995)	To be considered	This policy is not specific to this alternative.	- This alternative can be designed and implemented to comply with this policy.	- This alternative can be designed and implemented to comply with this policy.	- This alternative can be designed and implemented to comply with this policy.
	Massachusetts Air Pollution Control Regulations (310 CMR 7.00)	Applicable	- This ARAR is not specific to this alternative.	For this alternative's groundwater remedial action, if air stripping is used, then this alternative's groundwater remedial action will comply with this ARAR. Odor emissions from the groundwater treatment air stripper will be controlled with best available control technology.	For this alternative's groundwater remedial action, if air stripping is used, then this alternative's groundwater remedial action will comply with this ARAR. Odor emissions from the groundwater treatment air stripper will be controlled with best available control technology.	For this alternative's groundwater remedial action, if air stripping is used, then this alternative's groundwater remedial action will comply with this ARAR. Odor emissions from the groundwater treatment air stripper will be controlled with best available control technology.

APPENDIX F: MODFLOW PARTICLE TRACKING OUTPUT

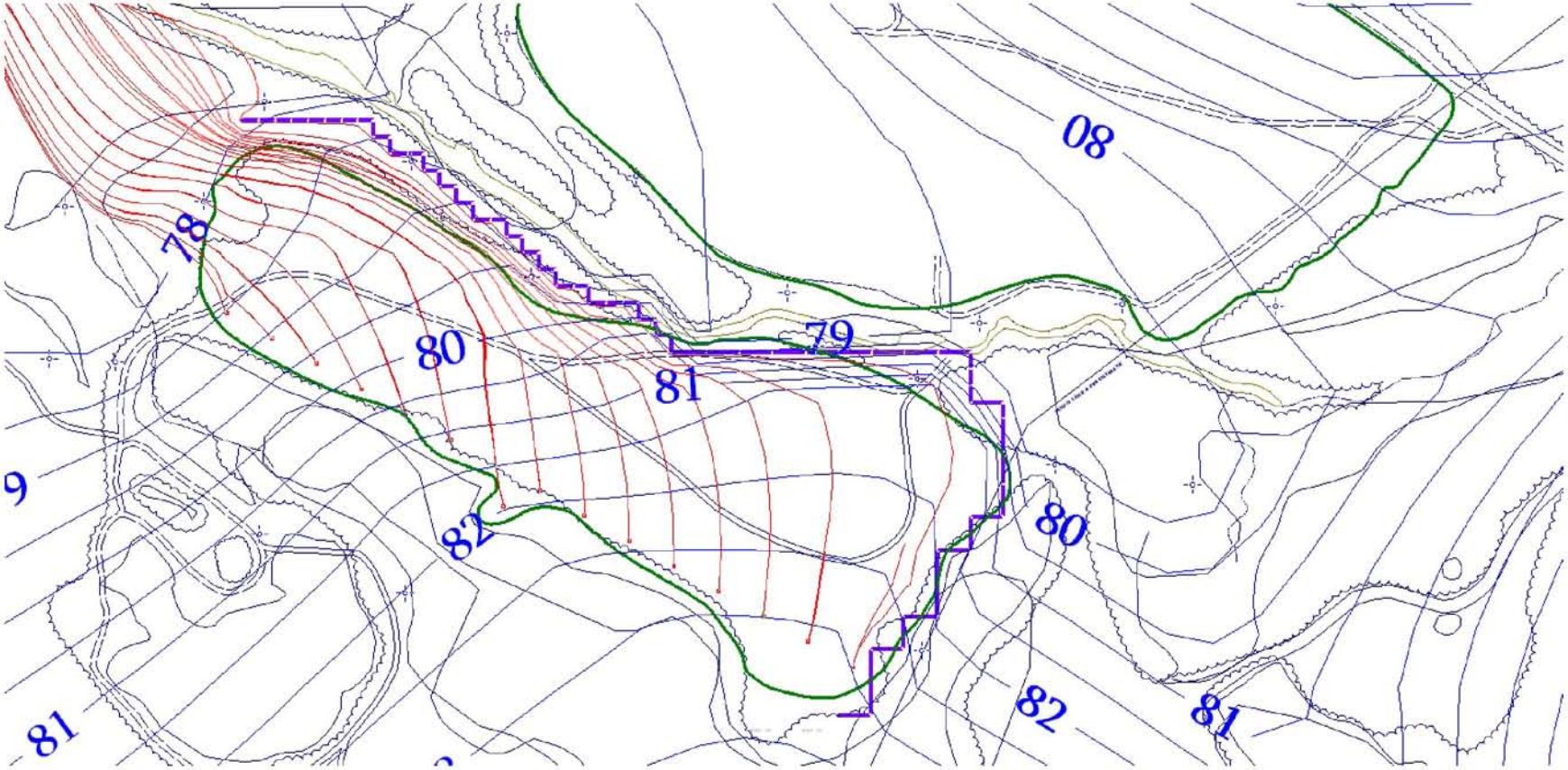
Appendix F

MODFLOW Particle Tracking Outputs

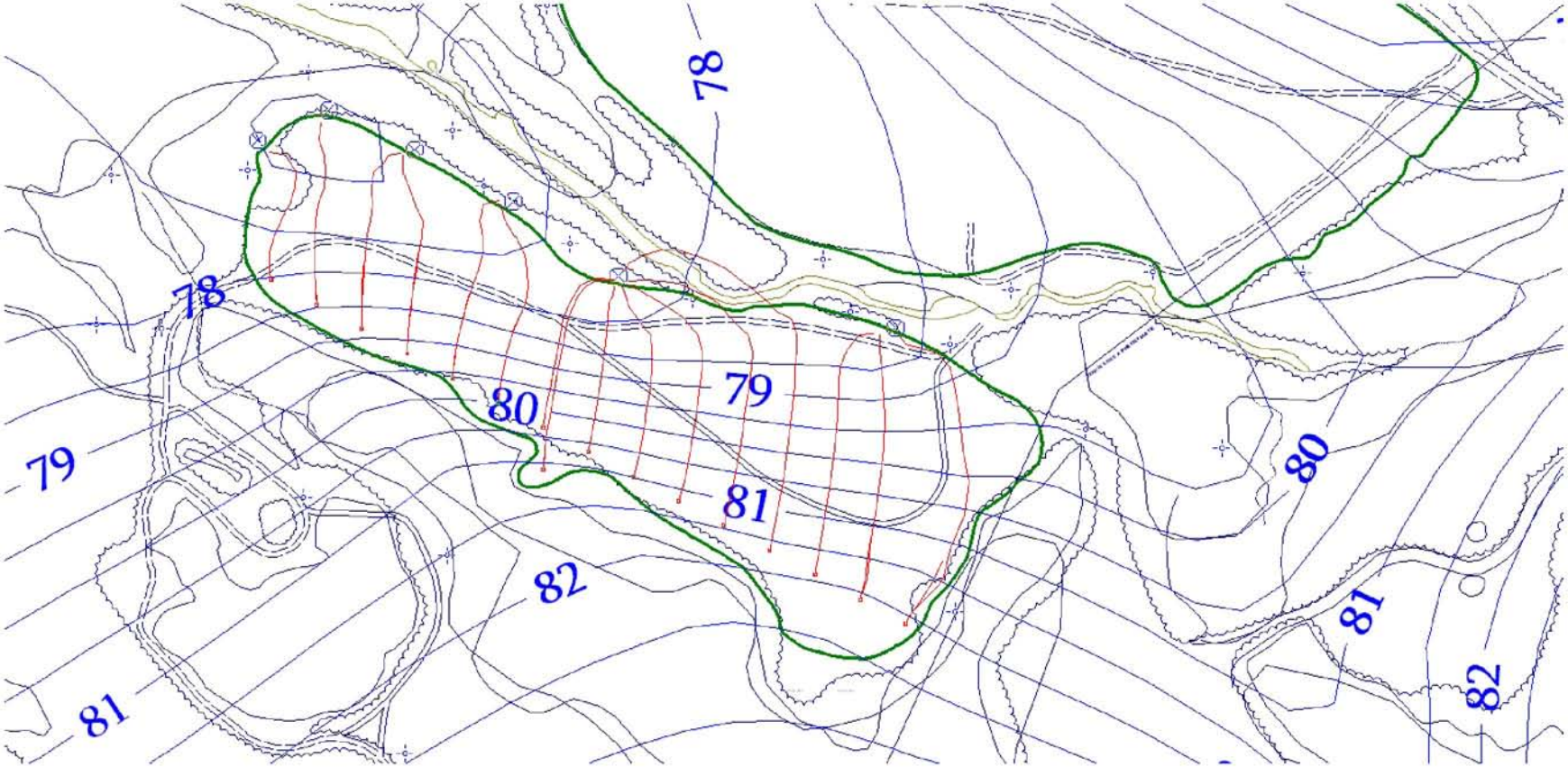
As part of the RI completed at the Site, a numerical groundwater flow model was developed and used during the RI and FS. A report describing the development and calibration of the model was presented in Appendix F of the RI Report.

This appendix includes various model outputs from particle tracking runs used to estimate relative capture zones, groundwater flow directions, and pore volumes as part of the remedial alternative analyses.

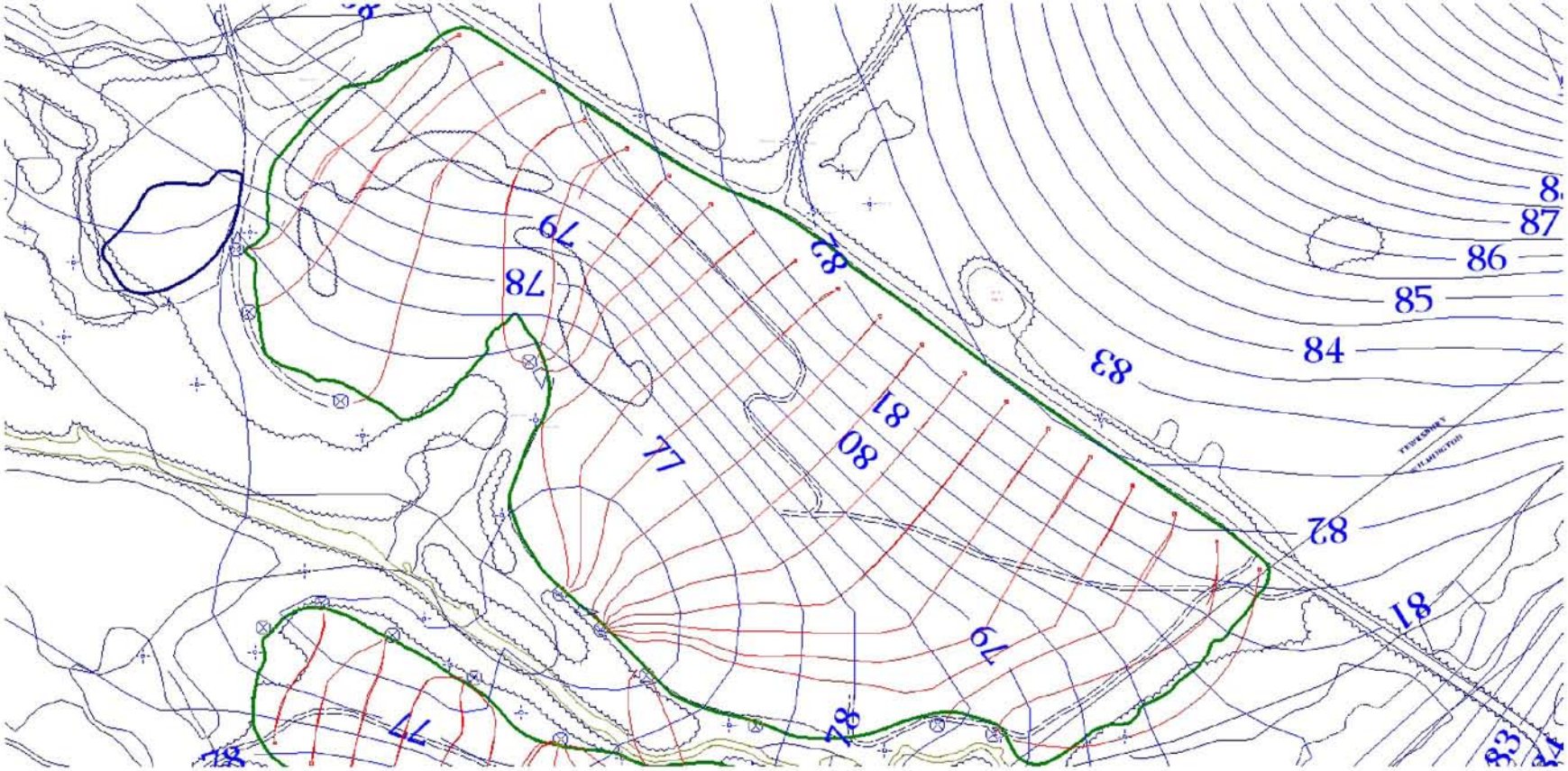
During the simulations multiple particle tracking was used as part of the evaluations. For presentation purposes, particles were vertically distributed throughout the cell because when multiple particles are used in both the vertical and horizontal sense, the resulting figures can become cluttered to the point of illegibility. The capture zones/migration pathways were first evaluated with multiple particles; however, for clarity a limited number were used in the attached figures.



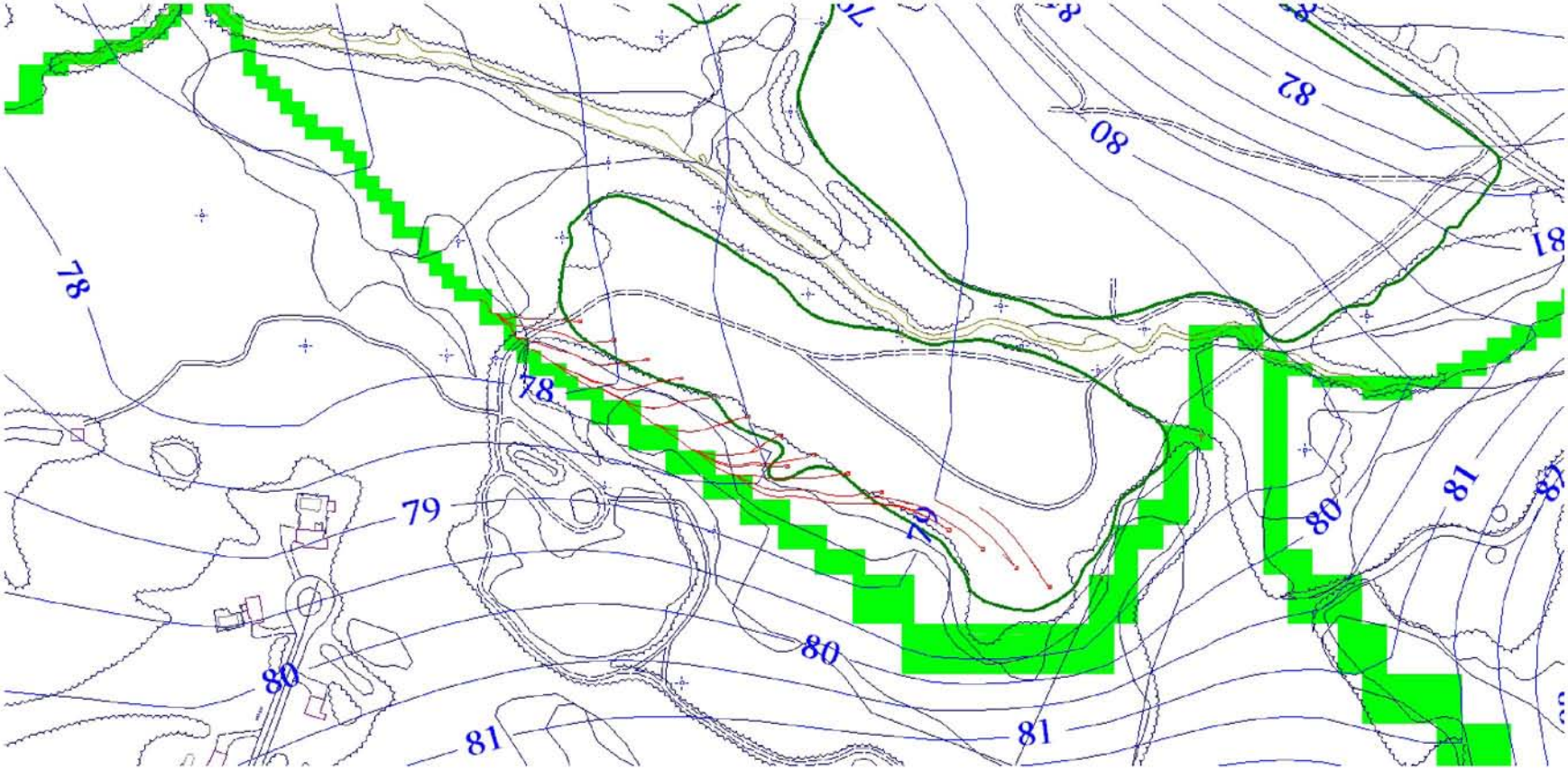
LF-2: Vertical barrier wall around east end of landfill.



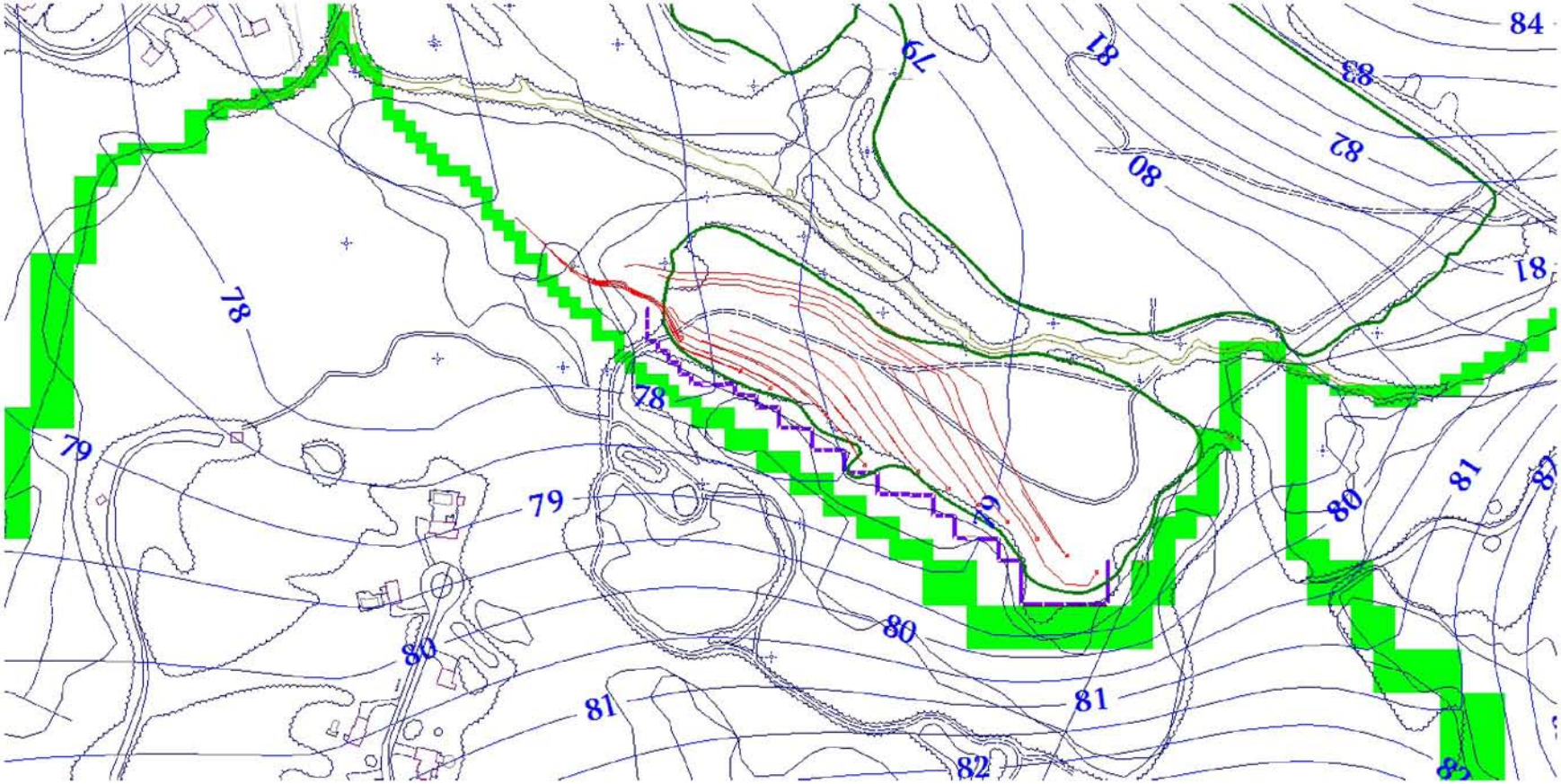
LF-3: Southern Lobe groundwater containment option. Seven wells pumping at combined rate of 95 gpm.



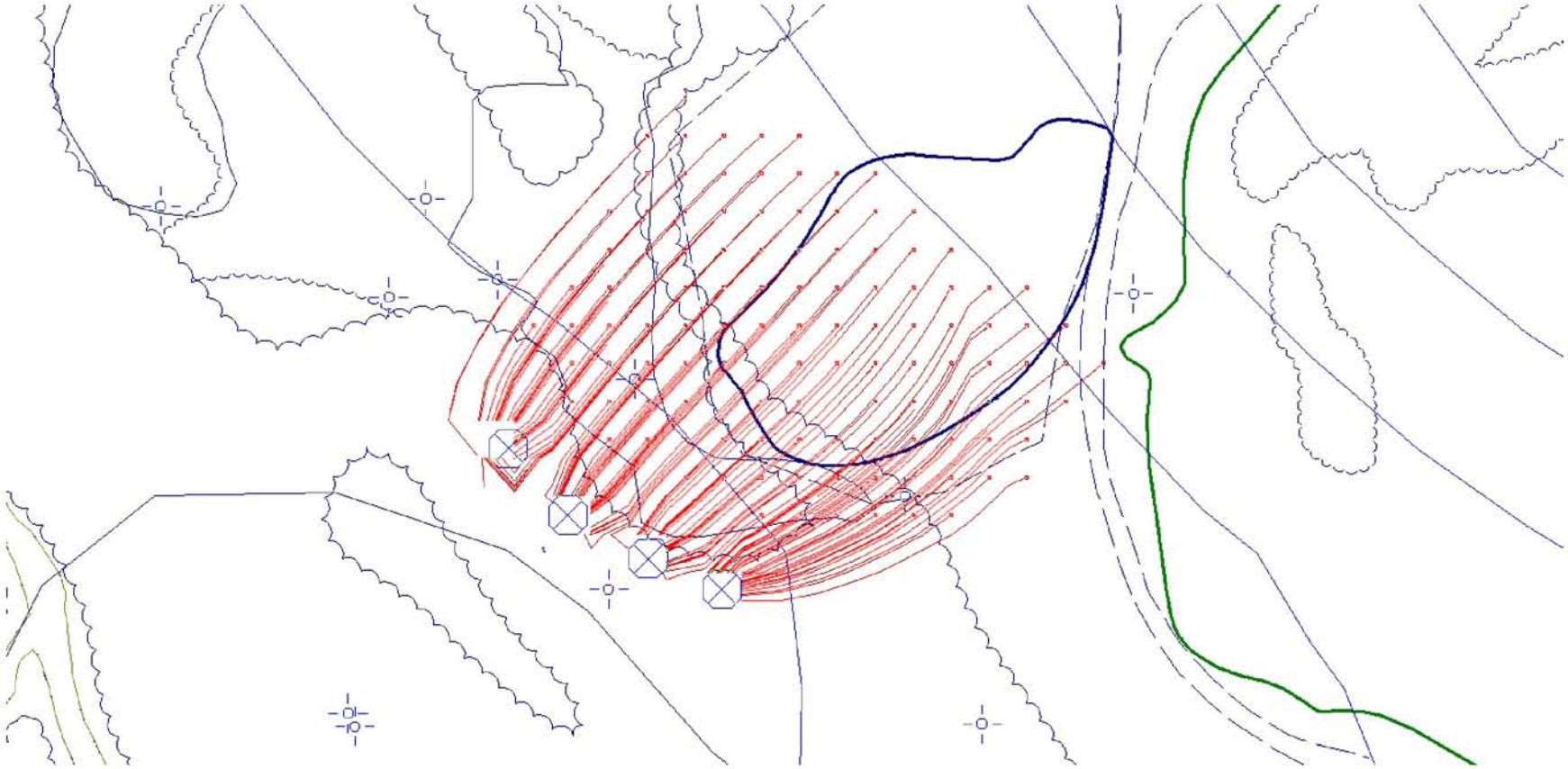
LF-3: Northern Lobe groundwater containment option. (note southern lobe containment included in this model run). Ten wells pumping at combined rate of 150 gpm.



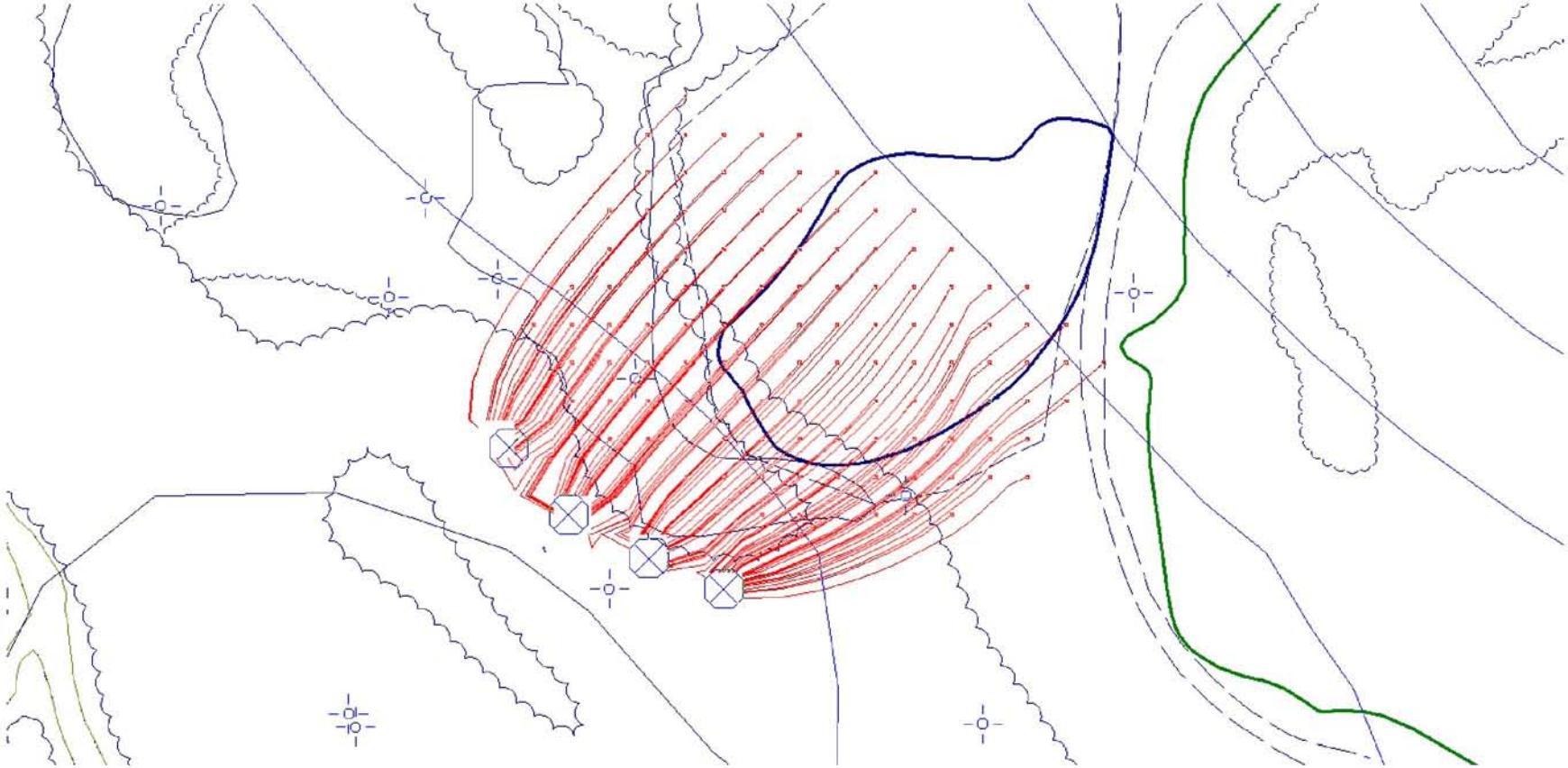
LF-4: Re-route brook to south side of Southern Lobe.



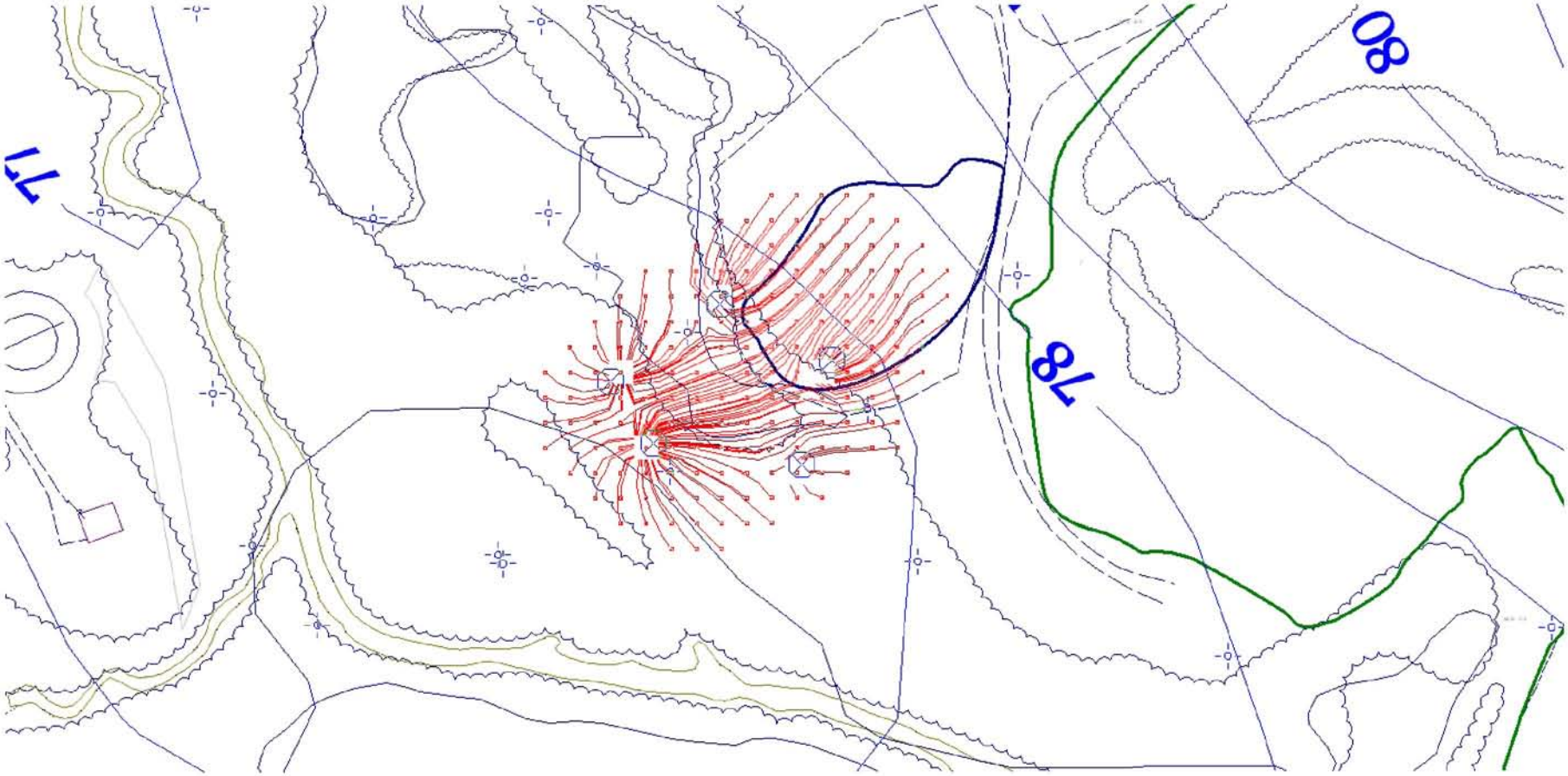
LF-4: Re-route brook to south side of Southern Lobe. Vertical barrier wall added between southern LF lobe and re-routed brook.



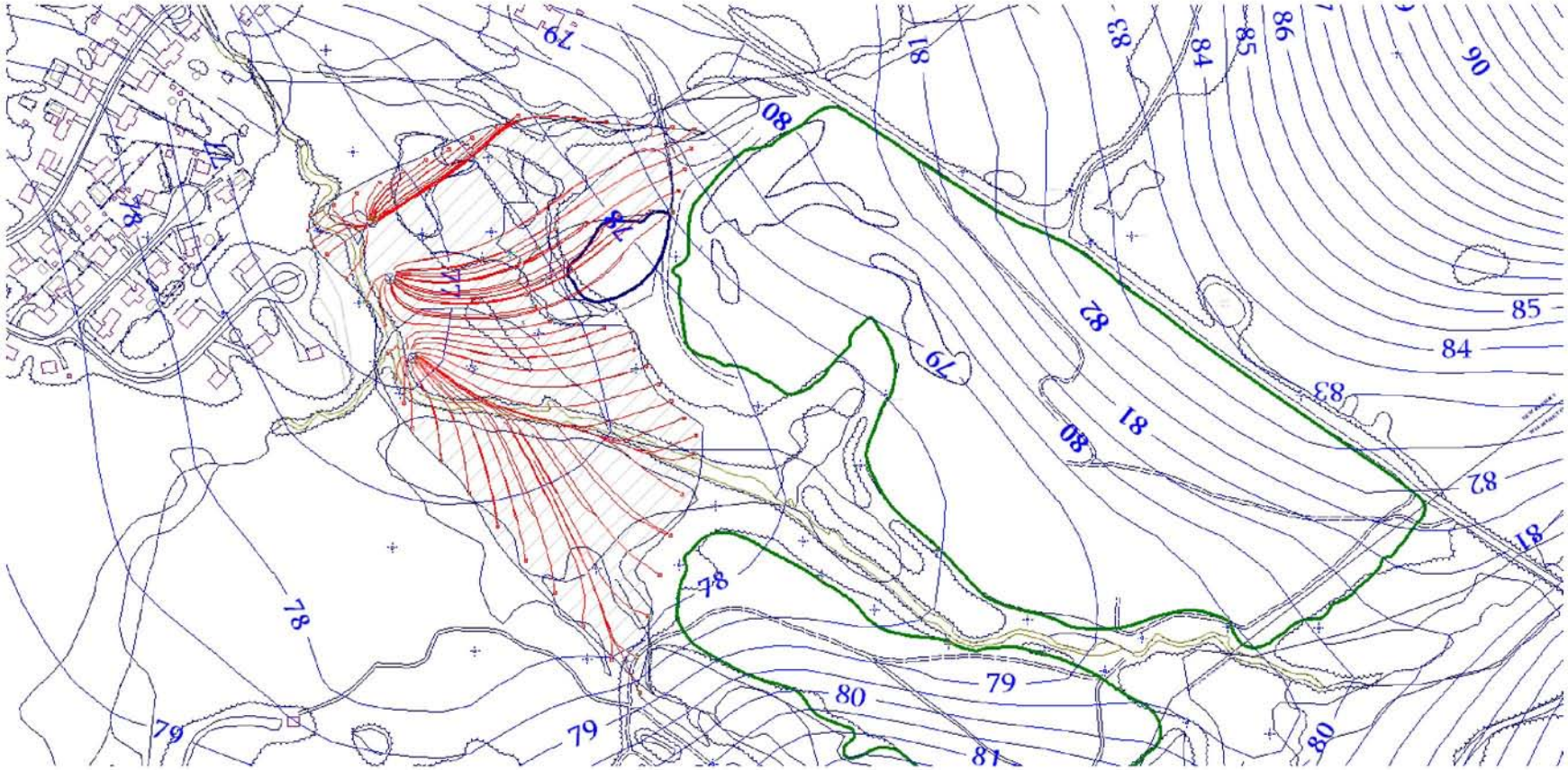
FDDA-2: Cap over FDDA with containment. Four wells pumping at 5 gpm each for a total of 20 gpm.



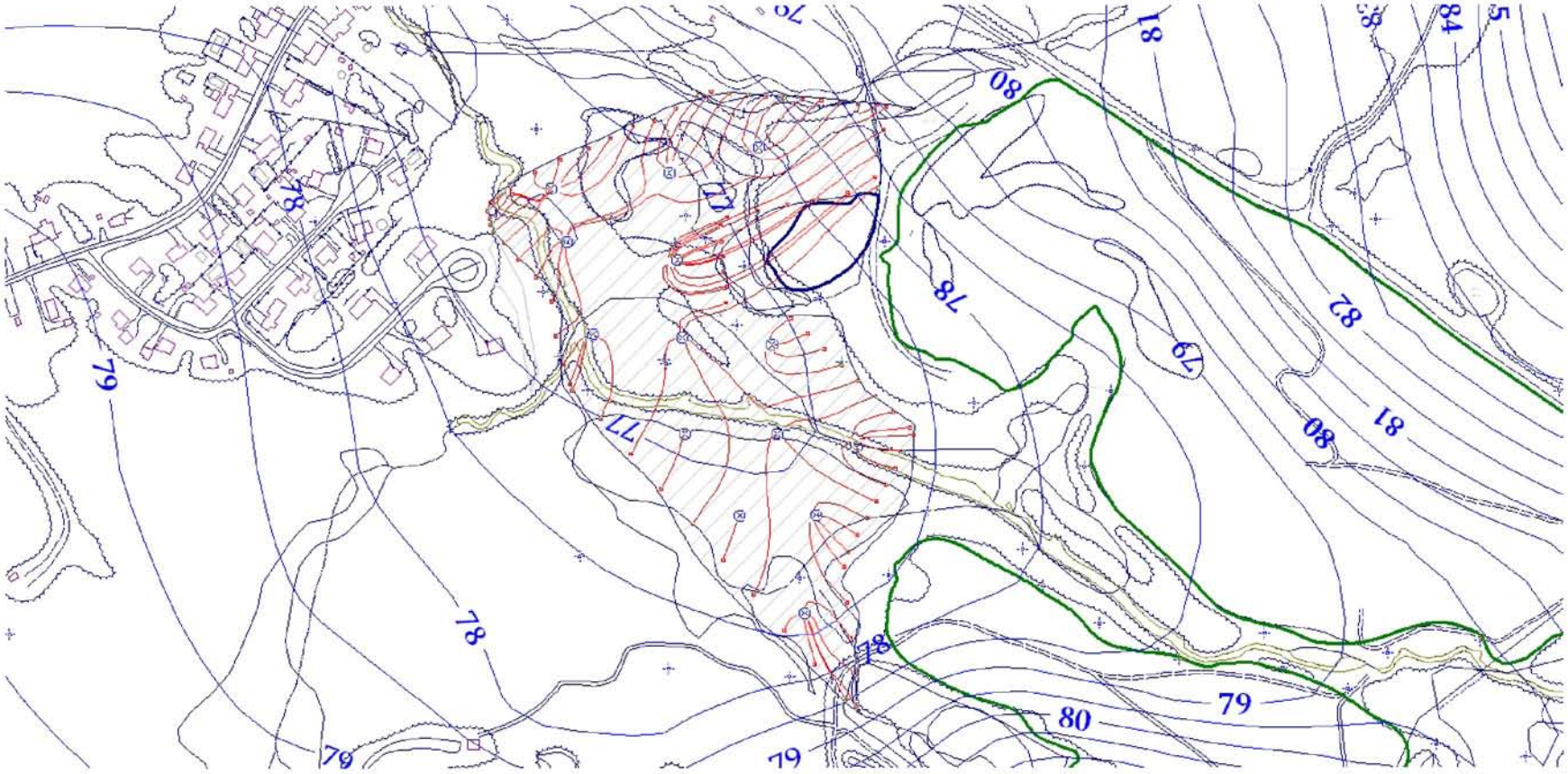
FDDA-3: Containment of FDDA groundwater no cap. Four wells pumping at 6 gpm each for total flow of 24 gpm. No cap adds minor amount of groundwater to flow system due to infiltration over source area.



FDDA-5: Area-wide contaminant reduction, no soil cap. Five wells pumping at a combined flow rate of 50 gpm.



DGGW-3 Three wells pumping at combined flow of 75 gpm.



DGGW-4 Fourteen wells pumping at combined flow of 140 gpm.