FINAL
FEASIBILITY REPORT
STANDARD MOTOR PRODUCTS, INC. SITE
(Site No. 2-41-016)
Long Island City, Queens, New York

Prepared for

Standard Motor Products, Inc.
37-18 Northern Boulevard
Long Island City, New York 11101

Prepared by

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Contents

List of Tables

List of Figures

List of Appendices

Acronyms and Abbreviations

AS	air sparging
bgs	below ground surface
BTEX	benzene, toluene, ethylbenzene, and xylene
CDM	Camp Dresser & McKee Inc.
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
DCA	dichloroethane
DCE	dichloroethene
EnviroAudit	EnviroAudit Ltd.
EPA	United States Environmental Protection Agency
FS	feasibility study
GES	Groundwater and Environmental Services, Inc.
GRA	general response action
GCW	groundwater circulation well
H2M	H2M Group
Hess Station	Hess (formerly Merit) gasoline station
IRM	interim remedial measure
ISCO	in situ chemical oxidation
K_{OC}	organic carbon partition coefficient
MTA	Metropolitan Transportation Authority
MTBE	methyl *tert*-butyl ether
NCP	National Contingency Plan
NYCRR	New York Environmental Conservation Rules and Regulations
NYSDEC	New York State Department of Environmental Conservation
NYSDOH	New York State Department of Health
O&M	operation and maintenance
OU	Operable Unit
PAH	polycyclic aromatic hydrocarbon
PCB	polychlorinated biphenyl
PCE	tetrachloroethene
PID	photo-ionization detector
PRB	permeable reactive barriers
RAO	remedial-action objective
RI	remedial investigation
ROI	radius of influence
SCG	standards, criteria, and guidance
the Site	Standard Motor Products, Inc. Site
SMP	Standard Motor Products, Inc.
SSDS	sub-slab depressurization system
Sunnyside Yard	Sunnyside Freight Railroad Yard
SVE	soil vapor extraction
SVOC	semi-volatile organic compound
TAGM	Technical and Administrative Guidance Memorandum
TCA	trichloroethane
TCE	trichloroethene

TCLP	toxicity characteristic leaching procedure
TOGS	Technical and Operational Guidance Series
TPH	total petroleum hydrocarbon
TSD	treatment, storage, and disposal
USGS	United States Geological Survey
UST	underground storage tank
UV	ultraviolet
VC	vinyl chloride
VOC	volatile organic compound

Unit of Measure

^{o}F	degree Fahrenheit
L	liter
mg	milligram
kg	kilogram
µg	microgram
m^3	cubic meter

CERTIFICATIONS

I, Mathew Millias, am currently a registered professional engineer licensed by the State of New York. I have primary direct responsibility for implementation of the remedial program for the Standard Motor Products, Inc (SMP) Site (NYSDEC Site No. 241016).

I certify that the Site description presented in this Feasibility Study (FS) is identical to the Site descriptions presented in the Consent Order for SMP and related amendments.

I certify that this plan includes proposed use restrictions, Institutional Controls, and Engineering Controls, applicable to the Site and provision for development of an Environmental Easement to be created and recorded pursuant to ECL 71-3605. This FS requires that all affected local governments, as defined in ECL 71-3603, will be notified that such Easement has been recorded. This FS requires that a Site Management Plan must be submitted by the Applicant for the continual and proper operation, maintenance, and monitoring of all Engineering Controls employed at the Site, including the proper maintenance of all remaining monitoring wells, for approval by the Department.

I certify that all information and statements in this certification are true. I understand that a false statement made herein is punishable as Class "A" misdemeanor, pursuant to Section 210.45 of the Penal Law.

MATTHEW DAVID MILLIAS
077468

077468
NYS Professional Engineer #

2/2/09
Date

Millias
Signature

It is a violation of Article 130 of New York State Education Law for any person to alter this document in any way without the express written verification of adoption by any New York State licensed engineer in accordance with Section 7209(2), Article 130 of New York State Education Law.

Executive Summary

E.1 Introduction

Camp Dresser & McKee Inc. (CDM) is submitting on behalf of Standard Motor Products, Inc. (SMP) this Feasibility Study (FS) Report in accordance with the March 30, 1998 Order on Consent Index (No. W2-0807-96-10) between New York State Department of Environmental Conservation (NYSDEC) and SMP. This Order on Consent stipulates requirements for the development and implementation of a Remedial Investigation/Feasibility Study (RI/FS) for the SMP site located at 37-18 Northern Boulevard in Long Island City, New York (herein referred to as the "Site"). The FS was developed in accordance with the recent New York State guidance entitled "*Draft DER-10 Technical Guidance for Site Investigation and Remediation*", dated December 2002 (NYSDEC 2002) and "*Final Guidance for Evaluating Soil Vapor Intrusion in the State of New York*", dated October 2006 (NYSDOH 2006). The objective of this FS is to develop and present remedial alternatives that are appropriate for addressing site contamination as currently understood.

E.2 Site Location and Description

The SMP property is in the northwestern section of Queens County, New York and is located at 37-18 Northern Boulevard in Long Island City, New York. The property was owned and operated by SMP until March 2008 and is located in an urban and industrial area. The property is approximately rectangular in shape and occupies approximately one acre of land. The property contains a large, six-story, industrial building with approximately 42,000 square feet per floor. Bordering the Site is Northern Boulevard to the north; Sunnyside Freight Railroad Yard (Sunnyside Yard) to the south; 39th Street, an automobile dealership, and a Hess (formerly Merit) gasoline station to the east; and commercial and industrial properties to the west. Various industrial and commercial properties are located across from SMP on Northern Boulevard. A narrow strip of land on the south side of the property contains a loading dock and a dirt access path for vehicles. This strip of land is owned by the Metropolitan Transportation Authority (MTA) and is part of a lease to SMP. Contamination has been identified in the soil adjacent to the loading dock. Thus, the Site includes the SMP property and the adjacent strip of land where contamination has been identified.

E.3 Site History

The Site has historically been involved in industrial and manufacturing activities since 1919. SMP has occupied the on-site building since the mid-1900s. S. Karpen & Brothers occupied the building prior to that time.

SMP maintained a small plating line for chrome plating of small machine parts from approximately 1975 to 1984. The wastes generated from the chrome plating process were temporarily stored on-site prior to off-site disposal. In addition, SMP was previously engaged in painting automobile parts prior to distribution. In 1984, aqueous based paints replaced the previously used solvent-based paints. All painting operations were gradually eliminated between 1990 and 1991. SMP performed several other processes that also generated hazardous wastes. These included die-casting operations that ceased in the 1970s; rubber production that was eliminated around 1985; and degreasing which utilized chlorinated solvents that ended in 1990.

Until March 2008, SMP produced automobile parts and components at the Long Island City facility primarily in the basement within recent years. The manufacturing operations included metal fabrication and machining, plastic injection molding, and assembly. SMP also operated a small photography laboratory for production of newsletters, brochures, etc. Hazardous or toxic materials involved in plant operations are lubricating oils for machinery, caustics for degreasing, phenolics used in molding processes, epoxies for coil production, and water-based inks involved in their small-scale printing. All wastes were temporarily stored on-site in secure containers prior to off-site disposal at a licensed treatment, storage, and disposal (TSD) facility.

The building occupies most of the property and SMP is the major occupant of the building. SMP manufactured car parts until March 2008 at this facility, and it is the SMP corporate headquarters. The building and associated property was sold by SMP in March 2008 to XEXII Northern Boulevard Acquisition, LLC, who will continue to operate this facility as commercial office space. SMP continues to occupy most of the office space within this building.

E.4 Physical Characteristics of the Site

The SMP property is mostly occupied by a six story building whose first floor is approximately at the same elevation as Northern Boulevard. The “backyard” of the SMP building (i.e., the area behind the building) is at a lower elevation than the basement floor. There is about a 15-20 foot drop in elevation between the front of the building and the backyard where most of the contamination was detected. The surface of the backyard or adjacent property is covered by soil, gravel, scattered vegetation, and miscellaneous construction debris and refuse. Several abandoned railroad lines which are presently being renovated pass through the southern portion of the Site and multiple active railroad lines are located beyond the southern extent of the Site (south of MW09 and MW13). Scattered vegetation is present throughout the “backyard” area - becoming denser towards the western part of the SMP rear yard - and is also present along the abandoned railroad lines.

The Site is underlain by the following units (in order by increasing depth): fill, Upper Pleistocene glacial deposits (including both till and channel deposits), and bedrock. The fill is predominantly comprised of reworked glacial deposits (sand, silt, clay, and gravel) and railroad ballast with minor amounts of construction debris and other materials. The Upper Pleistocene glacial deposits consist mainly of ground moraine deposits; unstratified, poorly sorted mixtures of sand, silt, clay, and gravel. In addition, a cobble layer was encountered in three soil borings drilled at the Site and three deep borings drilled at the Sunnyside Yard. This unit may represent a relict stream channel that was formed by glacial melt-water. Bedrock was encountered at a depth of 74 feet below land surface (i.e., 53 feet below mean sea level). In the southwestern portion of the Sunnyside Yard, a Holocene wetland deposit was encountered below the fill and above the Upper Glacial formation. This deposit consisted of organic silty clay and meadow mat. This deposit is associated with a buried stream channel.

The groundwater beneath the Site occurs under water table (unconfined) conditions. The depth to groundwater in the vicinity of the Site is approximately 5 feet below ground surface but may be influenced by surface runoff that results in standing water across most of the Site during rain events. The water table occurs in either fill or glacial deposits. Beneath the Site, the saturated fill deposits and the shallow Upper Glacial aquifer were not always distinguishable and are therefore, collectively referred to as shallow deposits.

Groundwater elevation data show that, underneath the Site, flow is primarily from east to west. Due to the proximity to the East River, the hydraulic gradients are gentle which is consistent with the regional groundwater contour map and the groundwater contours present in the Sunnyside Yard. Vertical groundwater movement is restricted by the Gardiners Clay where present or by the Precambrian bedrock which is considered to be the bottom hydrogeologic boundary of the groundwater flow system.

A gradient of 0.001 was calculated using data from monitoring wells MW10 and MW08. Based on the aquifer testing performed at the Site during the Phase II Field Investigation, the geometric mean hydraulic conductivity was calculated as 233 feet/day. Using this data the groundwater flow rate was estimated to be 0.78 feet/day.

E.5 Study Area Investigation

The RI was conducted to characterize the nature and extent of contamination in the Site and to identify areas that pose a potential risk to human health and the environment. The field investigation for the RI/FS was conducted in four phases from November 2002 through February 2008. The Phase I Investigation involved the collection of soil samples using hand augers and direct push drilling to delineate the nature and extent of soil contamination. Groundwater samples were also collected during the direct push sampling. In Phase II Investigation, the results of the hand auger and direct push samples were used to determine the locations for placement of groundwater monitoring wells and the depths of the screened intervals. Following installation of the monitoring wells, monitoring well development and aquifer testing was completed and groundwater samples were collected to evaluate water quality beneath the site. The Phase III Investigation involved two rounds of monitoring well groundwater sampling to verify the results of the Phase II Field Investigation as well as one round of soil vapor sampling. The Phase IV Field Investigation involved direct push soil and groundwater sampling inside and outside the facility, monitoring well sampling, sub-slab vapor sampling, and soil vapor sampling to further delineate contamination under the building and in proposed “hot spot” area identified during the previous phases.

E.6 Nature and Extent of Contamination

The primary media of concern at the Site are groundwater and vapor. The unsaturated soil does not contain elevated levels of site related constituents. The primary site-related constituents of concern are chlorinated volatile organic compounds (VOCs). Even though non-chlorinated volatile organic compounds are elevated at the Site, an upgradient source, the Hess station, has been identified as the source of these constituents. Therefore, non-chlorinated VOCs are not considered site related.

E.6.1 Groundwater Quality

Groundwater quality is assessed utilizing the results of both the direct push boring investigations conducted during the Phase I and IV Field Investigations and the monitoring well investigations conducted during the Phase II, III, and IV Field Investigations. A significant difference in the constituents detections are observed between the direct push groundwater and monitoring well collection results. The direct push groundwater results detect a greater number of constituents and at significantly higher concentrations than the monitoring well results.

E.6.1.1 Direct Push Groundwater Quality

The majority of the highest chlorinated volatile organic concentrations detected during the Phase I and IV Investigation are in the samples collected from the groundwater table interface (5 to 9 feet bgs). These results are consistent with soil analytical data in that the highest concentrations of both the soil and groundwater are located immediately adjacent to the loading dock approximately 120 feet west of the southeast corner of the building. These results are also consistent with the historical soil and groundwater data in that they indicate a “hot spot". Soil boring locations DD09 collected in 2002 and SG03 collected in 2008 both detect a wide range of chlorinated volatile constituents, including 1,1,1-TCA, 1,1-DCA, 1,1-DCE, chloroethane, TCE, and VC, and usually detecting the highest concentration. The soil borings also detected elevated concentrations of these constituents at depths below the water table interface. It can be confirmed that the “hot spot” is along the loading dock northeast of MW11, approximately 120 feet west of the southeast corner of the building.

In addition, the analytical results from the Phase I and Phase IV Investigations from these sampling locations conclude significant degradation of PCE. During the Phase I Investigation four direct push groundwater locations showed concentrations of PCE, DD09, SA01, SA02, and SA03. The highest concentration of PCE among those samples was 44 µg/L at DD09. The Phase IV Investigation identified only two locations containing PCE at relatively low concentrations, SB15 at 11 µg/L and SB01 at 8.7 µg/L. The majority of the constituents detected during the Phase IV Investigation are TCE, *cis*-1,2-DCE, and VC.

Also during the Phase I Investigation groundwater samples collected downgradient of the “hot spot” (DD03 and DD04) detected 1,1,1-TCA while similar placed borings SG10 and SG09 analyzed during the Phase IV Investigation only detected 1,1,1-TCA at

7.7 µg/L at SG09. The highest 1,1,1-TCA concentration (3,100 µg/L) detected during the Phase IV Investigation is in SG03 which is at the “hot spot” location. Other chlorinated VOCs detected include 1,1-DCA and chloroethane which are the breakdown products of 1,1,1-TCA. The highest chloroethane concentration (2,200 µg/L) is detected in SB-07. The increased concentration of chloroethane at SB07 can be contributed to the former 1,1,1-TCA tank located upgradient (northeast) of the soil boring. Since chlorinated VOC concentrations significantly diminish underneath the building, the source of the chlorinated VOCs was confirmed to be located adjacent to the loading dock and not underneath the building.

E.6.1.2 Monitoring Well Groundwater Quality

Chlorinated volatile organic groundwater contamination overall is declining significantly over time. MW09S, MW11S, MW11D, MW12, MW13S, and MW13D yielded samples that displayed low to non-detect concentrations in 2005 and 2008. The major constituents consist of *cis*-1,2-DCE, TCE, and VC which are degradation products of PCE. Newly installed wells in 2008, MW14S, MW14D, MW15, and MW16, also contained these degradation products. The sample from MW14D contained PCE at a concentration of 5.8 µg/L, which is close to the screening level of 5 µg/L. The sample from MW06 contained PCE and TCE at concentrations that were slightly higher in 2008 than concentration detected in 2003. Low detections of PCE of 17 µg/L and TCE of 8.2 µg/L were detected in the sample collected in 2008. The sample collected from MW10 contained 1,1,1-TCA and 1,1-DCA concentrations of 9.2 and 8.2 µg/L in 2008.

TCE and *cis*-1,2-DCE are detected in both the direct push groundwater samples and the monitoring well groundwater samples. The solubility of *cis*-1,2-DCE is higher than the solubility of the other chlorinated VOCs exceeding screening levels (with the exception of VC). The biodegradation process converts PCE into TCE; TCE into *cis*-1,2-DCE; and *cis*-1,2-DCE into VC. Thus, VC is also detected at concentrations exceeding screening levels at the same locations that *cis*-1,2-DCE is detected. The levels of *cis*-1,2-DCE, TCE and VC from the monitoring well data are clearly more representative of the mobile constituents in groundwater at the Site since these constituents extend beyond the immediate vicinity of the localized ”hot spot”.

E.6.2 Vapor Intrusion

The soil gas samples with elevated concentrations of chlorinated volatile constituents during the Phase III and Phase IV Investigations are located within the exterior “hot spot”. Sub-slab air samples displaying the highest concentrations of chlorinated volatile constituents are located to the east of the exterior localized “hot spot” in the vicinity of a stair well that may be impacting pressure gradients across the building. Vapor constituents detected diminish in the western side of the building and loading dock. The soil vapor results confirm the previously identified “hot spot” location. The chlorinated volatile constituent concentrations overall have diminished over time, from 2006 to 2008. This decrease in concentrations of Site-related contaminates suggest significant degradation of the source over time.

Ambient air samples detected elevated levels of 1,1,1-TCA; however, the concentration was less than the soil vapor detections. The ambient air contamination could be due to potential soil vapor pathways and/or being situated in a highly industrial and commercial area.

E.7 Fate and Transport

The fate of a constituent in the environment is a function of its chemical properties and the physical nature of the Site. The potential for environmental transport was examined by reviewing the topographic and hydrogeologic characteristics of the Site and a review of the available physical constants and chemical characteristics of each constituent. The following summarizes the most significant fate and transport processes for the Site:

- The greatest potential for transport of contaminants at the Site is via groundwater migration. Volatile organic compounds, including chlorinated compounds (i.e., *cis*-1,2-DCE, 1,1-DCA, chloroethane, VC, PCE, TCE, and 1,1,1-TCA) and non-chlorinated VOCs, (i.e., benzene, isopropyl benzene, MTBE, toluene, and xylenes) have been detected in groundwater plumes indicating their ongoing transport.

- Biodegradation has likely occurred over time due to an elevated carbon source from the commingled BTEX contamination.

- Volatilization is considered significant based on the results of the soil gas and sub-slab vapor results.

E.8 Conceptual Site Model

The Site is located in an industrial/commercial area. The Site is bordered to the north by a car dealership, to the south by the High Speed Rail station, to the west by a commercial building, and to the east by the Hess station. The chlorinated contamination originates from the Site. Based upon an extensive amount of data, it has been determined that the chlorinated groundwater "hot spot" is located external to the building, along the loading dock northeast of MW11, approximately 120 feet west of the southeast corner of the building. Unsaturated soil contamination is minimal and previously detected soil contamination has been flushed into the saturated zone.

Chlorinated constituents are retained in the eastern portion of the building, whereas the western portion of the building remains relatively uncontaminated even though groundwater flow is from east to west. Also, the highest levels of contamination exist in the capillary fringe of the water table interface on the eastern side of the building. Even though contamination has been relatively stagnant in the capillary fringe on the eastern side of the building, contamination has biodegraded over time when comparing monitoring well data collected from 2003 through 2008. Biodegradation can be enhanced with the addition of nutrients provided proper site-specific conditions are present.

In addition to groundwater transport and biodegradation, vapor migration is currently occurring at the Site. Vapors from the "hot spot" are being transported from the water table interface and are being drawn upward during the heating season due to stack effects. However, even though sub-slab concentrations are elevated, primarily along the south east perimeter of the building, current indoor air concentrations do not exceed guidance values. It is recommended that sub-slab vapors be mitigated to eliminate the potential for vapor intrusion and potential exposure in the future.

E.9 Risk Assessment

During the RI, a preliminary screening based on "*Draft DER-10 Technical Guidance for Site Investigation and Remediation"* (NYSDEC 2002) was performed to determine that a Fish and Wildlife Resources Impact Analysis (FWRIA) was not needed for the Site since there are no fish and wildlife resources on or adjacent to the Site or area of concern. There is also very limited vegetation present on the Site or in the immediate vicinity; thus, there is negligible potential environmental risk at the Site. Consequently, the main focus of the exposure assessment is human health. A qualitative human health exposure assessment was performed at the Site.

A qualitative estimate of potential health risks associate with site-specific COPCs under the current and future industrial use scenarios were evaluated at the Site. Under both the current and future land use scenarios, the primary exposure pathways at the Site are potential exposures to groundwater contaminations through incidental ingestion and dermal contact, and to trench air through inhalation for construction and utility workers while engaging in excavation activities. Risks associated with potential groundwater and trench air exposure pathways could be mitigated through engineering controls, health and safety measures, and groundwater and soil gas mitigations. Although the presence of residual contamination in the subsurface does not pose adverse health effects to current indoor workers, outdoor workers, and trespassers, mitigation is recommended because there is a potential for future migration of TCE and 1,1,1-TCA vapors from subsurface into the building.

E.10 Remedial Action Objectives

Based on the evaluated concentrations contaminants in soil, groundwater and vapor, the assessment of human risk associated with exposure to COPC, the following preliminary RAOs were developed:

- **Soil.** The primary media of concern at the Site are groundwater and vapor. The unsaturated soil does not contain elevated levels of site related constituents. Therefore, there was no unsaturated soil RAO developed for the Site.

- **Groundwater**. RAOs for groundwater include minimizing the off-site migration of volatile organic compounds in groundwater at concentrations that pose a potential risk to off-site receptors and protecting human health and the environment by restoring the contaminated groundwater to concentration below groundwater standards, criteria, and guidance (SCG)

- **Soil Vapor**. RAOs for soil vapor include minimizing potential building occupant exposure to elevated sub-slab vapor concentrations and protecting human health and the environment by monitoring indoor air and mitigating soil vapor to below SCG.

E.11 Preliminary Remediation Goals

Preliminary remediation goals (PRGs) were selected based on federal or state SCGs, background concentrations, and with consideration also given to other requirements such as analytical detection limits and guidance values. Groundwater PRGs are based on New York State Ambient Water Quality Standards and Guidance Values and Groundwater Effluent Limitations (TOGS 1.1.1). The Final Guidance for Evaluating Soil Vapor Intrusion in the State of New York (NYSDOH 2006) is considered relevant and appropriate to soil vapor at the Site. The 2006 NYSDOH Vapor Intrusion guidance indicates that the State of New York does not have any standards, criteria, or guidance values for subsurface vapors. However, air guideline values and the sub-slab vapor/indoor air matrices in the 2006 NYSDOH Vapor Intrusion guidance are compared to soil vapor concentrations that do not have a set standard, in order to identify if soil gas and sub-slab vapor should be mitigated. These PRGs are limited to chlorinated VOCs. Even though non-chlorinated VOCs are elevated at the Site, an upgradient source, the Hess station, has been identified as the source of these constituents. Therefore, non-chlorinated volatile organic compounds are not considered site related.

E.12 Remedial Action Alternatives

Remedial action alternatives have been developed based on the potential for these alternatives to meet the SCGs, RAOs, and PRGs.

E.12.1 Remedial Action Alternatives for Groundwater

E.12.1.1 Alternative G1 - No Action

The No Action alternative was retained for comparison purposes as required by the NCP. No remedial actions would be implemented as part of the No Action alternative. Groundwater would continue to migrate and the contamination would continue to attenuate through dilution, dispersion, limited biodegradation, etc. This alternative does not include institutional controls or long-term groundwater monitoring. Therefore, there are no capital or operation and maintenance (O&M) costs associated with this alternative.

E.12.1.2 Alternative G2 - Monitor Natural Attenuation

All properties within the area of contaminated groundwater are connected to municipal water. Institutional controls, such as well drilling permit restrictions, would be implemented to prevent future use of contaminated groundwater. Monitor Natural Attenuation would include periodic groundwater sampling and analysis. This alternative would partially meet the RAOs. It would be protective of human health by preventing ingestion and direct contact of contaminated groundwater, but it would not minimize the migration of contaminants and would not protect the environment since there are no active removal mechanisms to restore the groundwater quality. The total present worth cost for this alternative is approximately $1 million. The Capital cost associated with this alternative is $35,000; the monitoring cost is $56,000 per event for 20 years.

E.12.1.3 Alternative G3 - Air Sparging/Soil Vapor Extraction

An Air Sparging (AS)/Soil Vapor Extraction (SVE) system would be installed in the treatment area near the loading dock. AS will treat the groundwater in situ, and SVE would capture contaminated soil vapor, preventing it from migrating off site. This remedial option would eliminate the pathway of direct human contact with groundwater and soil vapor contaminants. Institutional controls would be implemented to prevent exposure to contaminated groundwater until the groundwater in the contamination plume meets NYSDEC standards. Long-term monitoring would be performed to support institutional controls and remediation efforts, providing an understanding of changes in contaminant concentrations, degradation, and distribution over time. This alternative would significantly reduce the toxicity, mobility, and volume of contamination. The total present worth for this alternative is $1.13 million. The estimated capital cost is $0.42 million. The O&M cost is $69,000 per year for 3 years. The long-term monitoring cost is $52,000 per event for 5 years.

E.12.1.4 Alternative G4 - Enhanced Aerobic Biodegradation and Monitor Natural Attenuation

EAB of chlorinated VOCs at the Site could be implemented via the injection of electron donors and nutrients into treatment area that exceed 20 times SCG criteria. At the Site, aqueous substrates might be more favorable than slow release compounds that have high viscosity because aqueous substrates can affect a greater radius of influence (ROI). The increased ROI decreases the number of injection points required. The implementation of EAB would require the monitoring of MNA parameters which is included as part of the MNA monitoring. For this alternative, institutional controls and monitoring would be implemented as described under Alternative G3. The total present worth for Alternative G4 is $1.14 million. The estimated capital cost is $0.57 million and the MNA monitoring cost is $56,000 per event for 5 years.

E.12.1.5 Alternative G5 – In Situ Chemical Oxidation

In this alternative, ISCO would be applied at the treatment area. Using ISCO at the Site could mineralize dissolved TCE, PCE, and *cis*-DCE in groundwater within a short period upon contact with the contaminants. In the event that extensive residual contaminant masses exist in relatively low permeability zones, treatment via chemical oxidation could significantly increase the mass transfer between the contamination and groundwater, subsequently reducing the duration of remediation at the Site. Fenton's Reagent is the assumed oxidant; other oxidation technologies would also be evaluated during the remedial design stage. A treatability study may be required prior to design and implementation of remediation. For this alternative, institutional controls and monitoring would be implemented as described for Alternative G3 for a shorter period of time. The total present worth for Alternative G5 is $1.2 million. The estimated capital cost is $0.66 million. The long-term monitoring cost is $52,000 per event for 5 years.

E.12.2 Remedial Action Alternatives for Soil Vapor

E.12.2.1 Alternative V1 - No Action

The No Action alternative was retained for comparison purposes as required by the NCP. No remedial actions would be implemented as part of the No Action alternative. Soil vapor would continue to migrate and the contamination would continue to attenuate through dilution, dispersion, limited biodegradation, etc. This alternative does not include institutional controls or long-term monitoring. Therefore, there would be no cost under this alternative.

E.12.2.2 Alternative V2 - Long-term Monitoring

Currently, there is no vapor intrusion concern for on-site building. Long-term monitoring would be implemented to include periodic sampling and analysis of soil vapor, sub-slab, and indoor air. Soil vapor, sub-slab, and indoor air would be sampled from selected vapor ports to monitor contaminant concentrations and migration over time. This alternative would partially meet the RAOs. This alternative would not minimize the migration of contaminants and would not protect the environment since there are no active removal mechanisms to restore the soil vapor quality. The total present worth cost for this alternative is approximately $0.71 million. Capital cost associated with this alternative is $35,000; the monitoring cost is $38,000 per event for 20 years.

E.12.2.3 Alternative V3 - Interim Remedial Measure

An IRM will be performed where a sub-slab depressurization system (SSDS) would be installed under the on-site building. This remedial option would eliminate the pathway of direct human contact with soil vapor contaminants through vapor intrusion that might occur in the future. This engineering control would be implemented to prevent exposure to contaminated soil vapor until the soil vapor meets NYSDOH guidance. Long-term monitoring would be performed to support engineering control efforts, providing an understanding of changes in contaminant concentrations, degradation, and distribution over time. The total present worth cost for this alternative is approximately $1 million. Capital cost associated with this alternative is $0.55 million; the O&M cost for IRM is $23,000 per year for 3 years and soil vapor monitoring is $38,000 per event for 5 years.

E.12.2.4 Alternative V4 - Interim Remedial Measure and Soil Vapor Extraction

This remedial alternative combines an SVE system with the IRM. The SVE system would be installed at the treatment area near the loading dock, capturing contaminated vapor and preventing it from migrating off site. This remedial option would eliminate the pathway of direct human contact with soil vapor contaminants through vapor intrusion that might occur in the future. The IRM would be implemented to prevent exposure to contaminated soil vapor until the soil vapor meets NYSDOH guidance. Long-term monitoring would be performed to support engineering control and remediation efforts, providing an understanding of changes in contaminant concentrations, degradation, and distribution over time. The total present worth for this alternative is \$1.28 million. The estimated capital cost is \$0.76 million. The O&M cost is \$46,000 per year for 3 years. The long-term monitoring cost is \$38,000 per event for 5 years.

E.13 Comparative Analysis of Alternatives

E.13.1 Groundwater

E.13.1.1 Overall Protection of Human Health and the Environment

Alternative G1 would not provide protection of human health and the environmental, since contamination would remain in groundwater for a long time in the future, and no mechanism would be implemented to prevent exposure to contaminated groundwater. Alternative G2 would be protective of human health by preventing ingestion and direct contact of contaminated groundwater, but it would not protect the environment since there are no active removal mechanisms to restore the groundwater quality. Alternative G3 would provide protection of human health and the environment, since AS/SVE would permanently remove and/or destroy the contaminants within the treatment zone (area exceeding 20 times SCGs). Alternative G4 would provide protection of human health and the environment. Contamination within the treatment area would be treated in situ through EAB. The remaining very low contaminant concentration areas could be readily reduced through natural processes in the subsurface. Alternative G5 would provide protection of human health and the environment, since the in situ chemical treatment would permanently remove and/or destroy the contaminants within the treatment zone.

E.13.1.2 Compliance with SCGs

The site groundwater is currently contaminated with chlorinated VOCs above the groundwater quality standards and drinking water standards. Alternatives G1 and G2 would not address the contamination so would not comply with the chemical-specific SCGs. Alternatives G3, G4, and G5 would all achieve chemical-specific SCGs. The groundwater contaminant concentrations would be reduced actively through the in situ treatment within the treatment area and passively through natural processes outside the treatment area.

E.13.1.3 Long-term Effectiveness and Permanence

Alternative G1 is not considered to be an effective or permanent remedy. The contaminants would not be destroyed, except by gradual reductions through natural dispersion and dilution. Alternative G2 would provide long-term effectiveness since the exposure pathway of contaminated groundwater to local receptors would be eliminated through institutional controls; however, it would probably not provide permanence since no active remedy would be implemented, and it is not likely that the contamination will reach cleanup levels within 30 years. Alternatives G3, G4, and G5 would provide an effective, permanent remedy for the most highly-contaminated area of the Site, where exceeding 20 times SCG. They would significantly reduce concentration in the near term and eventually eliminate the long-term health risks at the Site. Treatment residuals would meet SCG at the Site following completion of the remedy.

E.13.1.4 Reduction of Toxicity, Mobility, or Volume through Treatment

The implementation of Alternatives G1 and G2 would not affect the toxicity, mobility, or volume of the contaminants through treatment. Alternatives G3, G4, and G5 would significantly reduce the toxicity and volume of contaminated groundwater by actively removing or degrading the contaminants. They are unlikely to provide a significant reduction in the mobility of contaminated groundwater.

E.13.1.5 Short-term Effectiveness

Because nothing would be done, Alternative G1 would have no short-term impact to workers or the community. Alternative G2 would have minimal short-term impact to the community, since workers would only be on site for periodic sampling. Alternatives G3, G4, and G5 would have some short-term impacts to the community and the environment. Alternatives G4 and G5 would likely require repeated mobilizations to the Site for injections. Alternative G3 would require ongoing operation of a treatment system at the Site. With Alternatives G3, G4, and G5, risks to site workers posed by exposure to contaminants, heavy equipment, and treatment chemicals would be managed by implementation of a health and safety plan.

E.13.1.6 Implementability

Alternative G1 is easily implemented since no services or permits would be required. Alternative G2 is easily implemented. Administrative hurdles to attaining institutional controls are minimal, and groundwater monitoring services are readily available. Alternative G3 is technically implementable. SVE and AS are proven technologies, but a pilot study would be required for proper design of the remedy. Alternatives G4 and G5 are still considered innovative technologies, so a bench-scale study would be required for proper design of the remedy. Their implementability is dependent on subsurface conditions, which affect the degree of effort required to ensure the chemicals/amendments are successfully delivered to the entire treatment area. Due to this, they are the least implementable of the groundwater alternatives.

E.13.1.7 Cost

A comparative summary table of the cost estimates for each alternative is shown below.

Alternative	Present Value Cost	Capital Costs	Annual Costs
G1 – No Action	$0	$0	$0
G2 – MNA	$1,000,000	$35,000	$56,000
G3 – AS/SVE	$1,130,000	$416,000	$121,000
G4 – EAB	$1,140,000	$567,000	$56,000
G5 – ISCO	$1,200,000	$663,000	$52,000

E.13.2 Soil Vapor

E.13.2.1 Overall Protection of Human Health and the Environment

Site contaminants have currently been detected in soil vapor and indoor air. Because nothing would be done to address the vapor under Alternatives V1 andV2, these alternatives would not be protective of human health or the environment. Both Alternatives V3 and V4 are protective of human health because they eliminate the current pathway to indoor air; however, V4 is additionally protective of the environment by preventing off-site migration of contaminated vapor.

E.13.2.2 Compliance with SCGs

Alternatives V1 and V2 would not meet the chemical-specific SCGs since no treatment would be implemented to destroy or reduce contaminant concentrations in soil vapor. Alternative V3 would meet chemical-specific SCGs for indoor air, but not for soil vapor. Alternative V4 would meet chemical-specific SCGs for indoor air. It would eventually meet the chemical-specific SCGs for soil vapor, but this is likely to take a very long time (>3-year).

E.13.2.3 Long-term Effectiveness and Permanence

Although currently there is no risk to human health, Alternative V1 would not ensure the elimination of future risks and would not address the underlying contamination. Therefore, this alternative is neither effective in the long term, nor permanent. Alternative V2 would be effective by monitoring for future risks to human health. Alternatives V3 and V4 would also be effective by eliminating the pathway to human receptors. Alternatives V2 and V3 are not considered permanent because they would not address contaminated soil vapor. Alternative V4 provides a degree of permanence by capturing the most contaminated soil vapor, but it is not expected to permanently remove the source of contamination from the Site. In addition, if either Alternative G4 or G5 is selected, Alternative V4 would interfere with the effectiveness of the groundwater remedy by creating an aerobic condition within the treatment area that required an anaerobic condition.

E.13.2.4 Reduction of Toxicity, Mobility, or Volume through Treatment

The implementation of Alternatives V1 and V2 would not affect the toxicity, mobility, or volume of the contaminants through treatment. Alternatives V3 and V4 would direct the flow of the contaminated vapor by creating a vacuum in the subsurface. Alternative V4 provides the most control of vapor mobility and would also reduce the volume of contaminated soil vapor.

E.13.2.5 Short-term Effectiveness

Because nothing would be done, Alternative V1 would have no short-term impact to workers or the community. Alternative V2 would have minimal short-term impact to the community, since workers would only be on site for periodic sampling. Alternatives V3 and V4 would have the most, but still minimal, short-term impacts to the community and the environment due to the initial construction and ongoing operation the extraction systems. With Alternatives V3 and V4, risks to site workers posed by exposure to contaminants, heavy equipment, and treatment chemicals would be managed by implementation of a health and safety plan.

E.13.2.6 Implementability

Alternative V1 is easily implemented since no services or permits would be required. Alternative V2 is easily implemented. Administrative hurdles to attaining institutional controls are minimal, and groundwater monitoring services are readily available. Alternatives V3 and V4 are both technically implementable. SSDS and SVE are proven technologies, but pilot studies would be required for proper design of the remedy.

E.13.2.7 Cost

A comparative summary table of the cost estimates for each alternative is shown below.

Alternative	Present Value Cost	Capital Costs	Annual Costs
V1 – No Action	$0	$0	$0
V2 – MNA	$710,000	$35,000	$38,000
V3 – IRM	$1,010,000	$548,000	$61,000
V4 – IRM/SVE	$1,280,000	$763,000	$84,000

E.14 Recommended Remedy

The recommended alternative for groundwater is Alternative G3 – AS/SVE. As per NYSDEC direction during the FS scoping meeting on September 11, 2008, mitigation of soil vapor is necessary to prevent off-site migration of soil vapor contaminants by installing a SVE system. Therefore, in order to remove groundwater contamination, an AS system with SVE system is recommended. Although no current pathway exists for human exposure to the contaminated groundwater, the groundwater continues to act as a source of vapor contamination and has the potential to increase risk if a human or ecological pathway develops in the future. For this reason, active remedy is recommended, and an AS/SVE was selected as the most effective and permanent remedy to remove and degrade groundwater contamination. Alternative G4 and G5 would be effective in removing and degrading groundwater contamination. However, since NYSDEC requires soil vapor mitigation, an SVE system would interfere with the effectiveness of Alternatives G4 and G5. Therefore, Alternative G3 was recommended as the groundwater remedy.

The recommended alternative for soil vapor is Alternative V3 – Interim Remedial Measure. Although the risk assessment indicates that there is no current risk to human health, it is desirable to provide a remedy that ensures risk will not develop in the future. The IRM, by eliminating the potential transport of contaminated soil vapor to indoor air, will prevent any future risks to human health.

Section 1
Introduction

Camp Dresser & McKee Inc. (CDM) is submitting on behalf of Standard Motor Products, Inc. (SMP) this Feasibility Study (FS) Report in accordance with the March 30, 1998 Order on Consent Index (No. W2-0807-96-10) between New York State Department of Environmental Conservation (NYSDEC) and SMP. This Order on Consent stipulates requirements for the development and implementation of a Remedial Investigation/Feasibility Study (RI/FS) for the SMP site located at 37-18 Northern Boulevard in Long Island City, New York (herein referred to as the "Site"). The FS was developed in accordance with the recent New York State guidance entitled "*Draft DER-10 Technical Guidance for Site Investigation and Remediation*", dated December 2002 (NYSDEC 2002) and "*Final Guidance for Evaluating Soil Vapor Intrusion in the State of New York*", dated October 2006 (NYSDOH 2006).

1.1 Purpose

The objective of this FS is to develop and present remedial alternatives that are appropriate for addressing site contamination as delineated in the RI (CDM 2008) The FS serves as the mechanism for development, screening, and detailed evaluation of remedial alternatives.

It includes:

- Developing remedial action objectives (RAOs) for site-related contamination
- Developing site-specific remedial action criteria
- Identifying, screening, and selecting remedial technologies and process options applicable to the contamination associated with the Site
- Assembling the retained technologies and process options into remedial alternatives for evaluation and comparative analysis

1.2 Organization of Feasibility Study Report

This FS Report is comprised of nine sections. The following identifies the organization of the report and the contents of each section.

Section 1: Introduction. This section provides the background information regarding the purpose and the organization of this FS report.

Section 2: Site Description and History. This section provides the Site background including the Site location and description, site history, and summary of previous investigations.

Section 3: Summary of Remedial Investigation. This section provides the summary of field activities associated with each of the four phases comprising the field investigation for the RI/FS, description of physical characteristics of the Site, nature and extent of contamination, contaminant fate and transport, and exposure/risk assessment.

Section 4: Remedial Goals and Remedial Action Objectives. This section presents a list of remedial goals and RAOs by considering the characterization of contaminants, the risk assessments, and compliance with standard, criteria, and guidance (SCGs).

Section 5: General Response Actions. This section identifies general response actions.

Section 6: Identification and Screening of Remedial Technologies. This section identifies and screens remedial technologies and process options for each medium.

Section 7: Development and Analysis of Remedial Alternatives. This section presents the remedial alternatives developed by combining the feasible technologies and process options. This section also provides detailed descriptions and preliminary design assumptions regarding the alternatives that were retained. This information is used to develop the cost estimates for each alternative. This section also provides a detailed analysis of each alternative with respect to the following eight criteria: overall protection of public health and the environment; compliance with SCGs; long-term effectiveness and permanence; reduction of toxicity, mobility, or volume with treatment; short-term effectiveness; implementability; cost; and community acceptance. An overall comparison between the various remedial alternatives is also examined in this section.

Section 8: Recommended Remedy. This section provides the recommended remedy for each medium.

Section 9: References. A complete list of the references cited in the FS Report is presented in this section.

Section 2
Site Description and History

The following sections describe the site location and description, site history, and a summary of previous investigations.

2.1 Site Location and Description

The SMP property is in the northwestern section of Queens County, New York (Figure 2-1) and is located at 37-18 Northern Boulevard in Long Island City, New York (Figure 2-2). The property was owned and operated by SMP until March 2008 and is located in an urban and industrial area. The property is approximately rectangular in shape and occupies approximately one acre of land (Figure 2-3). The property contains a large, six-story, industrial building with approximately 42,000 square feet per floor. The building occupies most of the property and SMP is the major occupant of the building. SMP manufactured car parts until March 2008 at this facility, and it is the SMP corporate headquarters.

Bordering the Site is Northern Boulevard to the north; Sunnyside Freight Railroad Yard (Sunnyside Yard) to the south; 39th Street, an automobile dealership, and a Hess (formerly Merit) gasoline station to the east; and commercial and industrial properties to the west (Figure 2-3). Various industrial and commercial properties are located across from SMP on Northern Boulevard. A narrow strip of land on the south side of the property contains a loading dock and a dirt access path for vehicles. This strip of land is owned by the Metropolitan Transportation Authority (MTA) and is part of a lease to SMP. Contamination has been identified in the soil adjacent to the loading dock. Thus, the Site includes the SMP property and the adjacent strip of land where contamination has been identified. This adjacent area is mostly dirt and gravel covered with some concrete remaining from a nearby road-paving project. Access to this area is limited. The means of access to this area is from doors at the rear of the SMP building, and a locked access gate surrounding the perimeter of the leased strip of land. A highly industrialized area with a wide variety of activities ranging from small-scale assembly to large-scale manufacturing is located within the general vicinity of the Site.

2.2 Site History

The Site has historically been involved in industrial and manufacturing activities since 1919 (EnviroAudit 1996). SMP has occupied the on-site building since the mid-1900s. S. Karpen & Brothers occupied the building prior to that time.

SMP maintained a small plating line for chrome plating of small machine parts from approximately 1975 to 1984. The wastes generated from the chrome plating process were temporarily stored on-site prior to off-site disposal. In addition, SMP was previously engaged in painting automobile parts prior to distribution. In 1984, aqueous based paints replaced the previously used solvent-based paints. All painting operations were gradually eliminated between 1990 and 1991. SMP performed several other processes that also generated hazardous wastes. These included die-casting operations that ceased in the 1970s; rubber production that was eliminated around 1985; and degreasing which utilized chlorinated solvents that ended in 1990.

Until March 2008, SMP produced automobile parts and components at the Long Island City facility primarily in the basement within recent years. The manufacturing operations included metal fabrication and machining, plastic injection molding, and assembly. SMP also operated a small photography laboratory for production of newsletters, brochures, etc. Hazardous or toxic materials involved in plant operations are lubricating oils for machinery, caustics for degreasing, phenolics used in molding processes, epoxies for coil production, and water-based inks involved in their small-scale printing. All wastes were temporarily stored on-site in secure containers prior to off-site disposal at a licensed treatment, storage, and disposal (TSD) facility.

The building and associated property was sold by SMP in March 2008 to XEXII Northern Boulevard Acquisition, LLC, who will continue to operate this facility as commercial office space. SMP continues to occupy most of the office space within this building.

2.3 Summary of Previous Investigations

Several studies have been conducted at the Site or at adjacent sites (i.e., Sunnyside Yard and the Hess [formerly Merit] gasoline station). These previous investigations are summarized as follow and in the comprehensive RI report.

2.3.1 Standard Motor Products, Inc. Site Investigation

A preliminary investigation was initiated by Summit Environmental Evaluations, Inc. in September 1990 following the observation of an oily sheen in a puddle area in the southeast side of the Site off the loading dock. An area of approximately 2,700 square feet (30 feet by 90 feet) was excavated to a depth of 1 to 2 feet. The excavated soil (approximately 4,050 cubic feet) were either stockpiled or placed in roll-off containers located along the loading dock. Analysis of soil samples collected on October 11, 1990, indicated that this area contained elevated levels of petroleum hydrocarbons and volatile organic compounds (VOCs), particularly 1,1,1-trichloroethane (TCA).

Subsequent to the Summit Environmental Evaluations, Inc. investigation, SMP contracted Public Service Testing Laboratories, Inc. to conduct additional analyses on the soil. The results of these additional analyses indicated non-detectable levels of VOCs. However, levels of lead detected from toxicity characteristic leaching procedure (TCLP) analyses yielded results above the hazardous toxicity thresholds in three of the five samples.

In early 1991, H2M Group (H2M) conducted an assessment of the soil quality in the area off the loading dock. This assessment included a soil gas survey and analysis of additional soil samples. The results of this assessment are documented in the "*Soil Investigation Report*" prepared by H2M Group in 1991 (H2M 1991). A photo-ionization detector (PID) was used to screen the soil for VOCs. The highest concentrations were found immediately adjacent to the loading dock. In addition, an oily sheen was noted in the flooded excavation on the west side of the study area during the soil gas survey. Eleven soil samples were collected based on the results of the soil gas survey and visual inspections. Soil samples were collected at a depth of 18 inches below grade. Elevated levels of total petroleum hydrocarbon (TPH) and VOCs were found in the stockpiled soil and in the undisturbed soil off the loading dock in the south eastern portion of the Site. Though TPH and VOCs were also detected in background samples, the concentrations were up to three orders of magnitude less than those detected in the stockpiled soil and near the eastern portion of the loading dock. Based on the results, H2M reported that the soil could be classified as an environmental media contaminated with a listed hazardous waste and not as a hazardous waste.

Later in 1991, H2M began an RI in order to determine the nature, type, and physical state of soil and/or groundwater contamination associated with the operation of the SMP facility. Groundwater and soil samples were collected through the installation of six monitoring wells and thirteen soil borings in the eastern half of the Site. The results of this investigation are documented in the *"Remedial Investigation Report"* prepared by H2M in 1992 (H2M 1992).

Forty soil samples were collected at depths ranging from 5 to 40 feet below grade and were analyzed for VOCs. Total VOC concentrations were as high as 35 milligrams per kilogram (mg/kg). The most prevalent compounds detected in the shallow soil samples (above 7 feet) were chlorinated solvents, such as 1,1,1-TCA, tetrachloroethene (PCE), methylene chloride, and trichloroethene (TCE). Results indicated that soil contamination existed along the loading dock from the suspected source area near the southeast corner westward for approximately 200 feet and southward for approximately 15 to 20 feet. Though most chlorinated solvent contamination was found at shallow depth, elevated levels of benzene, toluene, ethylbenzene, and xylenes (BTEX) were detected at depths greater than 10 feet (beneath the water table) which could have originated from the upgradient Hess (formerly Merit) gasoline station site.

Groundwater level measurements indicated a northerly direction of groundwater flow that was contradictory to the general regional groundwater flow direction which is south to southwest, according to a 1981 United States Geological Survey (USGS) regional map. The differences in groundwater flow direction were presumed to be due to a sump pump that operates continually in the SMP basement to prevent flooding, as well as potential dewatering operations in the local subway system and other nearby buildings (H2M 1992). Subsequent to the H2M RI, the RI of the adjacent Sunnyside Yard has documented groundwater flow from the east to the west.

Groundwater samples were collected from the wells and analyzed for VOCs, TPH, and metals. Several metals and VOCs were found to exceed the NYSDEC groundwater standards in effect in 1991. VOCs ranged from non-detect to 2,600 micrograms per liter (µg/L) for xylenes. Xylenes are a BTEX constituent which could have originated from the upgradient Hess (formerly Merit) gasoline station site.

Chlorinated solvents were also detected to a lesser extent. Metals detected in groundwater samples included iron, manganese, sodium, lead, chromium, copper, and zinc (H2M 1992).

The 1992 RI report determined that unacceptable risks were unlikely from exposure to contaminated soil and that there is no exposure to groundwater. Therefore, No Action with site controls (e.g., paving and additional fencing) and continued groundwater monitoring was recommended in lieu of remediation.

In 1995, EnviroAudit Ltd. (EnviroAudit) conducted an investigation of surface and subsurface soil at the site and of the groundwater conditions within the upper aquifer. This investigation included the drilling of 15 soil borings with two borings completed as groundwater monitoring wells, collection and analysis of forty-four soil samples, and collection and analysis of three groundwater samples and two sump samples. The results of this investigation were documented in "*A Phase II EnviroAudit Subsurface Investigation and Summary Report of an Industrial Property Located at 37-18 Northern Boulevard in Long Island City, New York*", prepared by EnviroAudit in 1996. Elevated levels of VOCs were found in the area of the loading dock, in site soil and groundwater. The primary compounds detected in excess of clean-up guidelines in effect in 1996 were 1,1,1-TCA, 1,1-dichloroethane (DCA), and TCE. Lead was only detected at low levels using the TCLP analysis (EnviroAudit 1996).

2.3.2 Sunnyside Yard Investigation

The Sunnyside Yard is a train makeup and maintenance facility that is located south and west of the Site (Figure 2-3). It is listed as a Class II Site in the NYSDEC Registry of Inactive Hazardous Waste Disposal Sites (Site Number 2-41-016), and has been the subject of a remedial investigation since 1989. Due to the proximity of the Sunnyside Yard to the Site, the previous investigations at the Sunnyside Yard are relevant because they concern groundwater in the vicinity of and potentially downgradient of SMP. The Sunnyside Yard was subdivided into the following six operable units (OUs) in order to address remedial efforts and accommodate construction schedules at The Sunnyside Yard. However, OU5 and OU6 are the OUs that are particularly relevant to the investigation at the Site.

OU5 was designated as the sewer system beneath the Sunnyside Yard. The sewer system is a combined sewer system, receiving septic only from historical buildings on the Site which are no longer in use. Thus, the sewer system is primarily a storm sewer that drains surface runoff primarily from the Sunnyside Yard. A portion of this storm sewer runs behind the SMP facility. There are three manholes located adjacent to the SMP facility that are connected by a round brick 42-inch conduit that was built around 1908 or 1912 (Roux Associates, Inc. 2002). To date, the investigation for OU5 has not been initiated, and thus, any potential contamination within these sewers has not been determined.

OU6 was designated as the groundwater OU and included the saturated soil beneath the Sunnyside Yard. Several RI Reports have been issued to date for OU6; however, the most comprehensive RI Report is anticipated to be developed in the winter of 2008. Previous groundwater investigations of the Sunnyside Yard are discussed in this section since the most comprehensive RI is currently not available.

A Phase I Remedial Investigation (Roux Associates, Inc. 1992) was conducted in 1990 and 1991. The results of the Phase I RI shallow groundwater monitoring indicated the following:

- No VOCs or semi-volatile organic compounds (SVOCs) were detected above standards
- Only a limited number of SVOCs, predominantly polycyclic aromatic hydrocarbons (PAH), were detected
- Polychlorinated biphenyls (PCBs) were detected in only one monitoring well, which also contained separate-phase petroleum
- Iron, lead, manganese, and sodium were detected above the NYSDEC standards in most samples, which is typical for background conditions in industrialized urban environments with historical saltwater intrusion

Subsequent investigations of the groundwater were conducted to further delineate the extent of contaminants, to determine if migration of contaminants in groundwater is occurring either on-site or off-site, and to develop additional information regarding groundwater flow characteristics. These were reported in the previous OU6 RI Report (Roux Associates, Inc. 1999) and are summarized below.

Several VOCs, including BTEX, chlorinated solvents, styrene, carbon disulfide, and 4-methyl-2-pentanone, were detected in groundwater. Chlorinated solvents were detected in monitoring wells adjacent to the site and west (i.e., downgradient) of the site. The concentrations of *cis*-1,2-dichloroethene (DCE), TCE, and PCE generally show a decrease over the sample collection period. Though groundwater flows westward from the Site, the water table is nearly flat in the vicinity of SMP, indicating that the detected VOCs in these wells on the Sunnyside Yard may be due to groundwater contamination at SMP. Several SVOCs were also detected in the Sunnyside Yard groundwater samples. Due to the proximity of the wells containing SVOCs to the separate-phase petroleum plume at the Sunnyside Yard, these detections are likely due to that plume. Several metals were also found at concentrations above local background concentrations.

2.3.3 Hess (formerly Merit) Gasoline Station Investigation

The Hess (formerly Merit) gasoline station (Hess Station) is an active retail gasoline station with a one-story building, car wash, and kiosk. It is located east of the Site and was the subject of an environmental investigation (GES 1998). In 1995, five underground storage tanks (USTs) at the Hess Station were decommissioned and removed while two additional USTs were decommissioned by abandonment in place. A subsurface investigation as part of the site investigation was performed. The main objective of this investigation was to define the vertical and horizontal extent of the hydrocarbon impact detected during the post-excavation sampling. Four monitoring wells were drilled at the Hess Station in 1996 to assess groundwater quality. The highest concentrations of contaminants in groundwater were detected in the northeast section of the Hess Station near the former location of the larger USTs. The lowest concentrations were detected in the southeast section of the Hess Station, and concentrations were intermediate in the northwest and southwest sections of the Hess Station. BTEX concentrations ranged from below detection limits in the southwest section of the site to a maximum of 1,110 µg/L for benzene; 11,600 µg/L for toluene; 4,250 µg/L for ethylbenzene; and 20,500 µg/L for xylenes. Methyl *tert*-butyl ether (MTBE) concentrations in groundwater ranged from 11.4 µg/L to 8,770 µg/L. TPH concentrations in groundwater ranged from below detection limits to 8,400 µg/L. BTEX concentrations in groundwater at the Hess Station were significantly greater than concentrations detected on the Site.

Section 3
Summary of Remedial Investigation

The comprehensive RI Report characterized the nature and extent of contamination migration and the exposure/risk assessment. The draft comprehensive RI report for the Site was completed in July 2008 (CDM 2008). This section presents a description of physical characteristics of the Site, a summary of study area investigation, summary of the nature and extent of contamination, a summary of the fate and transport, and a summary of the exposure/risk assessment.

3.1 Physical Characteristics of the Site

The physical characteristics of the Site and surrounding area are important to understanding the current nature and extent of contamination and future transport of contaminants. These characteristics can be described in terms of the demography and land use, meteorology, surface features and drainage, geology and hydrogeology.

3.1.1 Demography and Land Use

The Site is located in Long Island City, Queens County, New York. According to the 2000 Census from the United States Census Bureau, 142,886 people reside in Long Island City, which covers an aerial extent of 2.6 square miles. Therefore, Long Island City has a population density of 54,956 people per square mile, making it the neighborhood in Queens County with the highest population density. With 2,229,379 people residing in Queens County and a land area of 109 square miles, the population density of Queens County is 20,453 people per square mile.

Located in the westernmost section of Queens, Long Island City covers approximately 1,664 acres (approximately 500 square blocks). Long Island City is bounded by Newton Creek to the south and the East River to the west. The north and east sides of Long Island City are defined by 31st Road and 34th Avenue to the north, and Barrett Avenue, 39th Street and the Brooklyn Queens Expressway to the east. The Queens-Midtown Expressway runs east-west through the southern part of the study area, while the Queens-Midtown Tunnel and the Queensboro Bridge connect the study area to midtown Manhattan. Long Island City is predominantly industrial with manufacturing occupying 32 percent of the area. Transportation (Sunnyside Yard), utilities, and other infrastructural types of uses occupy 22 percent of the area; commercial and auto storage service occupy 15 percent of the area; residential/mixed residential commercial occupying 22 percent of the area.

3.1.2 Meteorology

The mean monthly temperature in Long Island City is presented in Figure 3-1. The average annual temperature is 55 degrees Fahrenheit (°F). The coldest month January averages a monthly temperature of 36°F, while the warmest month July averages a monthly temperature of 79 °F.

Average monthly precipitation in Long Island City is approximately 4.2 inches with the wettest months being June through October. Figure 3-2 presents the total monthly precipitation for the years 2002, 2003, 2005, 2006, 2007, and 2008 and the 30-year mean for the month. The Phase I Field Investigation was performed during November 2002, during typical dry conditions. The Phase II Field Investigation was performed during June and July 2003 when precipitation events were significantly above the 30-year mean monthly values. Phase III Field Investigation was performed during September of 2005 and March 2006, during typical dry conditions. Phase IV Field Investigation was performed during January and February of 2008 when precipitation events were slightly above the 30 year mean monthly values. The prevailing winds are from northwest. However, during the summer the prevailing winds are from southwest.

3.1.3 Surface Features

The SMP property is mostly occupied by a six story building whose first floor is approximately at the same elevation as Northern Boulevard. The "backyard" of the SMP building (i.e., the area behind the building) is at a lower elevation than the basement floor. There is about a 15-20 foot drop in elevation between the front of the building and the backyard where most of the contamination was detected. The surface of the backyard or adjacent property is covered by soil, gravel, scattered vegetation, and miscellaneous construction debris and refuse. Several abandoned railroad lines which are presently being renovated pass through the southern portion of the Site and multiple active railroad lines are located beyond the southern extent of the Site (south of MW09 and MW13). Scattered vegetation is present throughout the "backyard" area - becoming denser towards the western part of the SMP rear yard - and is also present along the abandoned railroad lines.

3.1.4 Site Topography and Drainage

Sand and gravel cover the surface of the Site beneath the 39th street overpass and south of the open loading dock near the former excavation that was completed during the Summit Environmental Evaluations, Inc. investigation in September 1990. Underneath the 39th street overpass, a drain spout channels storm water from the bridge into the back yard and drains into the manhole that is in the vicinity of the former excavation (Figure 3-3). Storm water runoff also drains into the manhole located south of the covered and fenced drum area. These manholes freely allow surface runoff to drain into the storm sewer line. The manholes located south of the SMP building are interconnected by a 36-inch pipe and are a part of the primary sewer subsystem that drains over 90 percent of the Sunnyside Yard**.**

Even though the general storm water runoff drains from east to west, a slight topographic high point exists between the central and eastern manholes in the location of SG03. During heavy precipitation events, storm water runoff collected in the previous excavation area (near the eastern manhole) and the central manhole in the vicinity of SG05 (Figure 3-3). There is a significant quantity of vegetation around the western manhole preventing measurable soil erosion.

A petroleum sheen was observed on the storm water runoff from the bridge and other portions of the Sunnyside Yard as noted in previous investigations. The NYSDEC representative was made aware of this situation during a routine site walk.

The sewer system is located at an approximate depth of 12 feet below land surface. Currently, the water table elevation is usually between 4 and 5 feet below land surface; thus, the sewer system is below 8 feet of water during a high water table. Historically, prior to public water being supplied, the quantity of private drinking water wells in the area significantly depressed the water table by almost eight feet. The sub-basement of the SMP building must have been constructed during this period since an intermittent sump pump is currently needed to keep the groundwater table from rising to a level of eight feet above the sub-basement slab**.** The sump discharges directly into the sewer line located along Northern Boulevard and not into the Sunnyside Yard storm water drainage system.

3.1.5 Site Geology

The site geology was characterized based on published reports and observations made during previous investigations and during the Phase I, II, and IV Field Investigations. Observations made during the historical and recent field investigations at the Site indicate the presence of fill, including sand, silt, concrete fragments, and wood railroad ties, from the ground surface to approximately two feet below ground surface. Below the fill material, sands and gravel were observed to a depth of approximately 40 feet below ground surface (bgs). These observations were consistent with published information on subsurface geology in the area.

According to logs of borings drilled on the Site and the adjacent Sunnyside Yard during investigation of the Site, the area is underlain by the following units (in order by increasing depth): fill, Upper Pleistocene glacial deposits (including both till and channel deposits), and bedrock. Figures 3-3 through 3-8 present the borings performed during the Phase IV field investigation. The fill is predominantly comprised of reworked glacial deposits (sand, silt, clay, and gravel) and railroad ballast with minor amounts of construction debris and other materials. The Upper Pleistocene glacial deposits consist mainly of ground moraine deposits; unstratified, poorly sorted mixtures of sand, silt, clay, and gravel. In addition, a cobble layer was encountered in three soil borings drilled at the Site and three deep borings drilled at the Sunnyside Yard. This unit may represent a relict stream channel that was formed by glacial melt-water. One borehole was drilled to the bedrock surface beneath the Sunnyside Yard. In this soil boring located within the Sunnyside Yard due west of the Site, bedrock was encountered at a depth of 74 feet below land surface (i.e., 53 feet below mean sea level). In the southwestern portion of the Sunnyside Yard, a Holocene wetland deposit was encountered below the fill and above the Upper Glacial formation. This deposit consisted of organic silty clay and meadow mat. This deposit is associated with a buried stream channel (Roux Associates, Inc. 1995).

3.1.6 Site Hydrogeology

The hydrogeology of the Site has been characterized based on previously published reports and observations made during historical and recent field investigations at the Site. The hydrogeologic units correspond to the previously discussed geologic units.

The groundwater beneath the Site occurs under water table (unconfined) conditions. The depth to groundwater in the vicinity of the Site is approximately 5 feet below ground surface but may be influenced by surface runoff that results in standing water across most of the Site during rain events. The water table occurs in either fill or glacial deposits. Beneath the Site, the saturated fill deposits and the shallow Upper Glacial aquifer were not always distinguishable and are therefore, collectively referred to as shallow deposits.

Previous investigations performed at the Sunnyside Yard document groundwater flow to the west. The groundwater eventually discharges to the East River or one of its tributaries. Vertical groundwater movement is restricted by the Gardiners Clay where present or by the Precambrian bedrock which is considered to be the bottom hydrogeologic boundary of the groundwater flow system.

Groundwater elevation data collected in February 2008 is consistent with previous investigations and show that, underneath the Site, flow is primarily from east to west (Figures 3-9 and 3-10). Due to the proximity to the East River, the hydraulic gradients are gentle which is consistent with the regional groundwater contour map (Figure 3-12) and the groundwater contours present in the Sunnyside Yard (Roux Associates, Inc. 1999). For example, the February 2008 elevation contours ranged from a maximum of 16.3 feet on the east side of the Site to 16 feet at the west side of the Site. A gradient of 0.001 was calculated using data from monitoring wells MW10 and MW08. The deep groundwater contours were not prepared because, in February 2008, CDM could only access two wells. The deep potentiometric surface from 2003 is shown in Figure 3-11 for reference. In February 2008 the water level elevation readings from monitoring wells MW11S and MW11D were essentially the same: 16.18 and 16.19 respectively. The elevations at MW14S and MW14D were 15.89 and 16.06, respectively, which indicates an upward gradient at this location. Based on the aquifer testing performed at the Site during the Phase II Field Investigation, the geometric mean hydraulic conductivity was calculated as 233 feet/day. The published horizontal hydraulic conductivity of the Upper Glacial aquifer in Queens County ranges from 214 feet/day (McClymonds and Franke 1972) to 270 feet/day (Franke and Cohen 1972).

Using this data the groundwater flow rate was estimated as follows:

$$V = \frac{Ki}{n}$$

Where: V = groundwater flow rate
K = hydraulic conductivity: 233 feet/day

i = gradient, 0.001
n = effective porosity, assumed to be 30% or 0.3

Using these values V is calculated as follows:

$$V = \frac{(233\, feet/day) * (0.001)}{0.3}$$
$$V = 0.78\, feet/day$$

A sump pump is located in the basement of the SMP building. As previously stated, published regional data and historical investigations at the adjacent Sunnyside Yard site have documented groundwater flow to the west. The previous H2M 1992 RI Report speculated that groundwater flow direction in the immediate vicinity of the Site was to the north toward the basement sump pump. During the Phase IV investigation, three sumps were inspected. The flow rate for Sump 1 and Sump 2 were measured as 65 gallon per minute (gpm) and 130 gpm during maximum pumping capacity, respectively. These two pumps are operated intermittently. The pumps within the sumps are controlled via a level indicator. After initial drawdown, the water level is allowed to recover prior to the level indicator triggering activation of the pumps. The flow rate for Sump 3 was not measured since the pump was not purging water. Based on the hydrogeologic properties of the underlying formation, it is not anticipated that the operation of the sump pump has a major effect on the groundwater flow in the vicinity of the Site.

3.2 Study Area Investigation

The RI was conducted to characterize the nature and extent of contamination at the Site and to identify areas that pose a potential risk to human health and the environment. The field investigation for the RI/FS was conducted in four phases from November 2002 through February 2008. The Phase I Investigation involved the collection of soil samples using hand augers and direct push drilling to delineate the nature and extent of soil contamination. Groundwater samples were also collected during the direct push sampling (Figure 3-13). During the Phase II Investigation, the results of the hand auger and direct push samples were used to determine the placement of groundwater monitoring wells and the depths of the screened intervals. Following installation of the monitoring wells, monitoring well development and aquifer testing was completed and groundwater samples were collected to evaluate the groundwater quality beneath the Site. The Phase III Investigation involved two rounds of monitoring well groundwater sampling to verify the results of the Phase II Field Investigation as well as one round of soil vapor sampling (Figure 3-14). The Phase IV Field Investigation involved direct push soil and groundwater sampling inside and outside the facility, monitoring well sampling, sub-slab vapor sampling, and soil vapor sampling to further delineate contamination under the building and in proposed “hot spot” area identified during the previous phases (Figure 3-15). Sampling and analyses for these investigations consisted of the following:

Phase I Investigation

- Surface soil sampling
  - 5 surface soil samples collected via hand auger
- Direct push sampling of soil
  - 22 soil samples from the 11 shallow direct push locations
  - 40 soil samples from the 10 deep direct push locations
  - 12 soil samples from the 6 angled direct push locations
- Direct Push Sampling of Groundwater
  - 17 groundwater samples from the 9 deep direct push locations
  - 6 groundwater samples from the 6 angled direct push locations
- One Interior Sump Sample

Phase II Investigation

- Monitoring Well Installation and Development
  - 8 monitoring wells in 5 locations
- Monitoring Well Sampling
  - 8 newly installed monitoring wells
  - 1 interior existing monitoring well
- One Interior Sump Sample
- Aquifer Testing
  - 2 slug tests at each of the 8 newly installed monitoring wells

Phase III Investigation

- Two Rounds of Monitoring Well Sampling
  - 8 exterior existing monitoring wells
  - 1 interior existing monitoring well
- Soil Vapor Sampling
  - 6 exterior soil gas ports at 3 feet bgs
  - 2 interior sub-slab ports

Phase IV Investigation

- Exterior Direct Push Sampling of Soil
  - 26 samples from 10 direct push locations
    - 6 samples from 0 to 2 feet bgs
    - 10 samples from water table interface
    - 10 samples from deepest achievable depth
- Exterior Direct Push Sampling of Groundwater
  - 22 samples from 10 direct push locations
    - 10 samples from 5 to 9 feet bgs
    - 6 samples from 10 to 14 feet bgs
    - 6 samples from 15 to 19 feet bgs
- Exterior Soil Gas Sampling
  - 12 exterior soil gas ports at 3 feet bgs
  - 2 ambient air samples
- Interior Direct Push Sampling of Soil
  - 31 samples from 16 direct push locations

        - 15 samples from water table interface
        - 16 samples from deepest achievable depth
- Interior Direct Push Sampling of Groundwater
    - 15 samples from 15 direct push locations
        - 15 samples from water table interface
- Interior Sub-Slab Vapor Sampling
    - 16 interior sub-slab air ports
    - 3 indoor air samples
    - 1 ambient air sample
- Monitoring Well Sampling
    - 5 existing monitoring wells
    - 4 newly installed monitoring wells
- Vault Inspection and Sampling
    - 1 vault sample
- Sump Inspection and Sampling
    - 3 sump samples

3.3 Nature and Extent of Contamination

This section describes the findings of the investigation for all environmental media that were investigated. The following summarize the main contaminants of concern in each environmental medium at the Site. Tables 3-1 through 3-3 present the summary of Phase IV Investigation results for soil, groundwater, and soil vapor, respectively.

3.3.1 Soil Contamination

3.3.1.1 Chlorinated Volatile Organic Compounds

The subsurface soil samples containing elevated concentrations of chlorinated VOCs above screening levels were observed in the alleyway of the loading dock extending from the western edge of the totally enclosed storage area to approximately 20 feet west of the MW11 monitoring well cluster. The analytical results that exceeded screening levels for chlorinated VOCs in 2002 were from subsurface soil samples collected from 0 to 6 feet bgs, which coincides with the groundwater table interface and supersaturated areas. The analytical results from the recent Phase IV investigation do not contained concentration exceeding the screening levels for chlorinated VOCs.

The highest 1,1,1-TCA concentrations were observed at DD09 at 4,800 mg/kg in 2002, but it was detected below the screening criteria at an adjacent boring location SG03 in 2008. The consistency of the highest concentration of 1,1,1-TCA being in this localized area confirms the location of a “hot spot” identified during the Phase I and II Investigations. The significant decrease in concentration, however, suggests that there is an extensive degradation of 1,1,1-TCA and that the source is a historical release.

According to historical investigations, the surface soil within close proximity to DD09 contained significant levels of chlorinated VOC. In 1991, during the soil investigation, H2M detected the highest total VOCs in sample S-6 at a depth of 18 to 24 inches below grade at 894.21 mg/kg. Sample S-6 is located approximately 150 feet west of the southeast corner of the building. Unfortunately, only the 18 to 24 inches depth increment was sampled from all the soil borings. In 1992, during the remedial investigation, H2M performed soil sample screening (from various locations at depth increments of 5, 10, 15, and 20 feet bgs). Selected samples were analyzed for VOCs. The highest VOC, 1,1,1-TCA, was detected in soil samples collected from a depth of 5 to 7 feet bgs (saturated soil) at levels ranging from non-detect to 26 mg/kg. The most contaminated samples were again the samples collected closest to the surface although only saturated soil samples were collected during the 1992 investigation. Soil samples from the 0- to 2- foot depth increment were not collected. When comparing the 1991 H2M investigation to the 1992 H2M investigation, the 18 to 24 inches depth increment contained higher concentrations of VOCs. The H2M investigations did not sample the surface soil near the loading dock within the vicinity of 120 feet west of the southeast corner of the building.

During the 1996 EnviroAudit investigation, the highest VOCs, 1,1,1-TCA, was detected in sample AB-2, located 120 feet west of the southeast corner of the building, collected from a depth of 0 to 2 feet bgs. This sample contained a concentration of 1,1,1-TCA of 7,000 mg/kg. The sample collected from the 10 to 12 feet increment (7 mg/kg) contained significantly less VOCs. A soil sample from the 5 to 7 feet depth increment was not collected in boring AB-2. However, the sample AB-1 collected from a depth of 0 to 2 feet bgs contained a concentration of 1,1,1-TCA of 1,600 mg/kg. Samples collected from the 5 to 7 feet depth increment (4.6 mg/kg) and 10 to 12 feet increment were non-detect containing significantly less VOCs. The sample AB-1 is located approximately 100 feet west of the southeast corner of the building. These were the two borings that contained the highest detected levels of VOCs.

Since all historical investigations detected the highest concentration of chlorinated VOCs near the surface soil, the source of the chlorinated VOCs must have been a surface spill located immediately adjacent to the loading docks, approximately 120 feet west of the southeast corner of the building. The data collected during the RI supports this finding with the exception that currently the VOC contamination has been flushed over time from the surface soil into the subsurface unsaturated soil and finally into the subsurface saturated soil located a foot or two below the water table interface, indicating the absence of a continuing source of contamination.

3.3.1.2 Non-Chlorinated Volatile Organic Compounds

None of the soil samples collected in 2008 contained concentration exceeding the screening levels for non-chlorinated VOCs. From previous investigations, ethylbenzene and xylenes were the two common non-chlorinated VOCs that exceeded the screening level within the soil matrix in 2002. Almost all of the soil samples that contain elevated levels of ethylbenzene and xylenes were collected from a depth of 8 to 12 feet below grade. The 0 to 2 feet samples and the 5 to 7 feet samples collected during the Phase I Field Investigation did not contain elevated levels of these substances. The historical investigations conducted by H2M and EnviroAudit also detected elevated levels of ethylbenzene and xylene at a depth between 10 to 15 feet.

Since the water table interface is located between 4 to 5 feet below grade, the exterior soil boring contamination is detected at a depth which is significantly below the water table interface. If the historical source was located within the Site, contamination would be detected at the groundwater table interface. Contamination in the unsaturated zone migrates downward with gravity and precipitation. Once contacting the groundwater interface, the direction of contaminant migration is along the groundwater flow path which at the Site is in the western direction. No significant downward groundwater flow gradient exists at the Site. Also, the organic partition coefficients (K_{OC}) for ethylbenzene and xylene are fairly low and the solubility are fairly high, indicating that sorption onto soil particulates would only occur in areas of high groundwater concentrations. Thus, a contaminant source must exist at approximately 11 to 12 feet.

Since the sewer line is located at a depth of 12 feet and most of the non-chlorinated VOCs are located within close proximity to the sewer line, this sewer line may be a source of the non-chlorinated VOC contamination. Non-chlorinated VOCs may be entering the sewer line either via the drain spout that drains the 39th Street Bridge and adjacent Hess gasoline station and discharges contaminated storm water runoff overland into the on-site manholes or through upgradient sewer lines that convey non-chlorinated contamination from the adjacent Sunnyside Yard into the on-site sewer line. Both the Hess gasoline station and the Sunnyside Yard have detected non-chlorinated VOC contamination that is several orders of magnitude above those levels detected on the Site.

The locations of the three manholes that connect the sewer line were surveyed during the November 2002 investigation and the approximate depth of the manholes and connecting sewer line was measured at 12 feet. Conversations with Roux Associates indicated that there were no as-built drawings available for this sewer line. However, Roux interpreted the location and size of the sewer system during The Sunnyside Yard investigations. The information collected from Roux Associates, Inc., in October 2002 included the following:

- The 36-inch round brick conduit was built around 1908 or 1912
- This brick conduit carries the combined sanitary discharge (from old Sunnyside Yard buildings only) and storm water runoff
- The sewer line runs straight between manholes behind the SMP building
- Drainage is from Sunnyside Yard only (with the exception of the 39th Street drain spout)
- The three man-holes that were surveyed did not contain man-hole covers that would prevent surface water runoff from entering these man-holes and subsequently discharging along the sewer line.

In addition, located directly adjacent to the southeast corner of the building is a discharge drain that drains surface water runoff from the 39th Street overpass. Thus, any surface water discharge from the street above or the Hess site can be discharged onto the Site via the drain spout located under the 39th Street Bridge and flow directly into these man-holes and enter the sewer line.

In particular, during the Phase I Field Investigation, significant surface water runoff was being discharged onto the Site from this drain spout and flooding the SMP property. Storm water routinely floods the vicinity of the previously excavated soil (near the western manhole) and the area adjacent to the central manhole (SD05). An oily sheen was noticed within this surface drainage from the drain spout. The NYSDEC environmental manager was on-site at the time and the project team directed her attention to this condition.

In conclusion, the highest non-chlorinated volatile organic concentrations are located at the same depth as the sewer line and in close proximity to the sewer line. Thus, it is reasonable to conclude that the non-chlorinated volatile organic contamination is caused by upgradient sources. This conclusion is also supported by the elevated levels of non-chlorinated volatile organic constituents at SB13 which is located in the northwest corner of the building.

In addition, the contaminant distribution pattern for chlorinated VOCs is significantly different from the contaminant distribution pattern of the non-chlorinated VOCs. Thus, the data collected during the Phase I and IV Investigations and prior investigations indicate that the non-chlorinated VOCs are from an upgradient source. The Hess Station is located immediately upgradient and significant non-chlorinated VOCs contamination has been confirmed on this property as is the source of non-chlorinated VOCs on the Site.

3.3.1.3 Semi-Volatile Organic Compounds

During Phase IV Investigation, the exterior and interior subsurface soil samples displayed significantly different SVOCs, and therefore no correlation is made between the two.

The exterior soil boring sample, SG09, detected SVOCs found in no other borings throughout the Site. The constituents detected are common gasoline components (such as benzo(a)anthracene and dibenz(a,h)anthracene) and occur ubiquitously in products of incomplete combustion. Since the constituents are present along the loading dock area (not under the building) at relatively low depths, it is concluded that the source of these constituents are from the drainage pipe from the 39th Street bridge, debris stored in the alleyway, and/or degradation products of a gasoline plume migrating from an off-site source.

The interior soil boring sample from SB04 detected SVOCs found in no other borings throughout the Site as well. The constituents detected have an array of uses: 4-chloro-3-methylphenol is used as a fungicide and preservative; 4-nitrophenol is also used as a fungicide; and 2-chlorophenol is most likely a xenobiotic produced from the degradation products of the gasoline and chlorinated constituent plumes mixing together.

Since the constituents are present only at isolated locations, it is concluded that the source of these constituents are from the sewer connection which is connected to the former 1,1,1-TCA tank, the gasoline plume migrating on site from the southeast, and/or machine operational and maintenance practices.

3.3.1.4 Inorganic Constituents

During Phase I Investigation, lead concentration exceeded the screening level in two instances. The two samples that contained concentrations that exceeded lead screening levels are located within the area of previously excavated soil which corresponds to an area that is a low point within the Site and is frequently flooded via upgradient storm water.

Unlike ethylbenzene and xylene, lead has no partitioning coefficient between organic carbon in soil and groundwater since lead is insoluble and sorbs readily onto soil. Thus, these elevated levels of lead are probably due to leaded petroleum products migrating via storm water runoff. Since lead is transported primarily via particulate migration, settling particulates from the stagnant storm water after storm events in the area adjacent to the eastern manhole create elevated levels of lead on surface soil in this area.

The screening level for lead for Phase I Investigation is 400 mg/kg and was selected based upon the EPA risk-based soil screening level for the ingestion-dermal exposure for a residential scenario, which is very conservative. However, the NYSDEC soil cleanup objective is 500 mg/kg. Even though two samples contained lead levels (483 and 465 mg/kg) that exceeded the screening concentrations, lead levels in these samples are below the NYSDEC criterion of 500 mg/kg. No samples collected during Phase IV Investigation shows concentration exceeding the screening level under industrial exposure scenario (3,900 mg/kg).

During Phase IV Investigation, iron, arsenic, and vanadium were detected in soil at concentrations exceeding the soil screening levels. Iron is the major inorganic constituent above screening level present at all subsurface sampling locations. Since iron is ubiquitous in the environment in particular to urban settings such as Long Island City, Queens, New York where construction, adjacent rail transportation and industry are prevalent, this constituent is not assumed to be a Site-related contaminant.

Other constituents present in one or two borings located within the alleyway of the loading dock include arsenic and vanadium. Since these metal constituents were detected in isolated areas at relatively low concentrations their presence can be attributed to urban fill and urban setting where construction, adjacent rail transportation and general industry is prevalent.

3.3.2 Assessment of Groundwater Quality

Groundwater quality is assessed utilizing the results of both the direct push boring investigations conducted during the Phase I and IV Field Investigations and the monitoring well investigations conducted during the Phase II, III, and IV Field Investigations. The results of the analytical data collected from these investigations are compared with the groundwater screening levels. The direct push samples were utilized during the Phase I Investigation as a field screening technique to approximate locations of highest groundwater contamination and to properly place the permanent monitoring wells. The direct push samples were utilized during the Phase IV Investigation to further delineate contamination under the building and the previous identified “hot spot” area near the loading dock.

A significant difference in the constituents detections are observed between the direct push groundwater and monitoring well collection results. The direct push groundwater results detect a greater number of constituents and at significantly higher concentrations than the monitoring well results. The screened interval of the direct push groundwater sampling tool is approximately 4 feet in length, while the screened interval of the monitoring wells is 15 feet in length for the shallow wells and 10 feet in length for the deep wells. The longer screened interval of the wells integrates the sample over a larger interval diluting the sample. The direct push sample can more effectively target the localized “hot spot” for sampling. This dilution effect is particularly apparent in the results of the shallow wells since the contamination is observed at the water table interface. Thus, greater emphasis will be placed on the direct push groundwater samples as a true indicator of groundwater quality within the localized hot spot.

3.3.2.1 Direct Push Groundwater Quality

3.3.2.1.1 Chlorinated Volatile Organic Compounds

The majority of the highest chlorinated volatile organic concentrations detected during the Phase I Investigation are in the samples collected from DD09, DD13, DD11, SA01, SA02, and SA03 within the shallow 6-foot depth interval which coincides with the groundwater table interface. The Phase IV outdoor samples which contained the highest chlorinated volatile organic concentrations, SG02, SG03, SG04, and SG05, are also associated with the groundwater table interface (5 to 9 feet bgs) and in close proximity to the Phase I borings mentioned above. These results are consistent with soil analytical data in that the highest concentrations of both the soil and groundwater are located immediately adjacent to the loading dock approximately 120 feet west of the southeast corner of the building.

These results are also consistent with the historical soil and groundwater data in that they indicate a “hot spot". Soil boring locations DD09 collected in 2002 and SG03 collected in 2008 both detect a wide range of chlorinated volatile constituents, including 1,1,1-TCA, 1,1-DCA, 1,1-DCE, chloroethane, TCE, and VC, and usually detecting the highest concentration. The soil borings also detected elevated concentrations of these constituents at depths below the water table interface. It can be confirmed that the “hot spot” is along the loading dock northeast of MW11, approximately 120 feet west of the southeast corner of the building.

In addition, the analytical results from the Phase I and Phase IV Investigations from these sampling locations conclude significant degradation of PCE. During the Phase I Investigation four direct push groundwater locations showed concentrations of PCE, DD09, SA01, SA02, and SA03. The highest concentration of PCE among those samples was 44 µg/L at DD09. The Phase IV Investigation identified only two locations containing PCE at relatively low concentrations, SB15 at 11 µg/L and SB01 at 8.7 µg/L. The majority of the constituents detected during the Phase IV Investigation are TCE, *cis*-1,2-DCE, and VC.

Also during the Phase I Investigation groundwater samples collected downgradient of the “hot spot” (DD03 and DD04) detected 1,1,1-TCA while similar placed borings SG10 and SG09 analyzed during the Phase IV Investigation only detected 1,1,1-TCA at 7.7 µg/L at SG09. The highest 1,1,1-TCA concentration (3,100 µg/L) detected during the Phase IV Investigation is in SG03 which is at the “hot spot” location. Other chlorinated VOCs detected include 1,1-DCA and chloroethane which are the breakdown products of 1,1,1-TCA. The highest chloroethane concentration (2,200 µg/L) is detected in SB-07. The increased concentration of chloroethane at SB07 can be contributed to the former 1,1,1-TCA tank located upgradient (northeast) of the soil boring. Since chlorinated VOC concentrations significantly diminish underneath the building, the source of the chlorinated VOCs was confirmed to be located adjacent to the loading dock and not underneath the building.

3.3.2.1.2 Non-Chlorinated Volatile Organic Compounds

The contaminant distribution of the BTEX constituents is different from the chlorinated VOC contamination. The highest levels of BTEX contamination are detected in the most hydraulically upgradient borings adjacent to the eastern portion of the building. In 2002, DD23 and, in 2008, SG01, SB13, SB08, SB05, and SB03 displayed the highest concentrations of BTEX constituents. The soil boring SB13 is located in the northeast corner of the building near an office/storage area. The increased levels of BTEX constituents present at this location suggest an off-site source proposed below.

It should also be noted that the BTEX migration pathway does not coincide with the chlorinated constituent pathway. The highest chlorinated VOC contamination is located at the “hot spot” approximately 120 feet west of the southeast corner of the building. This “hot spot” location was also identified during historical investigation. The highest concentration of BTEX in the groundwater at the most hydraulically upgradient location is most likely due to the upgradient contaminant plume emanating from the Hess Station (Figure 3-16). The concentrations of BTEX detected at the Hess Station are several orders of magnitude higher than at the Site. The contaminant plume maps presented in Appendix C of RI indicate that the contamination is migrating from the Hess station toward the Site. The Hess station is likely the cause of the highest level of BTEX detected at the water table interface.

In addition to BTEX being transported from the Hess Station by the direct groundwater migration pathway, storm water runoff from the upgradient Hess Station, cross gradient portion of the Sunnyside Yard, and 39th Street Bridge are collected in the Site sewer line and contributes to the BTEX contamination at the water table interface. Both the Hess Station and the Sunnyside Yard have documented BTEX contamination that is orders of magnitude higher than the levels detected at the Site. These results indicate that the BTEX contamination detected on the Site originates from an upgradient off-site source.

The MTBE contaminant distribution is not only different from the BTEX contaminate distribution, but it is also different from the chlorinated VOC contaminate distribution. The highest levels of BTEX contamination are detected in the most hydraulically upgradient boring adjacent to the southeast corner of the building. The highest chlorinated VOC contamination is located at the "hot spot" approximately 120 feet west of the southeast corner of the building. In contrast, the highest MTBE contamination is detected in the southwestern samples collected from significant depth. Since MTBE has the lowest K_{oc} value of any volatile organic contaminant (chlorinated or non-chlorinated), it is highly mobile with little sorption onto soil to retard solute migration. MTBE is also highly persistent, and does not significantly biodegrade. Thus, the presence of MTBE located at significant depth on the southwestern edge of the Site is most likely attributable to an historical release from the Hess Station.

3.3.2.1.3 Semi-Volatile Organic Compounds

The three semi-volatile constituents, bis(2-ethylhexyl)phthalate, naphthalene, and phenol, are detected in isolated samples and at relatively low concentrations during Phase IV Investigation. Bis(2-ethylhexyl)phthalate is a common laboratory contaminant and detected at relatively low concentrations. Thus, bis(2-ethylhexyl)phthalate is not considered a Site related contaminant. Naphthalene and phenol however are common products of gasoline and are attributed to the BTEX plume migrating on site.

3.3.2.1.4 Inorganic Constituents

Several metal constituents detected in the outdoor groundwater samples exceeded the screening levels. The groundwater samples were collected from the water table interface (5 to 9 feet bgs) from direct push locations SG03, SG08, SG09. Additional groundwater samples were collected from 10 to 14 and 15 to 19 feet bgs from SG03.

A filtered metal sample was collected from SG09 to provide a realistic assessment of inorganic levels that are mobile in the groundwater flow regime. Since direct push sampling techniques typically contain an elevated level of particulates, inorganic analyses of direct push groundwater samples are not representative of constituents that are mobile in the aquifer. The SG09 filtered sample detected one metal constituent, iron, above the screening level. Since iron is ubiquitous in the environment in particular to urban settings such as Long Island City, Queens where increased construction and industry are prevalent, the constituent is likely not a Site related contaminant.

Several inorganic constituents were also detected in the indoor groundwater samples which exceeded the screening levels. A filtered indoor groundwater sample was not collected during this sampling round. Since the filtered sample contains significantly less inorganic constituents than the unfiltered sample, the high concentrations of inorganic constituents are attributed to suspended soil particulates.

3.3.2.2 Monitoring Well Groundwater Quality

3.3.2.2.1 Chlorinated Volatile Organic Compounds

Chlorinated volatile organic groundwater contamination overall is declining significantly over time (Figure 3-17). MW09S, MW11S, MW11D, MW12, MW13S, and MW13D yielded samples that displayed low to non-detect concentrations in 2005 and 2008. The major constituents consist of *cis*-1,2-DCE, TCE, and VC which are degradation products of PCE. Newly installed wells in 2008, MW14S, MW14D, MW15, and MW16, also contained these degradation products. The sample from MW14D contained PCE at a concentration of 5.8 µg/L, which is close to the screening level of 5 µg/L. The sample from MW06 contained PCE and TCE at concentrations that were slightly higher in 2008 than concentration detected in 2003. Low detections of PCE of 17 µg/L and TCE of 8.2 µg/L were detected in the sample collected in2008. The sample collected from MW10 contained 1,1,1-TCA and 1,1-DCA concentrations of 9.2 and 8.2 µg/L in 2008. TCE and *cis*-1,2-DCE are detected in both the direct push groundwater samples and the monitoring well groundwater samples. The solubility of *cis*-1,2-DCE is higher than the solubility of the other chlorinated VOCs exceeding screening levels (with the exception of VC). The biodegradation process converts PCE into TCE; TCE into *cis*-1,2-DCE; and *cis*-1,2-DCE into VC. Thus, VC is also detected at concentrations exceeding screening levels at the same locations that *cis*-1,2-DCE is detected. The levels of *cis*-1,2-DCE, TCE and VC from the monitoring well data are clearly more representative of the mobile constituents in groundwater at the Site since these constituents extend beyond the immediate vicinity of the localized source area.

3.3.2.2.2 Non-Chlorinated Volatile Organic Compounds

The six non-chlorinated volatile organic constituents (benzene, ethylbenzene, toluene, xylene, isopropylbenzene, and MTBE) were detected at concentrations above screening levels from samples collected from the monitoring wells in 2008. These same six compounds were also detected at concentrations above their respective screening levels from samples collected from direct push borings.

The monitoring well samples were collected from shallow and deep monitoring wells. The shallow monitoring wells were screened across the water table interface using a 15- foot screen to accommodate a fluctuating water table interface. Groundwater samples were collected from the center of the screened interval which was approximately 10 to 12 feet bgs (water table interface was located at approximately 5 feet). The deep monitoring wells were screened approximately from 30 to 40 feet with a 10- foot screen. The samples were collected from the center of the screened interval at approximately 33 to 35 feet.

Similar to the direct push groundwater result, the monitoring well groundwater results indicate that the contaminant distribution of the BTEX constituents is different from the chlorinated VOC contamination. As in the direct push groundwater results, the monitoring well results detected the highest levels of BTEX contamination in the most hydraulically upgradient boring adjacent to the southeast corner of the building. In contrast, the highest chlorinated VOC contamination is located at the "hot spot" approximately 120 feet west of the southeast corner of the building. This "hot spot" location was also identified during historical investigation. The highest concentration of BTEX in the groundwater at the most hydraulically upgradient location is most likely due to the upgradient contaminant plume emanating from the Hess gasoline station. The concentrations of BTEX detected at the Hess Station are several orders of magnitude higher than the Site. The contaminant plume maps presented in the Appendix C of the RI indicate that the contamination is migrating in the direction of the Site and is most likely the cause of the BTEX contamination. In addition to BTEX being transported from the Hess Station via groundwater migration, storm water runoff from overland flow, 39th Street Bridge and the buried sewer line are all potential upgradient sources of BTEX and associated constituent contamination.

3.3.2.2.3 Semi-Volatile Organic Compounds

Two semi-volatile constituents were detected above or equal to the screening levels, 1,1'biphenyl and naphthalene in 2008. 1,1'Biphenyl was detected at 5 µg/L in MW16. This constituent was not detected in any other sample and is at its screening level; therefore, it is determined that 1,1'biphenyl is not a Site-related contaminant.

Naphthalene was detected at 46 µg/L in MW10. This constituent was only detected in one other groundwater sample also at a low concentration. Naphthalene is a common product of gasoline and should be attributed to the BTEX plume migrating on site.

3.3.2.2.4 Inorganic Constituents

As previously discussed, samples collected from a developed and purged monitoring well are more representative of the aquifer's soluble metal constituents since particulates are not present. Particulates do not migrate with groundwater flow due to the filtering action of the saturated geologic formation. Thus, samples containing high particulate levels are not representative of contaminant migration patterns due to groundwater flow.

Four inorganic constituents were detected in the monitoring well samples which exceeded the screening levels, i.e. iron, magnesium, manganese, and sodium. Most of these inorganic constituents are ubiquitous in the environment due to geologic formations and urban settings such as Long Island City, Queens. The elevated levels of these inorganic constituents are not Site-related.

3.3.3 Assessment of Vapor Intrusion

3.3.3.1 Soil Gas and Sub-slab Vapor Chlorinated Volatile Organic Compounds

The soil gas samples containing elevated concentrations of chlorinated volatile constituents during the Phase III and Phase IV Investigations are located within the exterior "hot spot". Sub-slab air samples displaying the highest concentrations of chlorinated volatile constituents are located to the east of the exterior localized "hot spot" in the vicinity of a stair well that may be impacting pressure gradients across the building. Vapor constituents detected diminish in the western side of the building and loading dock. The soil vapor results confirm the previously identified "hot spot" location.

The chlorinated volatile constituent concentrations in total have diminished over time, from 2006 to 2008. The Phase III Investigation showed the highest 1,1,1-TCA and TCE concentrations at 51,000,000 microgram per cubic meter (µg/m^3) and 1,800,000 µg/m^3, respectively. The Phase IV Investigation showed the highest 1,1,1-TCA and TCE concentrations at 820,000 µg/m^3 and 120,000 µg/m^3, respectively (Figure 3-18). This decrease in concentrations of Site-related contaminates suggest significant degradation of the source over time.

Ambient air samples detected elevated levels of 1,1,1-TCA; however, the concentration was less than the soil vapor detections. The ambient air contamination could be due to potential soil vapor pathways and/or being situated in a highly industrial and commercial area. The indoor air samples detected one chlorinated volatile constituent, 1,1-DCA, at an isolated area and at a very low concentration, 0.4 µg/m^3. According to the 2006 NYSDOH Final *Guidance for Evaluating Soil Vapor Intrusion*, a 1,1,1-TCA level of 1,000 µg/m^3 and a TCE level of 250 µg/m^3 in a sub-slab sample would require mitigation regardless of the indoor air concentration; therefore, mitigation is recommended.

3.3.3.2 Soil Gas and Sub-slab Vapor Non-Chlorinated Volatile Organic Compounds

The highest non-chlorinated VOC concentrations in the soil vapor samples were detected in SG02, SG03, SB01, and SB02 in 2008. These four soil vapor locations detected non-chlorinated volatile constituents at concentrations greater than 50 µg/m^3. Soil vapor ports SG02 and SG03 are located within the exterior "hot spot" where chlorinated volatile constituents are detected at very high concentrations. The non-chlorinated volatile constituent detections at these locations suggest a mixture of the chlorinated and non-chlorinated plumes.

The soil vapor port SB01 is located along the southern wall of the office desk area. The soil vapor port SB02 is located in the western portion of the building. The elevated levels of non-chlorinated volatile constituents can be attributed to the gasoline plume and/or historical localized releases.

The ambient air samples collected during the soil gas and sub-slab events detected relatively low concentrations of non-chlorinated volatile constituents, unlike the indoor air. All three indoor air samples detected elevated levels of non-chlorinated constituents. The three indoor air samples were located throughout the building to gain a representative composite of indoor air quality. The elevated detections of non-chlorinated volatile constituents suggest a recent gasoline-related source present in the subsurface and degreasers (e.g., tetrahydrofuran) present in the building in poor conditioned containers. It should be noted that large containers storing degreasers were not identified during the on-site investigation. The only product identified with the potential to affect indoor air quality was W-D40 aerosol cans in relatively good condition.

3.4 Fate and Transport

The fate of a constituent in the environment is a function of its chemical properties and the physical nature of the Site. The potential for environmental transport was examined by reviewing the topographic and hydrogeologic characteristics of the Site and a review of the available physical constants and chemical characteristics of each constituent.

The dominant fate process for chlorinated VOCs (i.e., *cis*-1,2-DCE, 1,1-DCA, chloroethane, VC, PCE, TCE, and 1,1,1-TCA) at the Site is volatilization from the groundwater to the soil gas and migration via groundwater transport.

3.4.1 Groundwater Fate and Transport

Chlorinated VOCs are considered to have medium-to-high mobility in water depending on their degree of chlorination. Sorption to soils is expected to be relatively minor; thus, transport in groundwater from contaminant sources is expected to be the dominant transport pathway.

The dominant fate process of non-chlorinated VOCs is partitioning to the atmosphere through direct volatilization. In surface soils, volatilization to the atmosphere should dominate. In subsurface soils, leaching to groundwater will occur to the extent that it is not retarded by high levels of organic carbon. In surface water, volatilization also dominates through photolysis. None of these compounds are expected to bioconcentrate in aquatic organisms.

The degradation process for the Site groundwater is biodegradation. Five of the nine tested wells (MW10, MW11S, MW12, MW14S, and MW15) yielded groundwater that was anaerobic (dissolved oxygen less than 1 mg/L) and nitrate reducing (nitrate < 1 mg/L). These groundwater samples had neutral pH (approximately 7 units) and contained very little organic carbon (TOC < 7 mg/L). A sixth well, MW14D, yielded groundwater that was oxygen poor but not nitrate-reducing, with neutral pH and very low TOC (1.8 mg/L). Thus, the predominant groundwater environment, based on the February 2008 sampling round, is oxygen limited, mildly reducing, and with minimal organic carbon present.

Under reducing conditions, many chlorinated VOCs can undergo microbially mediated reductive dechlorination via sequential replacement of chlorine atoms by hydrogen atoms. Chlorinated ethenes and ethanes can be biodegraded by this process to yield ethene and ethane as final breakdown products. In reductive dechlorination, the bacteria utilize a separate carbon source for food, and they respire the chlorinated VOCs, which serve as terminal electron acceptors much like oxygen serves aerobic bacteria (or animals).

Site groundwater, with its very low TOC concentrations, provides minimal carbon source to fuel reductive dechlorination. Thus, biodegradation is not expected to be a dominant process affecting chlorinated VOC fate. Under the site groundwater's predominant mildly reducing conditions, any microbial breakdown of PCE is expected to stop at the *cis*-1,2-DCE intermediate, which can accumulate as it is produced. The fact that some VC is observed in groundwater samples probably indicates that higher concentrations of TOC and lower reduction-oxidation potentials existed earlier in the plume's history. TOC could have been supplied by previous hydrocarbon contamination from fuel-related sources. Under these hypothesized carbon rich, reducing conditions, dechlorination beyond *cis*-1,2-DCE to VC could have occurred previously.

Hydrocarbon VOCs, such as BTEX, biodegrade most rapidly under aerobic conditions. In the predominantly mildly reducing groundwater, hydrocarbons including MTBE would be expected to biodegrade slowly (if at all) to ultimately generate carbon dioxide and water.

Two other monitoring wells, MW11D and MW16, yielded aerobic groundwater with dissolved oxygen between 7.5 and 8.5 mg/L. Groundwater pH at these locations was rather low at 4.6 units. Aerobic groundwater here might support aerobic biodegradation of both hydrocarbons and the chlorinated VOCs that are not fully saturated with chlorine atoms. However, the low pH would be expected to keep most microbial activity to a minimum.

Near the northeast corner of the site, MW06 groundwater was weakly aerobic with a D.O. level of 1.5 mg/L and a neutral pH. In the vicinity of MW06, aerobic biodegradation of hydrocarbons and not fully chlorinated VOCs is possible

3.4.2 Vapor Fate and Transport

Diffusion of vapors from sources in shallow groundwater occurs as a result of a concentration gradient between the source and the surrounding area; in this case, the source is shallow groundwater contamination. This can result in the upward or lateral migration of vapors through the vadose zone. Since the groundwater table interface at the Site has elevated levels of constituents, particularly underneath the eastern portion of the building, upward diffusion due to the concentration gradient between the contaminated groundwater table interface and the uncontaminated unsaturated zone is occurring at this Site.

The horizontal and vertical movement of vapors located near the building foundation is affected via advective/convective transport mechanisms. Volatilized chemicals are drawn into the SMP building via soil gas advection and convection which is the result of a negative pressure that the building interior exhibits on sub-slab vapors. The reasons for this negative pressure differential include:

- Factors relating to operation of HVAC systems
- Use of combustion sources resulting in venting to the exterior
- Higher temperatures indoors relative to outdoors during the heating season; and
- Pressure exerted on the wall of a building caused by wind movement over the building

The combination of these actions/conditions results in a net convective flow of sub-slab vapors from the subsurface through the building foundation to the building interior. Thus, indoor air volatile concentrations are generally higher during the heating season.

Another advective transport mechanism called "barometric pumping" is caused by cyclic changes in atmospheric pressure. These changes create a "piston like" force on soil gas possibly causing a cyclic up and down flow of contaminant vapors in the affected interval. The magnitude of a barometric pressure cycle is typically a small percentage of atmospheric pressure and its effect decreases with depth. The soil texture, soil air permeability, and moisture content affect the depth to which the pressure change may affect vapor transport. Soil gas compression and expansion in response to barometric pressure fluctuations may alternately enhance or inhibit vapor intrusion.

Vapor migration can occur more rapidly via man made or natural preferential pathways. Some man-made preferential pathways include:

- Underground conduits
- High permeable bedding materials (underneath building foundations, pipelines, etc.)
- Cracks in building foundations
- Utilities penetrating foundations that are not air-tight

Some natural preferential pathways include:

- Heterogenic soil conditions
- Heterogenic groundwater conditions

- Fractures in bedrock

Since the Site geologic and hydrologic conditions in the vicinity of the water table interface are relatively homogeneous, most of the preferential pathways that exist at this Site are man-made and consist of foundation bedding materials, utilities penetrating the foundation and cracks in the foundation.

3.5 Conceptual Site Model

The Site is located in an industrial/commercial area. The Site is bordered to the north by a car dealership, to the south by the High Speed Rail station, to the west by a commercial building, and to the east by the Hess station. The chlorinated contamination originates at the Site as shown on Figure 3-19. Based upon an extensive amount of data, it has been determined that the chlorinated groundwater "hot spot" is located external to the building, along the loading dock northeast of MW11, approximately 120 feet west of the southeast corner of the building. Based upon this same extensive database, it has been determined that the non-chlorinated groundwater contamination originates from an upgradient source, the Hess station (east of the Site). Unsaturated soil contamination is minimal and previously detected soil contamination has been flushed into the saturated zone.

Both chlorinated and non-chlorinated constituents are retained in the eastern portion of the building, whereas the western portion of the building remains relatively uncontaminated even though groundwater flow is from east to west. Also, the highest levels of contamination exist in the capillary fringe of the water table interface on the eastern side of the building. In addition to capillary forces retaining contamination, it is evident by the direct push profiles that contamination significantly diminishes with depth. The sub-basement extends approximately eight feet into the groundwater table and acts as a hydraulic barrier to groundwater transport. Also, the Subway tunnel located along Northern Boulevard also acts as a hydraulic barrier to groundwater transport. These two structures impede groundwater flow in the northern and western direction in the vicinity of the sub-basement. This impediment to groundwater flow is also indicated on the shallow groundwater potentiometric surface map presented in Figure 3-9, since there is groundwater mounding present immediately upgradient of the sub-basement. Thus, stagnant groundwater immediately upgradient of the sub-basement has not been flushed over time and contains an elevated level of contamination. At depths greater than 8 feet, beyond the depth of the sub-basement, groundwater quality significantly improves due to hydraulic flushing and attenuation. This is also demonstrated on the VOC plume contour and cross-section maps presented in Figures 3-20 through 3-21.

Even though contamination has been relatively stagnant in the capillary fringe on the eastern side of the building, contamination has biodegraded over time when comparing monitoring well data collected from 2003 through 2008 (Figure 3-17). Biodegradation can be enhanced with the addition of nutrients provided proper site-specific conditions are present.

In addition to groundwater transport and biodegradation, vapor migration is currently occurring at the Site. Vapors from the "hot spot" are being transported from the water table interface and are being drawn upward during the heating season due to stack effects. However, even though sub-slab concentrations are elevated, primarily along the south east perimeter of the building, current indoor air concentrations do not exceed guidance values. It is recommended that sub-slab vapors be mitigated to eliminate the potential for vapor intrusion and potential exposure in the future.

3.6 Risk Assessment

During the RI, a preliminary screening based on "*Draft DER-10 Technical Guidance for Site Investigation and Remediation*" (NYSDEC 2002) was performed to determine that a Fish and Wildlife Resources Impact Analysis (FWRIA) was not needed for the Site since there are no fish and wildlife resources on or adjacent to the site or area of concern. There is also very limited vegetation present on the Site or in the immediate vicinity and ecological receptors/habitats have no exposure to groundwater; thus, there is negligible potential environmental risk at the Site. Consequently, the main focus of the exposure assessment is human health. A qualitative human health exposure assessment was performed at the Site.

A qualitative estimate of potential health risks associate with site-specific COPCs under the current and future industrial use scenarios were evaluated at the Site (CDM 2008). All methodologies and procedures are consistent with current NYSDOH and EPA guidance for human health risk assessments.

Under both the current and future land use scenarios, the primary exposure pathways at the Site are potential exposures to groundwater contaminations through incidental ingestion and dermal contact, and to trench air through inhalation for construction and utility workers while engaging in excavation activities. Risks associated with potential groundwater and trench air exposure pathways could be mitigated through engineering controls, health and safety measures, and groundwater and soil gas mitigations.

Although the presence of residual contamination in the subsurface does not pose adverse health effects to current indoor workers, outdoor workers, and trespassers, mitigation is recommended because there is a potential for future migration of TCE and 1,1,1-TCA vapors from subsurface into the building.

Section 4
Remedial Goals and Remedial Action Objectives

Remedial action objectives (RAOs) are media-specific goals for protecting human health and the environment that serve as guidance for the development of remedial alternatives. The process of identifying the RAOs follows the identification of affected media and contaminant characteristics; evaluation of exposure pathways, contaminant migration pathways and exposure limits; and the evaluation of chemical concentrations that will result in acceptable exposure. The RAOs are based on regulatory requirements that may apply to the various remedial activities being considered for the site. This section of the FS reviews the affected media and contaminant exposure pathways and identifies Federal, State, and local regulations that may affect remedial actions.

Preliminary remediation goals (PRGs) were selected based on federal or state SCGs, background concentrations, and with consideration also given to other requirements such as analytical detection limits. These PRGs were then used as a benchmark in the technology screening, alternative development, and detailed evaluation of alternatives presented in the subsequent sections of the FS report.

4.1 Standards, Criteria, and Guidance

To determine whether the soil, groundwater, and soil vapor contain contamination at levels of concern, State and Federal SCGs were assessed for each medium. The regulatory SCGs identified for each medium and the applicability of these SCGs to the Site are summarized in the following sections.

Potential SCGs are divided into three groups:

- Chemical-specific SCGs
- Location-specific SCGs
- Action-specific SCGs

4.1.1 Chemical-specific Standards, Criteria, and Guidance

Chemical-specific SCGs are health- or technology-based numerical values that establish concentration or discharge limits for specific chemicals or classes of chemicals. There are no chemical-specific Federal SCGs for cleanup of contaminated soil, but there is State SCG for soil. Therefore, NYSDEC Brownfield and Superfund Soil Cleanup Objectives are applicable requirements. Groundwater at the Site currently is not being used as a source of drinking water, but NYSDEC classifies all fresh groundwater in the state as “Class GA fresh groundwater”, for which the assigned best usage is as a source of potable water supply. Therefore, although there are no known current users of groundwater at or near the Site, the groundwater is assumed to be a source of drinking water in the future. Therefore, New York State Groundwater Quality Standards are applicable requirements and the Federal and New York State primary drinking water standards are applicable if an action involves future use of groundwater as a public supply source.

4.1.1.1 Federal Standards, Criteria, and Guidance

Federal Drinking Water Standards

- National Primary Drinking Water Standards (40 CFR 141). Potentially applicable if an action involves future use of groundwater as a public supply source.

4.1.1.2 New York Standards, Criteria, and Guidance

Soil Standards and Criteria

- NYSDEC Brownfield and Superfund Regulation 6 NYCRR Part – 375 Environmental Remediation Programs, Restricted Use Soil Cleanup Objectives – Industrial, December 14, 2006. Used as the primary basis for setting numerical criteria for soil cleanups.

- Technical and Administrative Guidance Memorandum (TAGM) No. 4046, Determination of Soil Cleanup Objectives and Cleanup Levels. The TAGM objectives were utilized when there are no SCGs.

Groundwater Standards and Guidance

- New York State Ambient Water Quality Standards and Guidance Values and Groundwater Effluent Limitations (Technical and Operational Guidance Series (TOGS) 1.1.1). Used for setting numerical criteria for groundwater cleanups.

- New York State Surface Water and Groundwater Quality Standards and Groundwater Effluent Limitations (6 New York Environmental Conservation Rules and Regulations (NYCRR) Part 703). Applicable for assessing water quality at the Site during remedial activities.

Drinking Water Standards

- NYSDOH Drinking Water Standards (10 NYCRR Part 5). Potentially applicable if an action involves future use of groundwater as a public supply source.

Soil Vapor Guidance

- Final Guidance for Evaluating Soil Vapor Intrusion in the State of New York (NYSDOH 2006) is considered relevant and appropriate to soil vapor at the Site. The 2006 NYSDOH Vapor Intrusion guidance indicates that the State of New York does not have any standards, criteria, or guidance values for subsurface vapors.

4.1.2 Location-specific Standards, Criteria, and Guidance

Location-specific SCGs are those which are applicable or relevant and appropriate due to the location of the Site or area to be remediated. Possible applicable regulations at the Site are relevant to costal zone, historical places, and archaeological significance.

4.1.2.1 Federal Standards, Criteria, and Guidance

Wetlands

- Statement on Procedures on Floodplain Management and Wetlands Protection (40 CFR 6 Appendix A)
- Policy on Floodplains and Wetland Assessments for CERCLA Actions (OSWER Directive 9280.0-12, 1985)
- Wetlands Executive Order (EO 11990)
- National Environmental Policy Act (NEPA) (42 United States Code [USC] 4321: 40 CFR 1500 to 1508)

Cultural Resources

- National Historic Preservation Act (40 CFR 6.301)

Coastal Zone

- Coastal Zone Management Act (16 USC 33)

Historic Preservation Standards and Regulations

- National Historic Preservation Act (40 CFR 6.301)

4.1.2.2 New York Standards, Criteria, and Guidance

Wetlands and Flood Plains Standards and Regulations (6 NYCRR)

- New York Wetland Laws (Articles 24-25)
- New York Freshwater Wetland Permit Requirements and Classification (Articles 663 and 664)

4.1.3 Action-specific Standards, Criteria, and Guidance

Action-specific SCGs are requirements which set controls and restrictions to particular remedial actions, technologies, or process options. These regulations do not define Site cleanup levels but do affect the implementation of specific remedial technologies. These action-specific SCGs are considered in the screening and evaluation of various technologies and process options in subsequent sections of this report.

4.1.3.1 Federal Standards, Criteria, and Guidance

General - Site Remediation

- Occupational Safety and Health Administration (OSHA) Worker Protection (29 CFR 1904, 1910, 1926)
- Federal Resource Conservation and Recovery Act - Identification and Listing of Hazardous Waste (40 CFR 261); Standards Applicable to Generators of Hazardous Waste (40 CFR 262); Standards Applicable to Owners and Operators of Treatment, Storage, and Disposal Facilities (40 CFR 264)

Transportation of Hazardous Waste

- Hazardous Materials Transportation Regulations (49 CFR 107, 171, 172, 177, and 179)
- Federal Resource Conservation and Recovery Act - Standards Applicable to Transporters of Hazardous Waste (40 CFR 263)

Disposal of Hazardous Waste

- Federal Resource Conservation and Recovery Act - Land Disposal Restrictions (40 CFR 268)

Discharge of Groundwater

- Federal Clean Water Act - National Pollutant Discharge Elimination System (40 CFR 100 et seq.); Effluent Guidelines and Standards for the Point Source Category (40 CFR 414); Ambient Water Quality Criteria (40 CFR 131.36)
- Federal Safe Drinking Water Act - Underground Injection Control Program (40 CFR 144, 146)

Off-Gas Management

- Federal Clean Air Act - National Ambient Air Quality Standards (40 CFR 50); National Emission Standards for Hazardous Air Pollutants (40 CFR 61)
- Federal Directive - Control of Air Emissions from Superfund Air Strippers (OSWER Directive 9355.0-28)

4.1.3.2 New York Standards, Criteria, and Guidance

New York Solid and Hazardous Waste Management Regulations (6 NYCRR)

- Hazardous Waste Management System - General (Part 370)
- Solid Waste Management Regulations (Part 360)
- Identification and Listing of Hazardous Waste (Part 371)

Transportation of Hazardous Waste (6 NYCRR)

- Hazardous Waste Manifest System and Related Standards for Generators, Transporters and Facilities (Part 372)
- Waste Transporter Permit Program (Part 364)

Disposal of Hazardous Waste (6 NYCRR)

- Standards for Universal Waste (Part 374-3)
- Land Disposal Restrictions (Part 376)

Discharge of Groundwater (6 NYCRR)

- The New York Pollutant Discharge Elimination System (NYPDES) (Part 750-757)

- New York State Surface Water and Groundwater Quality Standards and Groundwater Effluent Limitations (6 NYCRR Part 703)
- New York State Ambient Water Quality Standards and Guidance Values and Groundwater Effluent Limitations (TOGS 1.1.1)

Off-Gas Management

- New York General Provisions (6 NYCRR Part 211)
- New York Air Quality Standards (6 NYCRR Part 257)
- New York State Department of Environmental Conservation (DAR-1) Air Guide 1, Guidelines for the Control of Toxic Ambient Contaminants
- New York State Department of Health Generic Community Air Monitoring Plan

4.2 Remedial Action Objectives

Based on the evaluation of the nature and extent of contamination in soil, groundwater and vapor, the assessment of human risk associated with exposure to contaminants of potential concern, the following preliminary RAOs were developed:

4.2.1 Remedial Action Objectives for Soil

Currently the VOC contamination has been flushed over time from the unsaturated soil into the subsurface saturated soil located a foot or two below the water table interface, indicating the absence of a continuing source of contamination. The highest mass of chlorinated VOC contamination currently resides in the groundwater instead of the unsaturated soil. In addition, results from the RI indicate that no VOC exceeded SCGs in soil while SVOCs and inorganic contamination exceedances at the Site are not site-related. As a result, No Action is recommended for the unsaturated soil.

4.2.2 Remedial Action Objectives for Groundwater

The recommended RAOs for groundwater at the Site are as follows:

- Minimize the off-site migration of volatile organic compounds in groundwater at concentrations that pose a potential risk to off-site receptors
- Protect human health and the environment by restoring the contaminated groundwater to below SCGs

4.2.3 Remedial Action Objectives for Soil Vapor

The recommended RAOs for soil vapor at the Site are as follows:

- Minimize potential building occupant exposure to elevated sub-slab vapor concentrations
- Protect human health and the environment by monitoring indoor air and mitigating soil vapor to below SCG

4.3 Preliminary Remediation Goals

Preliminary remediation goals (PRGs) were selected based on federal or state promulgated SCGs, background concentrations, and with consideration also given to other requirements such as analytical detection limits and guidance values. The primary site-related constituents of concern are chlorinated VOCs. Even though non-chlorinated volatile organic compounds are elevated at the Site, an upgradient source, the Hess station, has been identified as the source of these constituents. Therefore, non-chlorinated VOCs are not considered site related. As a result, the PRGs for groundwater and soil vapor are limited to chlorinated VOCs.

4.3.1 Groundwater Preliminary Remediation Goals

Groundwater PRGs are based on New York State Ambient Water Quality Standards and Guidance Values and Groundwater Effluent Limitations (TOGS 1.1.1).

4.3.2 Soil Vapor Preliminary Remediation Goals

The Final Guidance for Evaluating Soil Vapor Intrusion in the State of New York (NYSDOH 2006) is considered relevant and appropriate to soil vapor at the Site. The 2006 NYSDOH Vapor Intrusion guidance indicates that the State of New York does not have any standards, criteria, or guidance values for subsurface vapors. However, air guideline values and the sub-slab vapor/indoor air matrices in the 2006 NYSDOH Vapor Intrusion guidance are compared to soil vapor concentrations that do not have a set standard, in order to identify if soil gas and sub-slab vapor should be mitigated.

Section 5
General Response Actions

Based on the established RAOs and site conditions, general response actions (GRAs) were identified. GRAs are those actions that, singly or in combination, satisfy the RAOs for the identified media by reducing the concentrations of hazardous substances or reducing the likelihood of contact with hazardous substances. The GRAs appropriate for addressing contamination at the Site includes:

5.1 No Action

The National Contingency Plan (NCP) and CERCLA require the evaluation of a No Action alternative as a basis for comparison with other remedial alternatives. Under the No Action alternative, remedial actions are not implemented, the current status of the Site remains unchanged, and no action would be taken to reduce the potential for exposure to contamination.

5.2 Institutional/Engineering Controls

Institutional/Engineering Controls typically are restrictions placed to minimize access (e.g., fencing) or future use of the site (e.g., well drilling restriction). These limited measures are implemented to provide some protection of human health and the environment from exposure to site contaminants. They are also used to continue monitoring contaminant migration (e.g., long-term monitoring). Institutional/ Engineering Controls are generally used in conjunction with other remedial technologies; alone they are not effective in preventing contaminant migration or reducing contamination.

5.3 Monitor Natural Attenuation

Monitor Natural Attenuation (MNA) is a response action by which the volume and toxicity of contaminants are reduced by naturally occurring processes in the groundwater. Processes which reduce contamination levels in groundwater include dilution, dispersion, volatilization, adsorption, biodegradation, and chemical reactions with other subsurface constituents. This naturally occurring attenuation is expected to reduce contaminant levels to the PRGs within a reasonable timeframe and/or within a reasonable physical boundary.

5.4 Containment

Containment actions use physical, low permeability barriers and/or groundwater extraction wells to minimize or eliminate contaminant migration. Containment technologies do not involve treatment to reduce the toxicity or volume of contaminants. The response actions require long-term monitoring to determine whether containment actions are performing successfully. The NCP does not prefer containment response actions since they do not provide permanent remedies.

5.5 Removal/Extraction

Removal response actions refer to methods typically used to excavate and handle soil, sediment, waste, and/or other solid materials. An extraction-based response action provides reduction in mobility and volume of contaminants by removing the contaminated groundwater from the subsurface using such means as groundwater extraction wells or interceptor trenches. Groundwater extraction can provide hydraulic control to prevent migration of dissolved contaminants. Groundwater extraction is usually used in conjunction with other technologies, such as treatment or disposal options, to achieve the RAOs for the removed media. The extraction response action does not reduce the concentrations of contaminants in groundwater. It merely transfers the contaminants to be managed under another response action.

5.6 Treatment

Treatment involves the destruction of contaminants in the affected media, transfer of contaminants from one media to another, or alteration of the contaminants thereby making them innocuous. The result is a reduction in toxicity, mobility, or volume of the contaminants. Treatment technologies vary among environmental media and can consist of chemical, physical, thermal, and biological processes. Treatment can occur in place or above ground. This GRA is usually preferred unless site- or contaminant-specific characteristics make it infeasible from an engineering or implementation perspective, or too costly.

5.7 Disposal/Discharge

Discharge response actions for groundwater involve the discharge of extracted groundwater via on-site injection, on-site surface recharge or surface water discharge following treatment to meet regulatory discharge and disposal requirements.

Section 6
Identification and Screening of Remedial Technologies

Potential remedial technologies and process options associated with each general response action are identified and screened in this section. Representative remedial technologies and process options that have been retained are used to develop remedial action alternatives.

The technology screening approach is based upon the procedures outlined in *Draft DER-10 Technical Guidance for Site Investigation and Remediation* (NYSDEC 2002) and *Final Guidance for Evaluating Soil Vapor Intrusion in the State of New York* (NYSDOH 2006). The evaluation process uses three criteria: Effectiveness, Implementability, and Relative Cost. Among these three, the effectiveness criterion outweighs the implementability and relative cost criteria. These criteria are described below:

Effectiveness. This evaluation criterion focuses on the effectiveness of process options to reduce the toxicity, mobility, or volume of contamination for long term protection and for meeting the RAOs and PRGs. It also evaluates the potential impacts to human health and the environment during construction and implementation, and how proven and reliable the process is with respect to site specific conditions.

Implementability. This evaluation criterion encompasses both the technical and administrative feasibility of the technology or process option. It includes an evaluation of pretreatment requirements, residuals management, and the relative ease or difficulty in performing the operation and maintenance (O&M) requirements. Process options that are clearly ineffective or unworkable at the site are eliminated by this criterion.

Relative Cost. Cost plays a limited role in the screening process. Both capital costs as well as O&M costs are considered. The cost analysis is based on engineering judgment and each process is evaluated as to whether costs are low, moderate, or high relative to the other options within the same technology type.

Retained remedial technologies and process options are used to develop remedial action alternatives, either alone or in combination with other technologies.

6.1 Groundwater

6.1.1 No Action

The No Action alternative is not a technology. The No Action alternative is considered as a basis for comparison.

Effectiveness - The No Action alternative is used as a baseline against which other technologies may be compared. It generally does not provide measures that would comply with SCGs, or otherwise meet RAOs.

Implementability - The No Action alternative is implementable given there is no action required.

Relative Cost - The No Action alternative involves no capital or O&M costs.

Conclusion – The No Action alternative is retained for further consideration.

6.1.2 Institutional Controls

Institutional Controls do not reduce the toxicity, mobility, or volume of contamination, but can be implemented to reduce the probability of exposure to contaminants. Institutional controls consist of administrative actions which control use of the site (e.g., well drilling restrictions) to reduce direct human contact of contaminated water. Institutional controls generally require long term monitoring of contaminant concentrations. Typical institutional controls are discussed below.

6.1.2.1 Deed Restrictions

Deed restrictions are regulatory actions that are used to prevent certain types of uses for properties where exposure pathways to contaminants may be created as a result of those uses. Deed restrictions may be used to prevent well drilling within the contamination plume.

Effectiveness - Deed restrictions could effectively restrict or eliminate use of contaminated groundwater, thereby reducing risks to human health. Deed restrictions would not reduce the migration and the associated environmental impact of the contaminated groundwater.

Implementability - Deed restrictions are easily implementable through the existing administrative system.

Relative Cost - The cost to implement deed restrictions is low. Some administrative, long-term monitoring and periodic assessment cost would be required.

Conclusion – Deed restrictions will be retained for further consideration.

6.1.2.2 Well Drilling Restrictions

Well drilling restrictions are regulatory actions that are used to regulate installation of groundwater drinking water wells.

Effectiveness - Well drilling restrictions may effectively meet RAOs through restriction of future site uses or activities which would create human exposure pathways to contaminated groundwater. Well drilling restrictions will not reduce the migration and the associated environmental impact of the contaminated groundwater.

Implementability - Implementation would be easy via the existing permitting process. Well drilling restrictions may also be implemented, in addition to remediation activities, as a protective measure to prevent future exposure to contaminants during remediation.

Relative Cost - The cost to implement well drilling restrictions is low.

Conclusion - Well drilling restrictions will be retained for further consideration.

6.1.2.3 Long-term Monitoring

Long-term monitoring includes periodic sampling and analysis of groundwater samples. This program would provide an indication of the movement of the contaminants and/or of the progress of remedial activities.

Effectiveness - Long-term monitoring alone would not be effective in meeting the RAOs. It would not alter the effects of the contamination on human health and the environment. Monitoring is a proven and reliable process for tracking the migration of contaminants during and following treatment.

Implementability - Long-term monitoring could be easily implemented. All monitoring wells are easily accessible for sample collection. Equipment, material, and sampling procedures are readily available.

Relative Cost - Long-term monitoring involves low capital and moderate O&M cost.

Conclusion - Long-term monitoring will be retained for further consideration.

6.1.3 Monitored Natural Attenuation

MNA refers to the remedial action that relies on naturally occurring attenuation processes to achieve site-specific RAOs within a reasonable time frame. Natural attenuation processes that reduce contaminant concentrations in groundwater include destructive (biodegradation and chemical reactions with other subsurface constituents) and nondestructive mechanisms (dilution, dispersion, volatilization, and adsorption).

Biodegradation is typically the most significant destructive attenuation mechanism. Chlorinated solvents, such as PCE and 1,1,1-TCA, attenuate predominantly by reductive dechlorination under anaerobic conditions. The primary reductive dechlorination pathway for PCE to ethene is given below:

$$\text{PCE} \rightarrow \text{TCE} \rightarrow \text{cis-1,2-DCE} \rightarrow \text{VC} \rightarrow \text{Ethene}$$

The primary reductive dechlorination pathway for 1,1,1-TCA to ethane is given below:

$$\text{1,1,1-TCA} \rightarrow \text{1,1-DCA} \rightarrow \text{Chloroethane} \rightarrow \text{Ethane}$$

Reductive dechlorination is a cometabolic process requiring an adequate supply of electron donors. The existence of other electron acceptors, such as oxygen, nitrate/nitrite, ferric iron, or sulfate can inhibit the dechlorination process. The highest reductive dechlorination rates have been observed under highly reducing conditions associated with methanogenic reactions. If the dechlorination process is inhibited, degradation of PCE will "stall" at the intermediate products, *cis*-1,2-DCE and VC and degradation of 1,1,1-TCA will "stall" at 1,1-DCA and chloroethane; however, these lesser oxidized chlorinated compounds are amenable to attenuate under aerobic conditions.

By analyzing biogeochemistry data, including distribution of electron acceptors (e.g. nitrate/nitrite, sulfate/sulfide, and ferrous/ferric iron concentrations), metabolic by-products, and the contaminant distribution and time trends, it is possible to determine whether active biotransformation of the chlorinated solvents is occurring.

Effectiveness - MNA is an effective remediation approach for sites where natural mechanisms can be demonstrated to minimize or prevent the further migration of groundwater contamination. Based on the review of the RI monitoring well data, it appears that anaerobic reductive dechlorination of VOCs is occurring in the groundwater. Concentrations of TCE are low while concentrations of the degradation products *cis*-1,2-DCE and VC are high. MNA may be an effective remedy for groundwater; reductive dechlorination at the site and aerobic biodegradation downgradient from the site.

Implementability - Natural attenuation is considered to be easily implementable. Materials and services necessary to model and monitor the contaminant dynamics are readily available. Site restrictions and/or institutional controls may be required as long-term control measures as part of the MNA alternative.

Relative Cost - MNA and associated modeling involves low capital cost and moderate O&M cost.

Conclusion - MNA is potentially effective at the Site and therefore will be retained for further consideration.

6.1.4 Containment

Low-permeability vertical barrier walls could be installed downgradient of source areas or plumes to control contaminant migration. The walls would be constructed using slurry or sheet piling to the top of a low permeability layer. Barrier walls would only be effective in areas of the Site where a high water table and shallow depth of the aquifer and confining clay unit are found. Within these areas, both types of barrier walls (i.e., slurry or sheet pile) would be effective for redirecting contaminated groundwater flow. Barrier walls can be used in combination with a groundwater extraction system; the walls would minimize the amount of pumping required to maintain hydraulic control by acting as a physical barrier, restricting clean groundwater inflow from side-gradient areas into the capture zone.

6.1.4.1 Slurry Walls

Slurry walls are constructed by pumping a low-permeability slurry, typically consisting of either a soil-bentonite or cement-bentonite mixture, into an excavated trench. Excavation can be completed using a long-arm excavator and a clam shovel to meet the required depth. The slurry would be pumped into the hole during the course of excavation to keep the sidewalls from collapsing.

Effectiveness - Slurry walls would effectively achieve hydraulic control if properly built. Upon the completion of remedial activities, the walls would remain in place and continue to influence groundwater flow patterns on a localized scale.

Implementability - Slurry walls are implementable, and the construction materials and services are readily available. However, the slurry wall construction requires the use of heavy construction equipment and involves excavation. The work space at the Site is limited due to the existing building. Other techniques are available to make construction more feasible in limited workroom at higher cost.

Relative Cost - Slurry walls involve high capital cost.

Conclusion - Slurry walls will not be retained for further consideration due to difficulties with implementability.

6.1.4.2 Sheet Pile Barriers

Sheet pile barriers are constructed by driving or vibrating sections of steel sheet piling into the ground. Each sheet pile section is interlocked at its edges, and the seams are often grouted to prevent leakage.

Effectiveness - Sheet pile walls can be effective at providing hydraulic control. Upon the completion of remedial activities, the sheet piles can be vibrated out of the ground, disassembled, and removed from the site, provided that the sheeting and joints are still of good structural integrity at the time of removal. Otherwise, the sheets would be cut off below ground surface, and the walls would continue to influence groundwater flow patterns on a localized scale. Sheet pile material may deteriorate overtime due to reaction with constituents in groundwater.

Implementability - Sheet pile walls are implementable, and construction materials and services are readily available. However, the construction requires the use of heavy construction equipment. The work space at the Site is limited due to the existing building. Other techniques are available to make construction more feasible in limited workroom at higher cost.

Relative Cost - Sheet pile walls involve high capital cost.

Conclusion - Sheet pile walls will not be retained for further consideration due to implementability difficulty.

6.1.5 Groundwater Extraction

Groundwater extraction involves placing extraction wells or extraction trenches to intercept the flow of contaminated groundwater and hydraulically prevent contamination from migrating downgradient. This technology is also used for dewatering when it is necessary to lower the water table to facilitate installation/operation of other remedial technologies. The extracted groundwater is typically treated ex situ and disposed of on site or off site.

6.1.5.1 Extraction Wells

This technology involves the installation of groundwater extraction wells within areas of contamination to provide hydraulic control and capture contaminants. The specific extraction well locations would be determined through groundwater modeling and/or pilot testing.

Effectiveness - Extraction wells are effective in providing hydraulic control for sites where the hydrogeology is well understood and the pumping rate necessary to maintain hydraulic control is sustainable. At this Site, the soil consists of sand, silt, clay, and gravel. The hydraulic conductivity is 233 feet per day which would support continuous pumping. Hydraulic containment using extraction wells is applicable at the Site. However, this may not be effective, due to the potential for causing off-site contamination to migrate on site.

Implementability - Extraction wells are implementable, and the equipment and materials are readily available. However, the extracted groundwater may require treatment to remove the contaminants. Due to space constraints, implementability would be reduced if large treatment vessels are required (i.e., high groundwater extraction flow rate). In addition, iron fouling would also reduce the implementability of this technology. Iron fouling can be reduced by pre-treatment for iron removal, but this would only be implementable for small volumes of water.

Relative Cost - Installation of extraction wells involves moderate capital costs and low O&M costs.

Conclusion - Groundwater extraction wells will not be retained for further consideration due to implementability issue.

6.1.5.2 Extraction Trenches

This technology involves construction of a trench or trenches, perpendicular to the direction of groundwater flow, to intercept and prevent downgradient migration of a contaminant plume. A bio-polymer slurry is typically used to temporarily support the sidewalls of the trench, preventing collapse of the trench sidewalls. The trench is typically backfilled with material of higher permeability than the native aquifer (e.g., gravel) to create a zone of preferential flow, and perforated piping or well screens are typically installed in the trench to collect the intercepted groundwater. After the piping and backfill have been installed, an additive is pumped into the trench to break down the slurry to simple sugars and water, thus reestablishing hydraulic connection to the aquifer. Extracted groundwater is then treated as necessary to meet discharge requirements.

Effectiveness -Extraction trenches are typically effective in capturing groundwater to provide hydraulic control. Extraction trenches are usually used at sites with low permeability. However the soil at this Site is highly permeable. Since the contamination within the localized hot spot has not significantly migrated from the area of initial impact, trenching would not be effective for the extraction of this groundwater. Thus, at this site trenching would not be the most effective method of groundwater extraction.

Implementability - Extraction trenches are implementable, and the equipment and materials are readily available. However, the extracted groundwater may require treatment to remove the contaminants. Due to space constraints, implementability would be reduced if large treatment vessels are required (i.e., high groundwater extraction flow rate). In addition, iron fouling would also reduce the implementability. Iron fouling can be reduced by pre-treatment for iron removal, but this would only be implementable for small volumes of water.

Relative Cost - Extraction trenches involve medium capital costs and low O&M costs.

Conclusion - Extraction trenches will not be retained for further consideration due to effectiveness and implementability issues.

6.1.6 In Situ Treatment

In situ treatment technologies either intercept and immobilize or degrade contaminants in the subsurface passively (for example: phytoremediation and permeable reactive barriers), or mobilize and/or destroy contaminants in the subsurface aggressively and significantly shorten the required remediation time (such as in situ chemical oxidation and in situ bioremediation). Many of the passive technologies require little maintenance. The active technologies significantly speed up the removal rate of residual free phase or adsorbed contaminants, which would not be possible via pump-and-treat technology. In situ treatment also reduces the possibility of exposure of contaminants to the site worker. Several in situ treatment technologies were identified as potentially applicable at the Site, and are discussed below.

6.1.6.1 Phytoremediation

Phytoremediation includes processes that use plants, and their associated rhizospheric microorganisms, to remove or degrade contaminants in groundwater. Phytoremediation is included as a biological process even though physical and chemical processes are also part of this technology. Contaminants are removed from groundwater through capture of groundwater for plant use; uptake and accumulation of contaminants; uptake and processing of contaminants through metabolization, mineralization, and transpiration; and rhizospheric degradation via microorganisms.

Effectiveness - Phytoremediation is applicable for relatively shallow groundwater (less than 10 feet bgs) and large groundwater plumes with low levels of contamination (high levels of contaminants may be toxic to the plants). The time to achieve remediation may extend over several growing seasons and is highly dependent on climatic conditions at the Site.

Implementability - Phytoremediation has been used to treat groundwater contaminated with chlorinated VOCs. Preliminary results from existing projects indicate that contaminated groundwater is contained through depression in the water table beneath the trees and the contaminants are degraded in the tissues of the trees. However, the toxicity and bioavailability of degradation products is not always known. More research is needed to define the fate of various compounds in the plant metabolic cycle to determine whether contaminants and associated degradation products can still pose a risk to human health and the environment. This technology is not applicable for the Site because contamination is found at depths greater than 10 feet bgs, which is the limit of most plant root zones.

Relative Cost - This technology involves low capital and O&M costs.

Conclusion - Phytoremediation will not be retained for further consideration due to effectiveness and implementability issues.

6.1.6.2 Permeable Reactive Barriers

Permeable reactive barriers (PRBs) provide in situ treatment of groundwater and are designed to intercept contaminated groundwater flow. These reactive barriers differ from highly impermeable barriers, such as slurry walls, or sheet pilings, which restrict the movement of a groundwater plume. PRBs can be installed as permanent, semi-permanent, or replaceable units which transect the plume flow path and act as a treatment wall. Natural hydraulic gradients transport contaminants through the strategically placed reactive media. When the contaminated groundwater passes through the reactive zone of the barrier, the contaminants are either immobilized or chemically degraded to less harmful product(s).

Effectiveness -PRBs have been effective in degrading chlorinated solvents. However, at this Site, placing a PRB downgradient of the plume to prevent contaminant migration would require the PRB to be effective for a very long time. Therefore, periodic reactivation of the PRB may be necessary to retain its effectiveness. The heterogeneity of subsurface (such as the low permeability layer) would prolong the operation required for PRBs due to the slow mass transfer of contaminants out of the low permeability lenses.

Implementability - PRBs are installed downgradient, perpendicularly intersecting the contaminated groundwater flow. They can be installed via trenching if the targeted portion of the aquifer is shallow and surface structures do not interfere with access. They can also be installed by well injection at a greater depth at a high cost. However, there is no clay layer for the PRB to key into. Contaminated groundwater could bypass the PRBs all together.

Relative Cost - PRBs involves high capital and low O&M costs. The replacement cost could be as high as the capital cost.

Conclusion - PRBs will not be retained for further consideration due to the implementability issue.

6.1.6.3 In Situ Chemical Oxidation

In situ chemical oxidation (ISCO) is an active approach that involves the injection into the subsurface of chemical oxidants that destroy organic contaminants in groundwater. Complete oxidation of contaminants results in their breakdown into innocuous compounds such as carbon dioxide, water, and chloride. In situ chemical oxidation can significantly increase the mass transfer between the residual contaminated soil and groundwater, subsequently destroying the contaminant mass in a shorter period of time. A number of factors affect the performance of this technology, including oxidant delivery to the subsurface, oxidant type, dose of oxidant, contaminant type and concentration, and non-contaminant oxidant demand.

The commonly used oxidants include ozone, Fenton's Reagent, potassium permanganate, activated sodium persulfate, catalyzed percarbonate, etc. Permanganate can oxidize TCE, DCE and VC effectively, generating manganese dioxide precipitation in the subsurface, but will not be effective for 1,1,1-TCA. Fenton's Reagent, activated persulfate, and catalyzed percarbonate generate radicals to oxidize contaminants. Radicals can oxidize a wide variety of contaminants, but they are non-selective and have extremely short lifetimes. Therefore, effectively delivering the oxidants into the contaminant zones and ensuring that the radicals come into contact with contaminants is a challenge.

Effectiveness - ISCO has been successful in treating residual soil areas. Delivery of the oxidants to appropriate locations is the key element for its success. Oxidant type is somewhat dictated by the contaminant. ISCO is dependent upon achieving adequate contact between oxidants and contaminants, which occurs within groundwater. If the contaminants exist within low permeable zones, such as clay lenses, it would be difficult to deliver the oxidants into such zones. The rates at which contaminants are treated in such zones would depend on the rates of diffusion. Because chemical reactions occur rapidly, the diffusion and mass transfer rate of contaminants out of low permeability zones would be significantly increased. However, to treat the contaminants in the subsurface completely, oxidants need to retain their effectiveness in the subsurface for some time, or be applied repeatedly to react with contaminants released from the low permeability zones. Poor application can result in large pockets of untreated contaminants. In addition, other oxidizable substrates, natural organics and reduced metals would also consume oxidants. To treat contamination effectively sufficient oxidants would need to be applied to meet these competing demands. As a result, this technology would be effective for the plume core but not for the large diluted plume.

Implementability - ISCO would be implementable at the Site. However, soil could consume a significant amount of oxidant. Therefore, using ISCO to treat the large low concentration groundwater plume would not be cost effective, but would be effective in treating residual soil contamination. Furthermore, ISCO would only be able to treat contamination effectively within a small radius of influence (ROI) at this Site due to its relatively slow groundwater velocity. Multiple applications would be required to treat the contaminated aquifer. The technology is more applicable to treat the localized residual soil and elevated groundwater contamination at the area exceeding 20 times SCG.

Relative Cost - Using ISCO to treat a large dilute plume is not cost effective. ISCO involves high capital and low O&M costs.

Conclusion - ISCO will be retained for further consideration for treatment of the area exceeding 20 times SCG.

6.1.6.4 In Situ Air Sparging/Soil Vapor Extraction

In situ air sparging (AS) is a technology in which air is injected into the groundwater for the purpose of removing organic contaminants by volatilization and stripping. As air moves up through the groundwater, VOCs partition into the gas phase and are transported to the vadose zone. Soil vapor extraction (SVE) is typically used in conjunction with air sparging to eliminate off-site migration of vapors. SVE uses vacuum (or vacuum and forced air together) to mobilize soil gas and remove volatile organic contaminants in the vadose zone by vaporization and volatilization. The AS/SVE combined system would employ a number of AS wells, with SVE trenches or wells placed among the AS wells. SVE trenches or wells would be installed above the water table and a vacuum would be applied to extract the sparge vapors. The captured soil gas/sparge vapors typically require ex situ treatment. An off-gas treatment system using vapor phase carbon adsorption and permanganate may be necessary to limit the release of contaminants to the atmosphere.

Effectiveness - AS/SVE has been shown to be effective in removing VOCs from groundwater. This process is dependent upon how well the injected air permeates into the groundwater from the injection point. The sandy soil at the Site would make air sparging an effective technology. The ability of the SVE to capture the contaminants forced into the unsaturated zone is also an important component due to the potential risk of VOC migration into basements located within the area of contaminated groundwater. Overall effectiveness for AS/SVE is expected to be high for the Site.

Implementability - Most components of AS/SVE are fairly easy to implement. For areas with shallow groundwater tables, SVE trenches are preferable to wells due to less potential for groundwater table upwelling and increased area of influence. For this reason, trenches would be more implementable than wells at the site.

Relative Cost - AS/SVE involves high capital and moderate O&M costs.

Conclusion - AS/SVE will be retained for further consideration for treatment of the area exceeding 20 times SCG.

6.1.6.5 Enhanced Anaerobic Bioremediation

Enhanced Anaerobic Biodegradation (EAB) is a remedial technology designed to facilitate the in situ biological destruction of chlorinated VOCs over a wide range of concentrations in groundwater. EAB involves the injection of an electron donor and potentially nutrients or dechlorinating microorganisms (i.e., bioaugmentation) into the subsurface. This combined delivery stimulates the natural reactions of microorganisms to detoxify chlorinated solvent contamination in an environment otherwise low in organic content.

Effectiveness - For most sites, biological dechlorination reactions are limited by (1) the availability of biodegradable organic carbon (i.e., electron donor) that serves as an energy source for indigenous microorganisms and/or (2) elevated concentrations of competing electron acceptors that create reducing conditions to competitively inhibit the activity of the dechlorinating microbes. The addition of an electron donor as an energy source for indigenous microorganisms would stimulate the development of reduced groundwater environments that are conducive to dechlorination reactions (i.e., methanogenic conditions), and fuel the dechlorination process itself. For some sites, the extent of VOC dechlorination may be stalled at a biological intermediate such as DCE, VC, DCA, or chloroethane due to the absence of the indigenous microorganisms capable of reductively biodegrading all source and intermediate VOCs to non-toxic compounds. Under this scenario, active dechlorinating microorganisms may be amended to the subsurface through a process termed bioaugmentation. EAB can be effective in a heterogeneous subsurface environment because once produced, the dechlorination conditions and bacteria would persist for some time, and contaminants diffusing out of low permeable zones can be treated.

Implementability - The groundwater at the site is anaerobic. There are indications that reductive dechlorination of TCE and 1,1,1-TCA is occurring.

Relative Cost - EAB involves moderate capital and O&M cost.

Conclusion - EAB will be retained for further consideration.

6.1.6.6 Groundwater Circulation Wells

Groundwater circulation well (GCW) technology focuses on creating in situ vertical groundwater circulation cells by drawing groundwater from an aquifer formation through one screened section of a double-screened well and discharging it through the second screened section. This circulation commonly occurs from the top of the formation to the bottom. Contaminated groundwater flows upward inside the well, and is then treated through air sparging or carbon adsorption, etc.

Effectiveness - This technology is effective to treat chlorinated VOCs if a vertical circulation pattern can be established. It has failed at many sites due to (1) short circuiting around the well or (2) horizontal hydraulic conductivity that is much greater than vertical hydraulic conductivity, such that the system cannot form a circulation loop to effectively treat the contamination in the designed treatment zone. At this site, the soil is permeable with some silt or clay seams, which would block air pathways locally. A pilot test would be required prior to full scale application.

Implementability - The site specific geology seems to favor the effective application of this technology. The equipment and materials are readily available. However, the groundwater contains high concentrations of ferrous iron, which will foul the treatment system and make it inoperable.

Relative cost - GCW technology involves medium capital and O&M cost.

Conclusion - GCW technology will not be retained for further consideration due to high iron concentrations in the groundwater.

6.1.6.7 Biosparging

In situ biosparging is a technique in which air is injected into the groundwater for the purpose of destroying the organic contaminants by aerating the water to stimulate biodegradation of VOCs. This technique will introduce enough air into the subsurface to increase the dissolved oxygen concentrations slightly in the groundwater to create an aerobic environment for microbial activity but not enough to cause significant volatilization or stripping of the VOCs. This approach minimizes the carbon usage and also has the potential to remove any non-volatile constituents. The biosparge system would employ one or more subsurface air injection wells using a slow injection rate.

Effectiveness - Biosparging is known to be effective in removing certain VOCs from groundwater. This process is dependent upon how well the injected air permeates into the groundwater from the injection point, which is dependent on the heterogeneity of the soil, and how well the injection rates match the kinetics of the microbiological bio-oxidation. When necessary, a carbon source (e.g., methane, butane, or propane) can be injected into the ground together with air to promote bioremediation. An important component of the method is the potential risk of VOC migration. Close monitoring should be performed to prevent VOCs being stripped into the vadose zone.

Implementability - Most components of the biosparge system are fairly easy to implement. At this Site, there are relatively low permeable silty sand zones and clay seams, which would block air pathways locally. Since the purpose of biosparging is not to volatilize or strip the VOCs, there are minimal risks of vapor intrusion and human exposure to the contaminants.

Relative Cost - Biosparging involves low capital and low O&M costs.

Conclusion - Biosparging will not be retained for further consideration due to effectiveness issue.

6.1.7 Discharge

Once groundwater has been treated, it will be discharged on-site or off-site. Potential on-site and off-site discharge options for groundwater are evaluated below.

6.1.7.1 On-site Injection

This on-site discharge technology involves injecting treated groundwater to the subsurface using a series of wells. Injection requires that the groundwater be treated to meet applicable groundwater standards prior to discharge to the subsurface.

Effectiveness - The effectiveness of this option would rely on proper injection well design and construction, including adequate pipe sizing, proper placement of the wells, and reliable construction materials.

Implementability - To discharge treated effluent to a series of injection wells would be easily and readily implementable, given that standard construction methods and materials would be utilized. Discharging treated water into the aquifer may cause spreading of contamination. Some implementability problems can arise during long term operation of injection wells, such as clogging of screen packs with precipitates or microbial fouling, particularly in high iron conditions. These issues can be overcome by proper removal of suspended solids and excess iron from the treated water, periodic chlorination of the injected water, and redevelopment and cycling on/off of wells.

Relative Cost - This technology involves moderate capital and high O&M costs.

Conclusion - This technology will be retained for further consideration.

6.1.7.2 On-site Surface Recharge

Treated groundwater can be discharged on site using a surface recharge system such as an excavated recharge basin. Recharge basins are shallow, man-made ponds that allow water to infiltrate gradually into the ground. Depending on the permeability of the soil, recharge basins generally require large surface areas. As with injection wells, on-site recharge requires that the extracted groundwater be treated to meet applicable groundwater standards prior to discharge.

Another method of artificial groundwater recharge is an infiltration gallery. This system would be developed as a series of perforated pipe galleries laid underground, which would receive treated groundwater from the on-site treatment plant, and disperse the flow evenly through the discharge system, down to the underlying aquifer system.

Another variation of a recharge basin is a leaching basin. Leaching basins are underground covered pits that are typically 5 to 10 feet wide and 10 to 20 feet deep. In comparison to recharge basin, leaching basins require less land surface area.

Effectiveness - The effectiveness of this option would rely on the proper construction of the recharge system and adequate sizing. The surface area required depends on the extraction rates and types of facilities.

Implementability - Surface recharge disposal is readily implementable, as standard construction methods and materials would be utilized. The interim remedy includes the use of a recharge basin, which was designed with extra capacity for future expansion. As a result, treated groundwater can readily discharge to the recharge basin.

Relative Cost - A surface recharge system involves low capital and O&M costs.

Conclusion - Surface recharge will be retained for further consideration.

6.2 Soil Vapor

6.2.1 No Action

The No Action alternative is not a technology. The No Action alternative is considered as a basis for comparison.

Effectiveness - The No Action alternative is used as a baseline against which other technologies may be compared. It generally does not provide measures that would comply with SCGs, or otherwise meet RAOs.

Implementability - The No Action alternative is implementable given there is no action required.

Relative Cost - The No Action alternative involves no capital or O&M costs.

Conclusion – The No Action alternative is retained for further consideration.

6.2.2 Institutional/Engineering Controls

Institutional/Engineering Controls do not reduce the toxicity, mobility, or volume of contamination, but can be implemented to reduce the probability of exposure to contaminants. Institutional/engineering controls consist of administrative actions which control use of the Site to reduce direct human contact of contaminated soil vapor. Institutional/engineering controls generally require long term monitoring of contaminant concentrations. Typical institutional/engineering controls are discussed below.

6.2.2.1 Deed Restrictions

Deed restrictions are regulatory actions that are used to prevent certain types of uses for properties where exposure pathways to contaminants may be created as a result of those uses. Deed restrictions may be used to prevent building construction, limit building use or occupancy, or limit access to certain portion of the buildings within the contamination plume.

Effectiveness - Deed restrictions could effectively prevent exposure to contaminated soil vapor, thereby reducing risks to human health. Deed restrictions would not reduce the migration and the associated environmental impact of the contaminated soil vapor.

Implementability - The SMP building is currently occupied. Limiting access to certain portion of building is not easily implementable through the existing administrative system.

Relative Cost - The cost to implement deed restrictions is low. Some administrative, long-term monitoring and periodic assessment cost would be required.

Conclusion – Deed restrictions will not be retained for further consideration.

6.2.2.2 Sub-slab Depressurization System

Sub-slab Depressurization System (SSDS) creates a negative pressure field directly under a building slab (in relation to building ambient pressure). This negative pressure field becomes a "sink" for any vapors present in the vicinity of the structure.

Effectiveness - SSDS could effectively prevent soil vapor intrusion, thereby reducing risks to human health. SSDS would not reduce the migration and the associated environmental impact of the contaminated soil vapor.

Implementability - SSDS are easily implementable, and the construction materials and services are readily available.

Relative Cost - SSDS involves moderate capital and low O&M cost. Some administrative, long-term monitoring and periodic assessment cost would be required.

Conclusion – SSDS will be retained for further consideration.

6.2.2.3 Passive Barrier

Passive barrier is a synthetic barrier placed below slab to prevent vapor entry to the buildings. Passive venting systems should be considered in addition to the barrier.

Effectiveness – Passive barrier is typically considered for new construction, but may be retrofitted for the existing building. The potential for barriers to prevent vapors from entering buildings is uncertain without testing the as-built system. In addition, future building movement, repairs, or renovations may impact the integrity of the passive barrier unless deed restrictions are in place to protect the barrier.

Implementability - Passive barrier are easily implementable, and the construction materials and services are readily available.

Relative Cost - The cost to implement passive barrier is low. Some administrative, long-term monitoring and periodic assessment cost would be required.

Conclusion – Passive barrier will not be retained for further consideration due to effectiveness issue.

6.2.2.4 Long-term Monitoring

Long-term monitoring includes periodic sampling and analysis of soil vapor, sub-slab vapor, and indoor air samples. This program would provide an indication of the movement of the contaminants and/or of the progress of remedial activities.

Effectiveness - Long-term monitoring alone would not be effective in meeting the RAOs. It would not alter the effects of the contamination on human health and the environment. Monitoring is a proven and reliable process for tracking the migration of contaminants during and following treatment.

Implementability - Long-term monitoring could be easily implemented. All sample ports are easily accessible for sample collection. Equipment, material, and sampling procedures are readily available.

Relative Cost - Long-term monitoring involves low capital and moderate O&M cost.

Conclusion - Long-term monitoring will be retained for further consideration.

6.2.3 Soil Vapor Extraction

SVE system involves placing extraction trenches or wells to intercept the flow of contaminated soil vapor from migrating downgradient. The extracted soil vapor is typically treated ex situ.

6.2.3.1 Soil Vapor Extraction Trenches

SVE uses vacuum (or vacuum and forced air together) to mobilize soil gas and remove volatile organic contaminants in the vadose zone by vaporization and volatilization. The SVE trenches would draw in mobilized VOCs and prevent soil vapor from migrating off site. An off-gas treatment system using vapor phase carbon adsorption and permanganate may be necessary to limit the release of contaminants to the atmosphere.

Effectiveness - SVE has been shown to be effective in removing VOCs from soil. SVE systems may provide sufficient sub-slab depressurization to protect on-site building.

Implementability - Most components of SVE are fairly easy to implement.

Relative Cost - SVE involves high capital and moderate O&M costs.

Conclusion - SVE will be retained for further consideration for preventing off-site migration and capturing air sparge vapors.

6.2.4 Ex Situ Treatment

An ex situ treatment system would be required to remove contaminants from the soil vapor before discharging.

6.2.4.1 Vapor Phase Activated Carbon Adsorption

Carbon adsorption can be used to treat vapor phase contamination. The contaminated effluent from SVE system is drawn through vessel(s) containing GAC to which contaminants are adsorbed, and are thereby removed from the vapor stream. When the concentration of contaminants in the effluent exceeds a breakthrough concentration, the GAC is removed for regeneration or disposal.

Effectiveness - Carbon adsorption is effective in removing contaminants with moderate or high K_{oc} in the vapor phase. Carbon adsorption is not effective in removing VC, a degradation product of TCE and DCE. Additional treatment will be required to treat VC.

Implementability - Activated carbon adsorption is implementable and a proven technology. The equipment and materials are readily available.

Relative Cost - This technology involves moderate capital and O&M costs.

Conclusion - Carbon adsorption will be retained for further consideration.

6.2.4.2 Chemical Oxidation of Off Gas

If high concentrations of VC are present in the SVE system off-gas, potassium permanganate can be used to remove VC. Typically an ion exchange resin (zeolite) is impregnated with a solution of potassium permanganate and forms manganese tetraoxide. Manganese tetraoxide would oxidize VC into potassium chloride and carbon dioxide. It is generally used as a final polish after the vapor phase carbon adsorption process.

Effectiveness - The technology is effective for oxidizing VC and is also known to reduce other chlorinated VOC concentrations (such as *cis*-1,2-DCE) to some extent.

Implementability - Potassium permanganate impregnated zeolite is a conventional technology that would be implementable at this Site.

Relative Cost - The cost for implementing potassium permanganate oxidation depends on flow rate, concentrations of contaminants, and required discharge concentration. Capital and O&M costs are moderate.

Conclusion - Chemical oxidation of off-gas with permanganate zeolite will be retained for further consideration.

6.2.5 Discharge

Once soil vapor has been extracted and treated, it will be discharged to the atmosphere.

6.3 Summary of Remedial Technology Screening

6.3.1 Groundwater

Remedial alternatives developed for treating groundwater at the Site are described briefly. The retained technologies and process options include the following:

- No Action
- Institutional/Engineering Control: Deed restrictions, well drilling restrictions, and long-term monitoring
- Monitor Natural Attenuation
- In Situ Treatment: ISCO, EAB, and AS/SVE
- Discharge: on-site injection or on-site surface recharge (There is no discharge requirements since there is no extracted GW. You need to have provision to dispose of condensate from SVE.)

6.3.2 Soil Vapor

Remedial alternatives developed for treating soil vapor at the Site are described briefly. The retained technologies and process options include the following:

- No Action
- Institutional/Engineering Control: SSDS and long-term monitoring
- Soil Vapor Extraction: SVE trenches
- Ex Situ Treatment: vapor phase activated carbon adsorption and chemical oxidation of off-gas with permanganate zeolite

Section 7

Development and Analysis of Remedial Alternatives

Potential remedial technologies and process options associated with each general response action are identified and screened in this section. Representative remedial technologies and process options that have been retained are used to develop remedial action alternatives.

7.1 Evaluation Criteria for Detailed Screening of Technologies

The technology screening approach is based upon the procedures outlined in *"Draft DER-10 Technical Guidance for Site Investigation and Remediation"* (NYSDEC 2002). These criteria are classified into the following three groups and are described below:

Threshold Criteria. Threshold criteria are requirements that each alternative must meet in order to be considered for selection.

- **Overall Protection of Human Health and the Environment**. This criterion is an evaluation of the remedy's ability to protect public health and the environment, assessing how risks posed through each existing or potential pathway of exposure are eliminated, reduced or controlled through removal, treatment, engineering controls or institutional controls. The remedy's ability to achieve each of the RAOs is evaluated.

- **Compliance with New York State Standards, Criteria, and Guidance (SCGs)**. Compliance with SCGs addresses whether a remedy will meet environmental laws, regulations, and other standards and criteria. In addition, this criterion includes the consideration of guidance which the Department has determined to be applicable on a case-specific basis.

Primary Balancing Criteria. These criteria are used to distinguish the relative effectiveness of each alternative so that decision makers compare the positive and negative aspects of each of the remedial strategies.

- **Long-term Effectiveness and Permanence**. This criterion evaluates the long-term effectiveness of the remedial alternatives after implementation. If wastes or treated residuals remain on-site after the selected remedy has been implemented, the following items are evaluated: 1) the magnitude of the remaining risks, 2) the adequacy of the engineering and/or institutional controls intended to limit the risk, and 3) the reliability of these controls.

- **Reduction of Toxicity, Mobility or Volume**. Preference is given to alternatives that permanently and significantly reduce the toxicity, mobility or volume of the wastes at the site.

- **Short-term Effectiveness**. The potential short-term adverse impacts of the remedial action upon the community, the workers, and the environment during the construction and/or implementation are evaluated. The length of time needed to achieve the remedial objectives is also estimated and compared against the other alternatives.

- **Implementability**. The technical and administrative feasibility of implementing each alternative are evaluated. Technical feasibility includes the difficulties associated with the construction of the remedy and the ability to monitor its effectiveness. For administrative feasibility, the availability of the necessary personnel and materials is evaluated along with potential difficulties in obtaining specific operating approvals, access for construction, institutional controls, and so forth.

- **Cost-Effectiveness**. Capital costs and annual operation, maintenance, and monitoring costs are estimated for each alternative and compared on a present worth basis. Although cost-effectiveness is the last balancing criterion evaluated, where two or more alternatives have met the requirements of the other criteria, it can be used as the basis for the final decision.

Modifying Criterion. This criterion is taken into account after evaluating those above. It is evaluated after public comments on the FS and Proposed Remedial Action Plan (PRAP) have been received. This criterion is not evaluated in this FS.

- **Community Acceptance**. Concerns of the community regarding the RI/FS reports and the PRAP are evaluated. A responsiveness summary will be prepared that describes public comments received and the manner in which the Department will address the concerns raised. If the selected remedy differs significantly from the proposed remedy, notices to the public will be issued describing the differences and reasons for the changes.

7.2 Development and Detail Analysis of Remedial Action Alternatives

Remedial action alternatives have been developed based on the potential for these alternatives to meet the SCGs, RAOs, and PRGs described in Section 4. In Section 6, a preliminary screening of available remedial action technologies was performed. The technologies and processes retained are used to develop remedial action alternatives in this Section.

7.2.1 Groundwater

The technologies and process options retained after the screening step were combined into five alternatives designed to satisfy the RAOs presented in Section 4. To develop remedial alternatives for the Site, representative process options were selected from the same groups of remedial technologies, as appropriate. However, each process option may still be applicable and should be considered during final remedy development. The No Action alternative was retained in accordance with the NCP to serve as a baseline for comparison with the other alternatives for the site. The following alternatives are evaluated in this FS and are described in detail below.

7.2.1.1 Alternative G1 – No Action

The No Action alternative was retained for comparison purposes as required by the NCP. No remedial actions would be implemented as part of the No Action alternative. Groundwater would continue to migrate and the contamination would continue to attenuate through dilution, dispersion, limited biodegradation, etc. This alternative does not include institutional controls or long-term groundwater monitoring.

Overall Protection of Human Health and the Environment
The no action alternative does not provide overall protection of human health and the environment and does not meet the RAOs. Currently, contaminated groundwater is not used as drinking water. However, this alternative does not prevent future use of contaminated groundwater, which poses potential human risks above EPA threshold values through direct contact, ingestion, and inhalation. Because no remedial action would be implemented under this alternative, no means would be available to prevent current and future exposure. This alternative relies on natural attenuation processes to restore groundwater quality. Based on results from the RI, naturally occurring biodegradation of contaminants is present. It would require a long time for the non-destructive natural attenuation processes (such as dispersion, dilution) to reduce the contaminant concentrations to meet groundwater and drinking water standards for the affected area.

Compliance with SCGs
Due to the presence of chlorinated VOCs above the groundwater quality standards and drinking water standards, this alternative would not comply with the chemical-specific SCGs for groundwater for a long time, about 20 year evaluation time. As this alternative involves no action, location- and action-specific SCGs are not applicable.

Long-term Effectiveness and Permanence
No Action is not considered to be a permanent remedy. The contaminants would not be destroyed, except by gradual reductions through natural dispersion and dilution. Destruction of contaminants via biodegradation would be expected at some portion of the Site. Even though the contaminant concentrations remained elevated in groundwater at the Site during the RI, it is expected that the groundwater aquifer would be restored to the NYSDEC groundwater and drinking water standards in the 20 years evaluation period.

This alternative, however, would not provide adequate control of risks to human health or the environment because there are no mechanisms to prevent current and future exposure. Under this alternative there would be no mechanism in place to prevent future risk to human health; therefore, this alternative would not be considered effective in the long term.

Reduction of Toxicity, Mobility or Volume through Treatment
The implementation of this alternative would not affect the toxicity, mobility, or volume of the contaminants. Biodegradation of chlorinated VOCs would be prevalent at some area because of the anaerobic nature of the groundwater as described in Section 3.

Short-term Effectiveness
This alternative would not include a remedial action. Therefore, it would have no short-term impact to workers or the community. There would be no adverse environmental impacts to habitats or vegetation as there is no remedial action under this alternative. A time period of 20 years is assumed for implementation of this alternative.

Implementability
This alternative is easily implemented, since no services or permits would be required.

Cost
There would be no cost under this alternative.

7.2.1.2 Alternative G2 – Monitor Natural Attenuation

All properties within the area of contaminated groundwater are connected to municipal water. This alternative consists of institutional control that would include placing well drilling restrictions within the contamination plume affected area. It is assumed that NYSDEC would be responsible for the enforcement of institutional controls.

Based on the RI data, biodegradation is occurring naturally at the Site; therefore, a natural attenuation monitoring program would be instituted to collect data on contaminant concentrations and movement at the study area. Nine existing monitoring wells would be used for the monitoring program. Based on the DER-10, the MNA monitoring should be performed quarterly for the first 8 quarters and could be reduced to be every fifth quarter if there is evidence that the contaminant is reducing. For cost comparison purposes, it is assumed that the monitoring program would be performed quarterly for the first two years and annually for the rest of the evaluation period. The monitoring data would be used to assess the migration and attenuation of the groundwater contamination over time and to monitor the effectiveness of remedial action.

A review of site conditions would be conducted every five years using data obtained from the annual sampling program. The site reviews would include an evaluation of the extent of contamination and an assessment of contaminant migration and attenuation over time. The MNA program would be modified based on the monitoring results. For cost comparison purposes, it is assumed that this alternative would be performed for the 20-year FS evaluation period. The five-year review would determine if institutional controls and MNA monitoring should be discontinued.

Overall Protection of Human Health and the Environment

Alternative G2 would partially meet the RAOs. It would be protective of human health by preventing ingestion and direct contact of contaminated groundwater. Groundwater would not be used within the contaminated area. This alternative would not minimize the migration of contaminants and would not protect the environment since there are no active removal mechanisms to restore the groundwater quality. The estimated time for institutional controls would be more than 20 years, and would be determined by results of monitoring program and periodic review.

Compliance with SCGs

This alternative would not meet the chemical-specific SCGs since no treatment would be implemented to destroy or reduce contaminant concentrations. This alternative does not involve any subsurface intrusion, operation, or treatment. Location-specific SCGs do not apply. Groundwater monitoring would comply with action-specific SCGs.

Long-term Effectiveness and Permanence

This alternative would provide long-term effectiveness since the exposure pathway of contaminated groundwater to local receptors would be eliminated through institutional controls. The MNA monitoring program and periodic review would assess and evaluate contaminant concentrations and the extent of contamination to ensure that it would not pose an increased risk to human health.

This alternative would not be permanence since no active remedy would be implemented. The magnitude of contamination would not be reduced in the near future; the contaminants would exist for a long time in the subsurface.

Institutional controls together with MNA monitoring are considered adequate to eliminate the exposure pathway and reliable through the current administrative system.

Reduction of Toxicity, Mobility or Volume through Treatment

This alternative would not reduce the toxicity, mobility, or volume of the Site contamination since natural processes other than biodegradation are unlikely to be sufficient to reduce contaminant toxicity, mobility, or volume. The destructive mechanism, biodegradation, would be prevalent at some area of the Site due to anaerobic subsurface conditions. The total volume of contaminated groundwater would increase as the contaminants continue to migrate, but due to biodegradation, the toxicity of contaminated groundwater might be decreasing.

Short-term Effectiveness

This alternative would include some site work and would have minimal and short-term impact to the communities and workers. Use of personal protective equipment (PPE) by workers during groundwater sampling and the site investigation would minimize the exposure.

Implementability

The institutional control, including well drilling restrictions, could be easily implemented. Groundwater monitoring and periodic investigations could be easily implemented since monitoring equipment is readily available and procedures are in place.

Cost

The total present worth cost for this alternative is approximately $1 million. Capital cost associated with this alternative is $35,000; the monitoring cost is $56,000 per event for 20 years. Detailed cost estimates are presented in Appendix A.

7.2.1.3 Alternative G3 – Air Sparging/Soil Vapor Extraction

An AS/SVE system would be installed in the treatment area near the loading dock. The treatment area is defined by the area exceeding 20 times groundwater SCG (Figure 7-1). AS would treat the groundwater in situ, and SVE would capture contaminated soil vapor, preventing it from migrating off site. This remedial option would eliminate the pathway of direct human contact with groundwater and soil vapor contaminants that exists now. The AS/SVE system would consist of the following components:

- Air sparge wells – Wells would be placed in the treatment area, with screens at or below the desired treatment depth. Based on a typical result for air sparging in sandy soil, a 20-foot radius of influence was estimated. Four wells would be required to treat the area exceeding 20 times SCG. See Figure 7-1 for the estimated well locations.

- Air compressor – The compressor would provide pressurized air to the sparge wells.

- Trenching - Trenches would be required for the compressed air lines to the wells.

- SVE trenches – The SVE trenches would be constructed with perforated pipes laid in a bedding of filter pack material. The filter pack would be covered with a seal (e.g., clay, bentonite, plastic) to prevent short-circuiting to the atmosphere. Backfill would be placed above the seal and compacted to grade. A conservatively lateral extent of influence of 15 feet has been used for costing purposes. This results in two trenches. One would be installed adjacent to the fence, and the other, adjacent to the loading dock. This provides full coverage of the treatment area and full capture of air sparge vapors. See Figure 7-1 for the estimated trench locations.

- SVE system – The system would include a blower for inducing a vacuum on the extraction trenches, a knockout tank for collection of soil vapor condensate, and any treatment units required to treat extracted vapor and condensed water.

A pre-design investigation would be performed to obtain the site-specific design parameters. The above estimates are for cost estimating purposes. The design will change based on the results of the ROI test.

Operation and maintenance would be performed weekly to monitor the system performance. Subsequent monitoring frequency would be determined based on system performance.

Institutional controls and long-term groundwater monitoring program would be implemented as described under Alternative G2. A review of site conditions would be conducted every five years as described under Alternative G2. The site reviews would include an evaluation of the extent of contamination and effectiveness of treatment. If contamination remains, the site reviews would also include an assessment of contaminant migration and attenuation over time. The total duration of this alternative is estimated to be 5 years based on the travel time of contaminants at the Site.

Overall Protection of Human Health and the Environment
This alternative would provide protection of human health and the environment. AS/SVE would remove and/or destroy the contaminants within the treatment zone permanently; the remaining very low contaminant concentrations are expected to be reduced through natural processes such as dilution and dispersion. This alternative would meet the RAOs. Institutional controls would eliminate the exposure pathway for contaminated groundwater to local receptors before the RAOs and the PRGs are achieved. In addition, the SVE portion of the remedy would prevent migration of contaminated vapor to the sub-slab area, where pathways to human receptors exist.

Compliance with SCGs
This alternative would achieve chemical-specific SCGs. The groundwater contaminant concentrations would be reduced actively through the AS system within the treatment area and passively through natural processes outside the treatment area. Location and action specific SCGs would also be met. Groundwater would be treated in situ, and the extracted vapor would be treated via a GAC and PPZ units prior to atmospheric discharge.

Long-term Effectiveness and Permanence
The alternative provides an effective, permanent remedy for the most contaminated area of the Site. AS/SVE would provide treatment of contaminated groundwater within area exceeding 20 times SCG, and would significantly reduce and eventually eliminate the long-term health risks at the Site. The environment would be protected by effectively removing the contaminants from groundwater. The remaining contaminants at low concentrations would be reduced over time through natural processes. Treatment residuals would meet the SCGs at the Site following completion of the remedy. The remaining risks would be effectively addressed by institutional controls prohibiting the use of Site groundwater as a potable water source.

Reduction of Toxicity, Mobility or Volume through Treatment
This alternative would significantly reduce the toxicity, mobility, and volume of contamination. The volume and toxicity of contaminated groundwater would be reduced by the stripping of contamination from the plume. Mobility of soil vapor would be controlled by the vacuum applied to the treatment area, which would prevent vapor migration.

Short-term Effectiveness
This alternative would have some short-term impacts to the community and the environment. AS/SVE would need to be installed and operated on private properties for 3 years or longer. Installation of the system would be performed without significant risk to the community. Site workers would wear appropriate PPE to minimize exposure to contamination and as protection from physical hazards. In addition, risks posed by the extracted vapor would be effectively managed by treatment of the vapor prior to discharge.

Implementability
AS/SVE technology has been demonstrated successfully in full scale applications. Successful implementation at this Site depends on an adequate understanding of site geology and its effects on system design. Pilot testing would be necessary to demonstrate effectiveness and to establish the site-specific design parameters. The small treatment area is conducive to quick, easy well and trench installation, so construction difficulties are anticipated to be minimal. Performance can be easily monitored using saturated-zone and vadose-zone monitoring points. The only implementation issue is that the area is prone to flooding. This would be addressed by configuring the AS/SVE systems to automatically shut down if the groundwater level rises to the level of the soil gas extraction trenches. In addition, the trenches would include cleanouts to facilitate maintenance of the extraction pipes, if necessary.

Cost
The total present worth for Alternative G3 is $1.13 million. The estimated capital cost is $416,000. The O&M cost is $69,000 per year for 3 years. The monitoring cost is $52,000 per event for 5 years. Detailed cost estimates are presented in Appendix A.

7.2.1.4 Alternative G4 – Enhanced Anaerobic Biodegradation and Monitor Natural Attenuation

EAB of chlorinated VOCs at the Site could be implemented via the injection of electron donors and nutrients into treatment area with relatively high contaminant concentrations. At the Site, aqueous substrates might be more favorable than slow release compounds that have high viscosity because aqueous substrates can affect a greater radius of influence (ROI). The increased ROI decreases the number of injection points required.

The primary objective of EAB is to deliver bioremediation amendments to the subsurface in the most cost effective and efficient configuration in order to stimulate in situ degradation of contaminants. This alternative would be implemented to treat the area exceeding 20 times groundwater SCGs.

A bench-scale study would be performed to obtain site specific data and effectiveness. For cost estimating purposes, lactate solution is selected, yet other technologies should also be evaluated during the design stage. Lactate solution is reported to last up to 18 months. For cost estimating purposes, direct-push injection would be placed every 12.5 feet in a grid system as shown on Figure 7-2. Groundwater modeling should be considered during development of the bench-scale study to assist in the placement of injection points. Based on 12.5 feet spacing, a total of 24 injection points would be installed at the treatment area.

Results from groundwater samples collected after the first EAB injection event would be used to determine the strategy for the second injection. The second round of injection would be implemented to target the remaining contaminants in the subsurface. The actual number of injections, the chemical usage, and the injection point spacing would be determined during remedial design and remedial action.

At least four weeks after the first round of chemical injection and before the second round of injection, groundwater samples would be taken from selected monitoring wells to analyze for VOCs. The results would be used to focus the second injection event on areas with contaminant concentrations exceeding the PRGs. The results would be used to evaluate the effectiveness of EAB.

This alternative would involve periodic performance monitoring in order to confirm the effectiveness of bioremediation. For cost estimating purposes, it is assumed that 4 rounds of sampling would be conducted prior to and after the EAB injections. It is estimated that the EAB material would last for 2 years at the Site. The bioremediation performance would be monitored quarterly for the first two years and annually for another 3 years. Samples would be collected for contaminants and degradation products, redox-sensitive parameters, biological activity indicators, and water quality parameters.

Institutional controls and MNA groundwater monitoring program would be implemented as described under Alternative G2. A review of site conditions would be conducted every five years as described under Alternative G2. The site reviews would include an evaluation of the extent of contamination and effectiveness of treatment. If contamination remains, the site reviews would also include an assessment of contaminant migration and attenuation over time. The total duration of this alternative is estimated to be 5 years based on the travel time of contaminant from the Site.

Overall Protection of Human Health and the Environment
This alternative would provide protection of human health and the environment. It would meet the RAOs. Contamination within the area exceeding 20 times SCGs would be treated in situ through EAB. The remaining very low contaminant

concentration areas could be readily reduced through natural processes in the subsurface. It is possible that at this Site, reductive dechlorination may stall at *cis*-DCE and 1,1-DCA formation. However, based on the RI data, *cis*-DCE and 1,1-DCA can be degraded through various pathways and in aerobic conditions. Therefore, even without bioaugmentation, *cis*-DCE and 1,1-DCA may be degraded by natural processes to attain its PRG. The groundwater monitoring program would be used to determine if these concentrations are higher than the PRG. Bioaugmentation could also be implemented to reduce these concentrations if the natural processes are not adequate.

Institutional controls would eliminate the exposure pathway for local receptors to contaminated groundwater before it is restored. The implementation of EAB includes the delivery to the subsurface of a considerable amount of food-grade amendment. This amendment may remain in the subsurface for years after the PRGs are achieved.

Compliance with SCGs

This alternative would meet the chemical-specific SCGs. Implementation of EAB would reduce contaminant concentrations in the treatment area. The remaining contaminants in groundwater would be reduced to PRGs through natural attenuation processes. The PRGs are anticipated to be achieved within 5 years based on two to three years of active bioremediation followed by groundwater flushing of the remaining dissolved contaminants of low concentrations.

This action would meet action- and location-specific SCGs. Health and safety requirements would be met.

Long-term Effectiveness and Permanence

This action would have long-term effectiveness and permanence. EAB, once established, would destroy the chlorinated VOC contaminants in the subsurface, therefore reducing the risk posed by the contaminants. The treatment would focus on the treatment area. The remaining areas would be remediated gradually through natural flushing action of the groundwater. There is a chance that the dechlorination process may stall at *cis*-DCE and 1,1-DCA; however, it is likely that natural subsurface processes would be adequate to degrade this concentration to attain its PRG.

The existence of relatively low permeable silt zones and clay seams would not reduce the effectiveness of EAB, since the dechlorination conditions and bacteria would stay in the subsurface for some time, any contaminants diffused out of the low permeable zones would also be treated. In addition, the concentration reductions of contaminants in the groundwater could increase the rates of mass transfer for contaminants out of the low permeable zones.

Institutional controls would prevent the exposure of contaminated groundwater before the groundwater quality is restored. The long-term monitoring program and five-year review would assess the contamination conditions and determine the operation time frame of the groundwater treatment system.

Reduction of Toxicity, Mobility or Volume through Treatment
In situ bioremediation would reduce the toxicity and volume of contamination. Chlorinated VOCs would be biotransformed to ethene, ethane, and methane. The intermediate product, VC, is more toxic than TCE, but accumulation of VC is unlikely because of its ability to degrade under aerobic conditions. Intermediates, such as DCEs, DCA, and VC, would be closely monitored.

Short-term Effectiveness
Although a fairly significant amount of site work would be required for this alternative, this type of construction is routine as installation of bioremediation amendment injection systems are common. Because of this, the work would be performed without significant risk to the community. Site workers would wear appropriate PPE to minimize exposure to contamination and as protection from physical hazards.

This alternative would not have short-term impacts to the community since the EAB would be injected through direct push technology. Injection requires a large amount of water that would need to be taken from a hydrant. The site-wide amendment injection system would be completed in six months. The amendment injected into the subsurface may remain for years even after the PRGs are met.

Implementability
This alternative is technically implementable. This alternative would be constructed and implemented using conventional construction methods and equipment. The processes that govern degradation reactions are well understood, and technical feasibility of enhanced bioremediation has been established at numerous sites. Despite this, bioremediation is still considered an innovative technology. As such, it would require bench and pilot scale testing prior to implementation. In general, no significant technical difficulties are anticipated. No difficulty in obtaining a permit for the injection of bioremediation amendments into groundwater is anticipated.

Services and materials for implementation of this alternative are readily available. Competitive bids can be obtained from a number of equipment vendors and remediation contractors. No problems are anticipated for the implementation and enforcement of the institutional controls.

Cost
The total present worth for Alternative G4 is $1.14 million. The estimated capital cost is $567,000 and the monitoring cost is $56,000 per event for 5 years. Detailed cost estimates are presented in Appendix A.

7.2.1.5 Alternative G5 – In Situ Chemical Oxidation

In this alternative, ISCO would be applied at the treatment area. Using ISCO at the Site could mineralize dissolved TCE, PCE, and *cis*-DCE in groundwater within a short period upon contact with the contaminants. In the event that extensive residual contaminant masses exist in relatively low permeability zones, treatment via chemical oxidation could significantly increase the mass transfer between the contamination and groundwater, subsequently reducing the duration of remediation at the Site. For cost estimating purposes, Fenton's Reagent is selected as the oxidant, however, other oxidation technologies should also be evaluated during the remedial design stage.

A pre-design investigation would be performed to obtain site specific data on soil oxidant demand. Groundwater modeling would be performed as described under Alternative G4.

For cost estimating purposes, direct-push injection would be placed every 12.5 feet in a grid system as shown on Figure 7-3. Fenton's Reagent is expected to last three to four months in the subsurface after injection. For cost estimating purposes, three rounds of chemical injection, at least four weeks apart, are proposed. The first round of injection would satisfy the soil oxidant demand in the treatment area and would destroy any dissolved and easily accessible contaminants. If there is any residual VOC contamination in the low permeability zones, it could dissolve after the first round of application and would react with the remaining oxidant. Fenton's Reagent solution could be prepared on-site with city water or with extracted groundwater from nearby wells perpendicular to the groundwater flow direction. This would help the dispersion of oxidant in the subsurface.

Results from groundwater samples collected after the first chemical injection event would be used to determine the strategy for the second injection. The second round of oxidant application would be implemented to target the remaining contaminants in the subsurface. If necessary, the third round of application would be implemented. The actual number of injections, the chemical usage, and the injection point spacing would be determined during remedial design and remedial action.

At least four weeks after the first round of chemical injection and before the second round of injection, groundwater samples would be taken from selected monitoring wells to analyze for VOCs. The results would be used to focus the second injection event on areas with contaminant concentrations exceeding the PRGs. The results would be used to evaluate the effectiveness of in situ oxidation. The same would apply to third round of injection.

Long-term groundwater monitoring would be implemented as described under Alternative G2. Institutional and engineering controls would be implemented as described under Alternative G2. Three years review would be implemented as opposed to five years review described under Alternative G2. In situ chemical oxidation operation at the Site is expected to be completed in four months. The treatment would only cover the area exceeding 20 times groundwater SCG since it is not cost effective to treat areas with low concentrations. The remaining low levels of contaminants would migrate down toward the treatment area. The estimated travel time for the remaining groundwater contaminants would be between 5 years.

Overall Protection of Human Health and the Environment
This alternative would provide protection of human health and the environment. The in situ chemical treatment would remove and/or destroy the contaminants within the treatment zone permanently; the remaining very low contaminant concentrations are expected to be reduced through natural processes such as dilution in the subsurface. This alternative would meet RAOs. Institutional controls would eliminate the exposure pathway for contaminated groundwater to local receptors before the RAOs and the PRGs are achieved.

Compliance with SCGs
This alternative would achieve chemical-specific SCGs, but the groundwater contaminant concentrations would be reduced actively through ISCO at the treatment area and passively through natural processes outside the treatment area. Location and action specific SCGs would also be met. Contaminated groundwater would be treated via ISCO.

Long-term Effectiveness and Permanence
The alternative would provide long-term effectiveness and permanence. In situ treatment of contaminated groundwater within the area exceeding 20 times SCG would significantly reduce and eventually eliminate the long-term health risks at the Site and protect the environment by effectively removing the contaminants from groundwater. The remaining contaminants at low concentrations would be reduced over time through natural processes. A bench-scale study would be required to obtain site specific design parameters, such as soil oxygen demand and the ROI.

Reduction of Toxicity, Mobility or Volume through Treatment
This alternative would significantly reduce the toxicity and volume of groundwater contamination by treating it via oxidizing the contaminants in situ. ISCO treatment would not reduce the mobility of the contaminants.

Short-term Effectiveness
This alternative would have some short-term impacts to the community and the environment. Installation of the ISCO injection points would be performed without significant risk to the community. Site workers would wear appropriate PPE to minimize exposure to contamination and as protection from physical hazards.

Implementability
ISCO has been demonstrated successfully in full scale applications. Bench scale testing for the chemical oxidation technology would be necessary to establish site-specific soil oxidant demand information. Experienced companies would be procured through competitive bid to implement this alternative. Construction difficulties are anticipated to be minimal.

Cost
The total present worth for Alternative G5 is $1.2 million. The estimated capital cost is $663,000. The monitoring cost is $52,000 per event for 5 years. Detailed cost estimates are presented in Appendix A.

7.2.2 Soil Vapor

The technologies and process options retained after the screening step were combined into four alternatives designed to satisfy the RAOs presented in Section 4. To develop remedial alternatives for the Site, representative process options were selected from the same groups of remedial technologies, as appropriate. However, each process option may still be applicable and should be considered during final remedy development. The No Action alternative was retained in accordance with the NCP to serve as a baseline for comparison with the other alternatives for the site. The following alternatives are evaluated in this FS and are described in detail below.

7.2.2.1 Alternative V1 – No Action

The No Action alternative was retained for comparison purposes as required by the NCP. Remedial actions would not be implemented as part of the No Action alternative. Soil vapor would continue to migrate and the contamination would continue to attenuate through dilution, dispersion, limited biodegradation, etc. This alternative does not include institutional controls or long-term monitoring.

Overall Protection of Human Health and the Environment
The no action alternative does not provide overall protection of human health and the environment and does not meet the RAOs. This alternative does not prevent future exposure to contaminated soil vapor, which poses potential human risks above EPA threshold values through inhalation. Because no remedial action would be implemented under this alternative, no means would be available to prevent current and potential future exposure.

Compliance with SCGs
There are no chemical specific SCGs for contaminated soil vapor. This alternative involves no action; therefore, there are no location-specific or action-specific SCGs involved.

Long-term Effectiveness and Permanence
No Action is not considered to be a permanent remedy. The contaminants would not be destroyed, except by gradual reductions through natural dispersion and dilution. Even though the contaminant concentrations remained elevated in soil vapor at the Site during the RI, vapor intrusion through indoor air is still below the NYSDOH guidelines. This alternative, however, would not provide adequate control of risks to human health or the environment because there are no mechanisms to prevent future exposure. Under this alternative there would be no mechanism in place to prevent future risk to human health; therefore, this alternative would not be considered effective in the long term.

Reduction of Toxicity, Mobility or Volume through Treatment
The implementation of this alternative would not affect the toxicity, mobility, or volume of the contaminants.

Short-term Effectiveness
This alternative would not include a remedial action. Therefore, it would have no short-term impact to workers or the community. There would be no adverse environmental impacts to habitats or vegetation since no remedial action is taken under this alternative.

Implementability
This alternative is easily implemented, since no services or permits would be required.

Cost
There would be no cost under this alternative.

7.2.2.2 Alternative V2 – Long-term Monitoring

A long-term monitoring program would be instituted to collect data on contaminant concentrations and movement at the study area. Seven soil vapor samples would be used for the monitoring program. The monitoring data would be used to assess the migration and attenuation of the soil vapor contamination over time and to monitor the effectiveness of remedial action.

A review of site conditions would be conducted every five years using data obtained from the annual sampling program. The site reviews would include an evaluation of the extent of contamination and an assessment of contaminant migration and attenuation over time. The monitoring program would be modified based on the monitoring results. For cost comparison purposes, it is assumed that this alternative would be performed for the 20-year FS evaluation period where the first two years would be performed quarterly and the rest annually. Based on the DER-10, the monitoring could be reduced to be every fifth quarter if there is evidence that the contaminant is reducing. Annual sampling is assumed for the cost estimate purpose. The five-year review would determine if monitoring should be discontinued.

Overall Protection of Human Health and the Environment
Alternative V2 would not meet the RAOs. This alternative would not minimize the migration of contaminants and would not protect the environment since there are no active removal mechanisms to restore the soil vapor quality. The estimated time for monitoring program would be 20 years, and it would be determined by results of each monitoring program and periodic review.

Compliance with SCGs
This alternative would not meet the chemical-specific SCGs since no treatment would be implemented to destroy or reduce contaminant concentrations. This alternative

does not involve any subsurface intrusion, operation, or treatment. Location-specific SCGs do not apply. Soil vapor monitoring would comply with action-specific SCGs.

Long-term Effectiveness and Permanence
This alternative would not provide long-term effectiveness since the exposure pathway of contaminated soil vapor to the on-site building would not be eliminated. The monitoring program and periodic review would assess and evaluate contaminant concentrations and the extent of contamination to ensure that it would not pose an increased risk to human health.

This alternative would not provide permanence since no active remedy would be implemented. The magnitude of contamination would not be reduced in the near future; the contaminants would exist for a long time in the subsurface.

Reduction of Toxicity, Mobility or Volume through Treatment
This alternative would not reduce the toxicity, mobility, or volume of the Site contamination since natural processes other than biodegradation are unlikely to be sufficient to reduce contaminant toxicity, mobility, or volume. The elevated groundwater concentration would continue to affect the soil vapor contamination.

Short-term Effectiveness
This alternative would include some site work and would have minimal and short-term impact to the communities and workers. Use of personal protective equipment (PPE) by workers during soil vapor sampling and the site investigation would minimize the exposure.

Implementability
The institutional control could be easily implemented. Soil vapor monitoring and periodic investigations could be easily implemented since monitoring equipment is readily available and procedures are in place.

Cost
The total present worth cost for this alternative is approximately $0.71 million. Capital costs associated with this alternative are $35,000; the monitoring cost is $38,000 per event for 20 years. Detailed cost estimates are presented in Appendix A.

7.2.2.3 Alternative V3 – Interim Remedial Measure

Recently collected soil gas samples indicate that VOC concentrations are above NYSDOH guidelines. Therefore, a sub-slab depressurization system (SSDS) would be installed as an IRM beneath the on-site building to prevent the concentrations of VOCs in indoor air to rise above NYSDOH guidelines. Mitigation measures are taken at the on-site buildings to address potential human exposures (via inhalation) to VOCs associated with soil vapor intrusion.

The SSDS includes vapor piping sub-slab mitigation system connecting to the blower located within the enclosed storage area and venting outside of the building as shown in Figure 7-4. The vapor is passed through a carbon unit prior to discharge to the atmosphere. Operation and maintenance is performed monthly to monitor the system operation. Subsequent monitoring frequency will be determined based on system operation and requirements. The long-term monitoring program would be as described in Alternative V2.

Overall Protection of Human Health and the Environment

This alternative would meet the RAOs. It would be protective of human health by preventing inhalation of contaminated soil vapor. This alternative would not minimize the migration of contaminants and would not protect the environment since there are no active removal mechanisms to restore the soil vapor quality. The estimated time for institutional controls would be more than 5 years, and would be determined by results of monitoring program and periodic review.

Compliance with SCGs

This alternative would meet the chemical-specific SCGs since vapor mitigation would be implemented to destroy or reduce contaminant concentrations in indoor air and prevent vapor intrusion to the on-site building. This alternative does not involve any subsurface intrusion, operation, or treatment. Location-specific SCGs do not apply. Soil vapor monitoring would comply with action-specific SCGs.

Long-term Effectiveness and Permanence

This alternative would provide long-term effectiveness since the building occupant's exposure to contaminated soil vapor would be eliminated through the SSDS system. The monitoring program and periodic review would assess and evaluate contaminant concentrations and the extent of contamination to ensure that it would not pose an increased risk to human health.

This alternative would provide permanence of exposure protection to the building's occupants for as long as the SSDS system is operational. However, this alternative would not significantly reduce the source of the contaminate vapor (localized groundwater contamination) or the soil vapor located external to the building sub-slab. The magnitude of contamination in indoor air would be reduced, but the contamination in soil vapor external to the building would not be reduced in the near future without source treatment. The contaminants would persist for a long time in the subsurface if no source treatment occurred.

Institutional controls together with MNA monitoring are considered adequate to eliminate the exposure pathway and reliable through the current administrative system.

Reduction of Toxicity, Mobility or Volume through Treatment

This alternative would reduce the toxicity and mobility of the Site contamination to indoor air, but it would not reduce the volume of the Site vapor contamination. Natural processes other than biodegradation are unlikely to be sufficient to reduce contaminant volume since the elevated groundwater concentration would affect the soil vapor contamination.

Short-term Effectiveness
This alternative would have some short-term impacts to the community and the environment. Indoor construction of the IRM is likely to cause some disruption to the existing building occupants during construction. The IRM system would need to be installed and operated on private property for 3 years or longer. Installation of the system would be performed without significant risk to the community. Site workers would wear appropriate PPE during soil vapor sampling and the site investigation to minimize exposure to contamination and as protection from physical hazards.

Implementability
The institutional control could be easily implemented. Soil vapor monitoring and periodic investigations could be easily implemented since monitoring equipment is readily available and procedures are in place.

Cost
The total present worth cost for this alternative is approximately $1 million. Capital cost associated with this alternative is $548,000; the O&M cost for the IRM is $23,000 per year for 3 years and soil vapor monitoring is $38,000 per event for 5 years. Detailed cost estimates are presented in Appendix A.

7.2.2.4 Alternative V4 – Interim Remedial Measure and Soil Vapor Extraction System

This alternative consists of the IRM performed as described in Alternative V3, coupled with an SVE system to prevent the soil vapor from migrating off-site. The layout for the SVE and SSDS system is presented in Figure 7-5. The additional SVE system would be placed in the treatment area, and would consist of the following components:

- SVE trenches – The SVE trenches would be constructed with perforated pipes laid in a bedding of filter pack material. The filter pack would be covered with a seal (e.g., clay, bentonite, plastic) to prevent short-circuiting to the atmosphere. Backfill would be placed above the seal and compacted to grade. A conservatively lateral extent of influence of 15 feet has been used for costing purposes. This results in two trenches. One would be installed adjacent to the fence, and the other, adjacent to the loading dock. This provides full coverage of the treatment area and full capture of soil vapor. See Figure 7-5 for the estimated trench locations.

- SVE system – The system would include a blower for inducing a vacuum on the extraction trenches, a knockout tank for collection of soil vapor condensate, and any treatment units required to treat extracted vapor and condensed water.

A pre-design investigation would be performed to obtain the site-specific design parameters. The above estimates are for cost estimating purposes. The design will change based on the results of the ROI test.

Operation and maintenance would be performed monthly to monitor the system performance. Subsequent monitoring frequency would be determined based on system performance and requirements.

Soil vapor monitoring program would be implemented as described under Alternative V2. A review of site conditions would be conducted every five years as described under Alternative V2. The site reviews would include an evaluation of the extent of contamination and effectiveness of treatment. If contamination remains, the site reviews would also include an assessment of contaminant migration and attenuation over time. The total duration of this alternative is estimated to be 5 years based on the travel time of contaminants at the Site.

Overall Protection of Human Health and the Environment
This alternative would provide protection of human health and the environment. This alternative would meet all RAOs. Institutional controls would eliminate the exposure pathway for contaminated groundwater to local receptors before the RAOs and the PRGs are achieved. In addition, the SVE portion of the remedy would prevent migration of contaminated vapor to the sub-slab area, where pathways to human receptors exist. It would also prevent contaminated vapor from migrating off site.

Compliance with SCGs
This alternative would achieve chemical-specific SCGs, but it may take a very long time (> 3 years) to do so without the groundwater remedy. The groundwater contaminant concentrations would be reduced slowly within the treatment area by continuous removal of vapors from the vadose zone, and contaminants outside the treatment area would dissipate or degrade passively through natural processes outside the treatment area. Location and action specific SCGs would also be met.

Long-term Effectiveness and Permanence
Although effective at preventing exposure during operation, the remedy is not considered permanent because it is not expected to remove all contamination within the timeframe considered for this FS. Risks would still exist from the subsurface contamination remaining at the Site.

Reduction of Toxicity, Mobility or Volume through Treatment
This alternative would significantly reduce the mobility and volume of contaminated vapor by applying vacuum to the subsurface and removing contaminated soil vapor. Some reduction in contamination toxicity is expected from natural biodegradation processes, but the remedy does not actively reduce toxicity through treatment.

Short-term Effectiveness
This alternative would have some short-term impacts to the community and the environment. Indoor construction of the IRM is likely to cause some disruption to the existing building occupants during construction. The IRM and SVE systems would need to be installed and operated on private property for 3 years or longer. Installation of the system would be performed without significant risk to the community. Site workers would wear appropriate PPE to minimize exposure to contamination and as protection from physical hazards. In addition, risks posed by the extracted vapor would be effectively managed by treatment of the vapor prior to discharge.

Implementability
SSD and SVE technology has been demonstrated successfully in full scale applications. Successful implementation at this Site depends on an adequate understanding of site geology/hydrogeology and its effects on system design. Pilot testing would be necessary to demonstrate effectiveness and to establish the site-specific design parameters. The small SVE treatment area is conducive to quick, easy well and trench installation, so SVE construction difficulties are anticipated to be minimal. Performance can be easily monitored using sub-slab and vadose-zone monitoring points. The only implementation issue is that the SVE area is prone to flooding. This would be addressed by configuring the SVE system to automatically shut down if the groundwater level rises to the level of the extraction trenches. In addition, the trenches would include cleanouts to facilitate maintenance of the extraction pipes, if necessary.

Cost
The total present worth for Alternative V4 is $1.28 million. The estimated capital cost is $763,000. The O&M cost is $46,000 per year for 3 years. The long-term monitoring cost is $38,000 per event for 5 years. Detailed cost estimates are presented in Appendix A.

7.3 Comparative Analysis of Alternatives

7.3.1 Groundwater

7.3.1.1 Overall Protection of Human Health and the Environment

Alternative G1 would not provide protection of human health and the environment, since contamination would remain in groundwater for a long time in the future, and no mechanism would be implemented to prevent exposure to contaminated groundwater. Alternative G2 would be protective of human health by preventing ingestion and direct contact of contaminated groundwater, but it would not protect the environment since there are no active removal mechanisms to restore the groundwater quality. Alternative G3 would provide protection of human health and the environment, since AS/SVE would permanently remove and/or destroy the contaminants within the treatment zone (area exceeding 20 times SCGs). Alternative G4 would provide protection of human health and the environment. Contamination within the treatment area would be treated in situ through EAB. The remaining very low contaminant concentration areas could be readily reduced through natural processes in the subsurface. Alternative G5 would provide protection of human health and the environment, since the in situ chemical treatment would permanently remove and/or destroy the contaminants within the treatment zone.

7.3.1.2 Compliance with SCGs

The site groundwater is currently contaminated with chlorinated VOCs above the groundwater quality standards and drinking water standards. Alternatives G1 and G2 would not address the contamination so would not comply with the chemical-specific SCGs. Alternatives G3, G4, and G5 would all achieve chemical-specific SCGs. The groundwater contaminant concentrations would be reduced actively through the in situ treatment within the treatment area and passively through natural processes outside the treatment area.

7.3.1.3 Long-term Effectiveness and Permanence

Alternative G1 is not considered to be an effective or permanent remedy. The contaminants would not be destroyed, except by gradual reductions through natural dispersion and dilution. Alternative G2 would provide long-term effectiveness since the exposure pathway of contaminated groundwater to local receptors would be eliminated through institutional controls; however, it would probably not provide permanence since no active remedy would be implemented, and it is not likely that the contamination will reach cleanup levels within 30 years. Alternatives G3, G4, and G5 would provide an effective, permanent remedy for the most highly-contaminated area of the Site, where exceeding 20 times SCG. They would significantly reduce concentration in the near term and eventually eliminate the long-term health risks at the Site. Treatment residuals would meet SCG at the Site following completion of the remedy.

7.3.1.4 Reduction of Toxicity, Mobility, or Volume through Treatment

The implementation of Alternatives G1 and G2 would not affect the toxicity, mobility, or volume of the contaminants through treatment. Alternatives G3, G4, and G5 would significantly reduce the toxicity and volume of contaminated groundwater by actively removing or degrading the contaminants. They are unlikely to provide a significant reduction in the mobility of contaminated groundwater.

7.3.1.5 Short-term Effectiveness

Alternative G1 would have no short-term impact to workers or the community since remedial actions would not be performed. Alternative G2 would have minimal short-term impact to the community, since workers would only be on site for periodic sampling. Alternatives G3, G4, and G5 would have some short-term impacts to the community and the environment. Alternatives G4 and G5 would likely require repeated mobilizations to the Site for injections. Alternative G3 would require ongoing operation of a treatment system at the Site. With Alternatives G3, G4, and G5, risks to site workers posed by exposure to contaminants, heavy equipment, and treatment chemicals would be managed by implementation of a health and safety plan.

7.3.1.6 Implementability

Alternative G1 is easily implemented since no services or permits would be required. Alternative G2 is easily implemented. Administrative requirements for obtaining institutional controls are minimal, and groundwater monitoring services are readily available. Alternative G3 is technically implementable. SVE and AS are proven technologies, but a pilot study would be required for proper design of the remedy. Alternatives G4 and G5 are still considered innovative technologies, so a bench-scale study would be required for the proper design of the remedy. Their implementability is dependent on subsurface conditions, which affect the degree of effort required to ensure the chemicals/amendments are successfully delivered to the entire treatment area. Since Site soils are fairly permeable, delivery is implementable.

7.3.1.7 Cost

A comparative summary table of the cost estimates for each alternative is shown below.

Alternative	Present Value Cost	Capital Costs	Annual Costs
G1 – No Action	$0	$0	$0
G2 – MNA	$1,000,000	$35,000	$56,000
G3 – AS/SVE	$1,130,000	$416,000	$121,000
G4 – EAB	$1,140,000	$567,000	$56,000
G5 – ISCO	$1,200,000	$663,000	$52,000

7.3.2 Soil Vapor

7.3.2.1 Overall Protection of Human Health and the Environment

Site contaminants have currently been detected in soil vapor and indoor air. Because nothing would be done to address the soil vapor under Alternatives V1 andV2, these alternatives would not be protective of human health or the environment. Both Alternatives V3 and V4 are protective of human health because they eliminate the current pathway to indoor air; however, V4 is additionally protective of the environment by preventing off-site migration of contaminated soil vapor.

7.3.2.2 Compliance with SCGs

Alternatives V1 and V2 would not meet the chemical-specific SCGs since no treatment would be implemented to destroy or reduce contaminant concentrations in soil vapor. Alternative V3 would meet chemical-specific SCGs for indoor air, but not for soil vapor. Alternative V4 would meet chemical-specific SCGs for indoor air. It would eventually meet the chemical-specific SCGs for soil vapor, but this is likely to take a very long time (>3-year).

7.3.2.3 Long-term Effectiveness and Permanence

Although currently there is no risk to human health, Alternative V1 would not ensure the elimination of future risks and would not address the underlying contamination. Therefore, this alternative is neither effective in the long term, nor permanent. Alternative V2 would be effective by monitoring for future risks to human health. Alternatives V3 and V4 would also be effective by eliminating the pathway to human receptors. Alternatives V2 and V3 are not considered permanent because they would not address contaminated soil vapor beneath the slab. Alternative V4 provides a degree of permanence by capturing the most contaminated soil vapor, but it is not expected to permanently remove the source of contamination from the Site. In addition, if either Alternative G4 or G5 is selected, Alternative V4 would interfere with the effectiveness of the groundwater remedy by creating an aerobic condition within the treatment area that required an anaerobic condition.

7.3.2.4 Reduction of Toxicity, Mobility, or Volume through Treatment

The implementation of Alternatives V1 and V2 would not affect the toxicity, mobility, or volume of the contaminants through treatment. Alternatives V3 and V4 would both direct the flow of the contaminated vapor by creating a vacuum in the subsurface. Alternative V4 provides the most control of vapor mobility and will also reduce the volume of contaminated soil vapor.

7.3.2.5 Short-term Effectiveness

Alternative V1 would have no short-term impact to workers or the community, since no action would be performed. Alternative V2 would have minimal short-term impact to the community, since workers would only be on site for periodic sampling. Alternatives V3 and V4 would have the most, but still minimal, short-term impacts to the community and the environment due to the initial construction and ongoing operation the extraction systems. With Alternatives V3 and V4, risks to site workers posed by exposure to contaminants, heavy equipment, and treatment chemicals would be managed by implementation of a health and safety plan.

7.3.2.6 Implementability

Alternative V1 is easily implemented, since no services or permits would be required. Alternative V2 is easily implemented. Administrative requirements in obtaining institutional controls are minimal, and groundwater monitoring services are readily available. Alternatives V3 and V4 are both technically implementable. SSD, SVE, and AS are proven technologies, but pilot studies would be required for the proper design of the remedy.

7.3.2.7 Cost

A comparative summary table of the cost estimates for each alternative is shown below.

Alternative	**Present Value Cost**	**Capital Costs**	**Annual Costs**
V1 – No Action	$0	$0	$0
V2 – MNA	$710,000	$35,000	$38,000
V3 – IRM	$1,010,000	$548,000	$61,000
V4 – IRM/SVE	$1,280,000	$763,000	$84,000

Section 8
Recommended Remedy

This section recommends the final remedy for each environmental media.

8.1 Groundwater

The recommended alternative for groundwater is Alternative G3 – AS/SVE. As per NYSDEC direction during the FS scoping meeting on September 11, 2008, NYSDEC required soil vapor mitigation to prevent off-site migration of soil vapor contaminants onto the adjacent property by installing a SVE system. Therefore, in order to remove groundwater contamination, an AS system with SVE system is recommended. Although no current pathway exists for human exposure to the contaminated groundwater, the groundwater continues to act as a source to soil vapor and has the potential to impact human health and the environment in the future. For this reason, active remedy is recommended, and an AS/SVE was selected as the most effective and permanent remedy to remove and degrade groundwater contamination. Alternative G4 and G5 would be effective in removing and degrading groundwater contamination, but a SVE system would interfere with the effectiveness of these alternatives. Alternative G4 relies on anaerobic degradation and an SVE system would introduce oxygen creating aerobic conditions instead of anaerobic conditions. Alternative G5 requires injection of an oxidant which would create mounding in the area of treatment. Since the groundwater table interface is approximately 5 feet bgs, the shallow SVE horizontal pipelines may intercept the mounding groundwater table interface. Based upon NYSDEC's verbal requirements presented during the September 11, 2008 meeting, soil vapor would need mitigation to prevent off-site migration even if a groundwater remedy was implemented. Therefore, Alternative G3 was recommended as the groundwater remedy.

8.2 Soil Vapor

The recommended alternative for soil vapor is Alternative V3 – Interim Remedial Measure. Although the risk assessment indicates that there is no current risk to human health, it is desirable to provide a remedy that ensures that future risks will not develop. The IRM, by eliminating the potential for building occupants to be exposed to contaminated soil vapor, will prevent any future risks to human health. Since Alternative G3-AS/SVE was selected for the treatment of groundwater, this SVE system will already be incorporated into the final remedy and will also address the existing external soil vapor contaminants.

Section 9
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