Job No. 10653/35919

FINAL REPORT

Feasibility Study
Former Duso Chemical Site
Poughkeepsie, New York

New York State Department of Environmental Conservation Albany, New York

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1. Introduction

1.1. Purpose

The purpose of this report is to present the Feasibility Study (FS) for the former Duso Chemical facility located in Poughkeepsie, Dutchess County, New York. The site encompasses the former Duso Chemical property. Surrounding properties include the former railroad bed (Conrail property), the southeast portion of the Mid-Hudson Business Park (MHBP) property and other off-site areas. A site location map is provided as Figure 1. The Remedial Investigation/Feasibility Study (RI/FS) is being performed in accordance with the New York State Department of Environmental Conservation (NYSDEC) Superfund Work Assignment #D004090-19 (NYSDEC 2004).

The FS was also conducted in accordance with:

- the provisions of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) as amended by the Superfund Amendments and Reauthorization Act (SARA) (U.S. Code, Title 42, Chapter 103)
- the National Oil and Hazardous Substances Pollution Contingency Plan (Federal Register 1990)
- the NYSDEC Division of Environmental Remediation (DER) Technical Guidance for Site Investigation and Remediation (DER-10) (NYSDEC 2002)
- the NYSDEC DER Technical Guidance for Presumptive/Proven Remedial Technologies (DER-15) (NYSDEC 2007)
- the United Stated Environmental Protection Agency (USEPA) Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA (USEPA 1988)
- the NYSDEC revised Technical Administrative Guidance Memorandum (TAGM) #4030, Selection of Remedial Actions at Inactive Hazardous Waste Sites (NYSDEC 1990)
- the Remedial Investigation/Feasibility Study Work Plan (O'Brien & Gere 2005a).

1.2. Site Location and Description

The former Duso Chemical property is located at 33 Fulton Street, in Poughkeepsie, New York. The property is estimated to be approximately 3 acres in size and is currently operated by Star Gas Products, Inc., a propane distribution facility. The topography of the site and surrounding properties is relatively level, sloping gently to the west. A steep embankment borders the property to the east and a former railroad track bed and intermittent surface water border the property to the west.

The site is located within a mixed neighborhood of commercial establishments and private properties, with the MHBP property, a shopping center, to the west of the site. A site map is included as Figure 2.

1.3. Site History and Background

Sanborn records from 1950 through 1990 indicate that the property owner was Duso Chemical Company. A chemical fire occurred at the former Duso Chemical Company warehouse in 1963 (Chazen 1998). Migration of contaminants from the former Duso Chemical property, through the Conrail property, to the MHBP property likely took place following a sudden discharge of contaminants during the fire. During the early 1990s, the former Duso Chemical property was bought and became Star Gas Products, Inc.

From 1910 to 1917 FIAT of Poughkeepsie manufactured approximately 2000 automobiles at the MHBP property. Western Publishing began production at the property in 1935. By the 1950s the plant grew to nearly 400,000 square feet (sq. ft.). Operations at the facility included photography; lithography plate production; rotary and offset web printing operations; coating, gluing and binding operations; shipping and receiving; and general plant operations and maintenance. The facility used inks, dyes and solvents, which were transported to the facility by truck and tanker. Large items like roll paper and some ink products were transported to the facility by rail. Types of chemicals used at the facility, as identified by a former employee, included acetone, benzene, carbon tetrachloride, isopropyl alcohol, kerosene, Salvasol #5, trichloroethane (TCA), and trichloroethene (TCE). Some of these chemicals were reported to have been purchased from the Duso Chemical Company (Chazen 1998).

In association with the demolition of the 30 Fulton St. property, owned by Marist College Real Property Services, Inc., the abandoned railroad tracks at, to the north of, and to the south of the site were removed and a gravel was established in August 2005. The intermittent surface water and associated drainage patterns were disturbed during the excavation.

1.4 Summary of Remedial Investigation

A Remedial Investigation (RI) was performed in accordance with the State Superfund Work Assignment #D004090-19 (NYSDEC 2004) and the RI/FS Work Plan (O'Brien & Gere 2005a). The RI Report was developed by O'Brien and Gere (O'Brien & Gere 2007). Figure 2 identifies sample locations from the RI.

1.4.1. Objectives

The objectives of the RI were to:

- Collect data necessary to evaluate and characterize the nature and extent of site-related contaminants in ground water, soil, surface water, soil vapor, and indoor air.
- Evaluate potential exposure pathways between human receptors, fish and wildlife resources, and site-related contaminants.
- Gather data necessary for the development and evaluation of remedial alternatives during the FS for media of concern.

1.4.2. Geologic and Hydrogeologic Conditions

The geology in the vicinity of the site consists of three major unconsolidated geologic units. The uppermost unit is a brown fine sand and silt unit. This unit is underlain by a lower permeability gray silt and clay unit. Below the silt and clay unit is a coarse sand and gravel unit. All three unconsolidated units are continuous across the site and surrounding properties. The overburden ground water flow has two components. Ground water flow east of the site generally mimics topography and flows east to west until it is influenced by the intermittent surface water and subsurface utilities that are located on the Conrail property between the site and the MHBP property. The other component of overburden ground water flow travels in a southeastern direction across the MHBP property until it is also influenced by the intermittent surface water and underground utilities. The average hydraulic conductivity of the overburden is 1.44×10^{-3} cm/sec, or 4.09 ft/day. The average linear velocity of ground water flowing west is 0.483 ft/day, while the average linear velocity of ground water flowing southeast is 0.137 ft/day. Depth to ground water ranges from 5 to 12 feet below ground surface (bgs).

Bedrock is located directly under the coarse sand and gravel unit mentioned above. It dips approximately 30 degrees, and has abundant horizontal and vertical fractures. In the northern portion of the MHBP property, the bedrock dips uniformly in a south/southeastern direction, while in the southern portion of the site and MHBP property, the bedrock dips in a north/northwestern direction. Thus, the bedrock forms a trough with the shallowest portion under the northern portion of the site and the deepest portion under the southwestern side of the MHBP property. The average hydraulic conductivity of the bedrock is 8.94×10^{-4} cm/sec, or 2.53 ft/day, while the average linear velocity is 0.252 ft/day. Upward vertical gradients are present during high water conditions.

1.4.3. Nature and Extent of Contamination

Contamination at the site is generally limited to volatile organic compounds (VOCs) and metals. VOCs include 1,1,1-TCA and its breakdown products, and tetrachloroethene (PCE), TCE, and their breakdown products. Metals include antimony, arsenic, barium, beryllium, cadmium, chromium, cobalt, copper, cyanide, lead, mercury, nickel, selenium, thallium, vanadium, and zinc. Both VOCs and metals were detected at concentrations above standards and/or background conditions in ground water, surface water, and subsurface soil. However, the high concentrations of metals in ground water can be attributed to the high turbidity of the samples. VOCs were also detected in indoor air at concentrations that required mitigation at the Star Gas facility. No VOCs were detected in surface soil above soil cleanup objectives (SCOs), which may be because the area has likely been reworked and clean fill added during property redevelopment. However, there were several detected concentrations of metals and semi-volatile organic compounds (SVOCs) above SCOs and/or background concentrations.

Contamination is mostly limited to the site, the Conrail property, and the MHBP property; most contaminants were primarily found in the silty clay unit and above. The contaminants on the MHBP property probably migrated from the site as dense non-aqueous phase liquid (DNAPL) or in an aqueous phase due to the water flooding that likely occurred when fire suppression water was applied to the fire on-site. Following the release of chemicals during the fire, the migration pathway of the contaminants likely included overland runoff on-site and shallow to deep flow on the MHBP property, which most likely resulted in the contamination found there. Contaminants were also detected in shallow bedrock on the MHBP Property, but at concentrations much lower than in the overburden. There is no evidence that the VOCs in shallow bedrock migrated to other surrounding properties.

It is likely that natural attenuation is occurring at the site and surrounding properties. As indicated by the oxidation-reduction potential (ORP) and dissolved oxygen (DO) readings, reductive conditions are present at the site. Also, the detected concentrations of PCE, TCE, and 1,1,1-TCA breakdown products, in addition to the presence of chloride in ground water, indicate that dechlorination has occurred. The alkalinity and pH measured at the site and surrounding properties indicate that conditions are favorable for microbial growth, while detected concentrations of methane, ethane, and ethene imply that biodegradation is occurring in ground water across the site.

There are some downgradient off-site monitoring wells where concentrations of VOCs and metals were detected at significantly lower concentrations than were observed on-site and on the MHBP property. In these off-site wells, the concentrations of VOC breakdown products were higher than the parent VOCs concentrations. There were also detected concentrations of VOCs and metals in the surface water taken from the intermittent surface water. It is likely that ground water is flowing from the MHBP property, toward these wells, and then to the intermittent surface water off-site. Essentially, the contamination is located in the overburden on-site and on the MHBP property, and converges to the intermittent surface water off-site.

1.4.4. Chlorinated VOC Distribution in Ground Water

Both chlorinated ethenes and chlorinated ethanes have been detected in ground water beneath the site. DNAPL was observed in the field during historic investigations in 1995 at the MHBP property (MHC-29) at approximately 20 feet bgs. Analytical results of samples of the DNAPL showed 790,000 mg/L TCA; 24,000 mg/L dichloroethane (DCA); and 330,000 mg/L dichloroethene (DCE). DNAPL was not observed during subsequent sampling events.

The chlorinated ethenes are found primarily on the Duso property in the vicinity of MHC-27, MHC-22, MHC-26, MHC-23, and MHC-24. TCE; cis-1,2-DCE; 1,1-DCE; and vinyl chloride have consistently been detected at these locations at concentrations generally ranging from 0.1 to 1.6 mg/L (all wells were screened from 3 to 13 bgs). PCE has also been detected at MHC-22, MHC-23, and MHC-24 at concentrations ranging from 2-16 µg/L. Historically, chlorinated ethenes extended over to the MHPB property in the vicinity of MHBP-13S, but the latest round of data indicated non-detectable concentrations for TCE and breakdown products at that well.

The chlorinated ethanes were generally found on both the Duso property (near wells MHC-26 and MHC-23) and the MHBP property (near wells MHBP-11, MHC-29, MHBP-10, MHC-28, MHBP-8, MHBP-13S, and MHBP-12 and north to MHC-30). TCA, DCA, and chloroethane (CA) are found at these locations at concentrations ranging from 15 to 1,110 mg/L (wells generally screened at 5 to 15 or 10 to 20 bgs).

1.4.5. Chlorinated VOC Distribution in Soil

There were no detections of chlorinated VOCs in surface soil. The distribution of chlorinated VOCs in subsurface soil is described below.

1.4.5.1. Former Duso Property

Historically, concentrations of 1,1,1-TCA and its degradation products and PCE, TCE, and their degradation products were detected in soil on the former Duso Chemical property. The 1,1,1-TCA and degradation products were limited to the southwestern portion of the property, specifically immediately west of the current Star Gas office building. PCE, TCE and their degradation products were detected in the remaining samples collected from the property. Most of these samples were collected along the western edge of the property; the only sample along the eastern edge was collected from the installation of monitoring well MHC-25D.

At the former Duso property, VOC concentrations detected in saturated soil during Phase I of the RI were higher than the respective SCOs at five of the subsurface soil borings at depths ranging from 4 to 12 ft bgs. The maximum detected concentration of 1,1,1-TCA was 410 mg/kg at GP-9 (8 to 12 ft), while the maximum detected concentration of PCE was 24 mg/kg at GP-11 (4 to 8 ft). The soil samples collected from the former Duso Chemical property during Phase I varied at depth, and there was no clear correlation between contamination and depth. The Phase I soil samples were collected at depths below the water table. Therefore, it is unclear if detected contaminant concentrations are representative of the soil matrix, or if the detected concentrations can be attributed to the ground water in the sample, or both.

Unsaturated soil in the area to the north of the Star Gas office building was sampled during Phase II. Vinyl chloride was the only detected chlorinated VOC concentration above SCOs at the former Duso property at a concentration of 0.024 mg/kg at GP-25 (3 to 4 ft), located towards the center of the Site.

1.4.5.2. MHBP property

Historically, 1,1,1-TCA and its degradation products were detected from subsurface soil samples on the MHBP property. These samples were located on the western edge of the intermittent surface water that divides the two properties, and there was one sample that was located on the eastern edge of the current Staples building. Several of these subsurface soil samples were unsaturated; the main contamination was limited to the saturated subsurface soil samples.

At the MHBP Property, 1,1,1-TCA and 1,2-DCA were detected in five of the subsurface soil samples collected during Phase I at concentrations above their respective SCOs at depths ranging from 4 to 24 ft bgs. The maximum detected concentrations of 1,1-DCA and 1,2-DCA were 29 mg/kg and 15 mg/kg, respectively, at GP-16 (20 to 24 ft). The maximum detection of 1,1,1-TCA was 46 mg/kg in GP-19 (19 to 23 ft). Soil samples collected from the MHBP property during Phase I varied at depth, and there was no clear correlation between contamination and depth. The soil samples collected during Phase I were collected at depths below the water table. Therefore, it is unclear if detected contaminant concentrations are representative of the soil matrix, or if the detected concentrations can be attributed to the ground water in the sample, or both.

During Phase II, no unsaturated subsurface soil samples were collected on the MHBP property.

1.4.5.3. Other off-site properties

During Phase I of the RI, there were several detected concentrations of VOCs (1,1-DCA, 1,2-DCA, chloroethane, and cis-1,2-DCE) above SCOs. 1,1-DCA, 1,2-DCA, chloroethane, and cis-1,2-DCE were detected at 0.69 mg/kg (J), 0.1 mg/kg (J), 3.7 mg/kg, and 0.33 mg/kg (J), respectively, at the soil sample associated with OBG-11S (8 to 10 ft). The soil samples collected during Phase I were collected at depths below the water table. Since there would be no expectation of off-site subsurface soil contamination at this location (south of Fulton St.), it is likely that the detected concentrations can be attributed to the ground water in the sample. During Phase II, no subsurface soil borings were collected off-site.

1.5 Summary of Risk Assessments

As part of the RI, a qualitative exposure pathway analysis was performed for the site and surrounding properties to evaluate the potential risks to human health. A summary of the human exposure pathway analysis can be found in Section 1.5.1.

Also, an evaluation of the impacts to ecological receptors was performed by EcoLogic (2007) as part of the RI. A summary of the conclusions of the fish and wildlife impact analysis can be found in Section 1.5.2.

1.5.1. Human Health Exposure Pathway Analysis

Potentially complete exposure pathways identified in the RI included the following;

Current and Future On-site Exposure Pathways

- Ingestion and dermal contact of surface soil by adult construction, industrial, or maintenance worker or trespasser
- Ingestion and dermal contact of subsurface soil by adult construction worker
- Inhalation of airborne particles and vapors from surface soil on undeveloped areas of the site by adult construction, industrial, or maintenance worker or tresspasser
- Inhalation of airborne particles and vapors from subsurface soil by adult construction worker.
- Ingestion and dermal contact of ground water by adult construction worker
- Inhalation of ground water vapors from exposed ground water by adult construction worker
- Inhalation of ground water vapors due to vapor intrusion (VI) into closed space by adult industrial worker or office worker
- Ingestion and dermal contact of surface water by adult construction, industrial, or maintenance worker or tresspasser
- Inhalation of surface water vapors by adult construction, industrial, or maintenance worker or tresspasser.

Current and Future Potential Off-site Exposure Pathways

- Ingestion and dermal contact of ground water by adult construction worker
- Ingestion and dermal contact of ground water as potable water by adult industrial worker or office worker
- Ingestion and dermal contact of ground water as postable water by adult, adolescent, and child residents
  Inhalation of ground water vapors from open trenches/excavations by adult construction worker
  Inhalation of ground water vapors due to VI into closed spaces by adult industrial worker or office worker
- Ingestion and dermal contact of surface water by adult construction, industrial, or maintenance worker or trespasser
  Inhalation of surface water vapors by adult construction, industrial, or maintenance worker or trespasser.

1.5.2. Fish and Wildlife Impact Assessment
Conclusions of the FWIA of the site (EcoLogic 2007) are listed below.

- There are valuable wildlife resources within two miles of the site.
- Wildlife resources within a half-mile of the site are impacted by development, both residential and commercial.
- Wildlife likely to be found in developed areas may utilize the former railway bed that runs north to south along the western edge of the site as a travel corridor, since the railway traverses a forested area north of the site.
- Evidence of wildlife utilizing these areas was observed, including woodchuck burrows, animal bones, deer tracks, and other animal and bird sightings. This suggests complete pathways of exposure via surface water, surface soils, and subsurface soils.
- Concentrations of analytes detected in ground water, surface water, surface soils, and subsurface soils exceeded ecological screening values.

2. Development of Remedial Alternatives

The objective of this phase of the FS was to develop a range of remedial alternatives for the site. The process for development of alternatives consisted of six steps:

- identification of potential standards, criteria and guidance (SCGs)
- development of remedial action objectives (RAOs)
- identification of general response actions (GRAs)
- identification of areas or volumes of media
- identification, screening, and evaluation of remedial technologies and process options
- assembly of remedial alternatives.

2.1. Identification of Applicable Standards, Criteria, and Guidance (SCGs)

There are three types of SCGs: chemical-, location-, and action-specific SCGs. Chemical-specific SCGs are health- or risk-based numerical values or methodologies which, when applied to site-specific conditions, result in the establishment of numerical values. These values establish the acceptable amount or concentration of a chemical that may be found in, or discharged to the ambient environment. Location-specific SCGs set restrictions on activities based on the characteristics of the site or immediate environs. Action-specific SCGs set controls or restrictions on particular types of remedial actions once the remedial actions have been identified as part of a remedial alternative. The identification of potential SCGs is documented in Table 1.

2.2. Presumptive Remedies

NYSDEC identifies remedial technologies in *DER-15: Presumptive/Proven Remedial Technologies* (NYSDEC 2007). The presumptive remedies identified by NYSDEC are those that are have already been proven to be both feasible and cost-effective for specific site types and/or contaminants. Presumptive remedies identified for VOCs in ground water are extraction and treatment, air stripping, granular activated carbon (GAC), chemical/ultraviolet (UV) oxidation, separate phase recovery, air sparging, in-well air stripping, and bioremediation. Presumptive remedies identified for VOCs in vapor are soil vapor extraction (SVE), vapor mitigation system, vapor phase carbon adsorption, catalytic oxidation, and thermal oxidation. Presumptive remedies identified for VOCs in soil are SVE, thermal desorption, incineration, bioremediation, and excavation/off-site disposal. Several of these presumptive remedies were considered in the FS.

2.3. Physical and Technical Limits to Remediation

Site conditions limit the alternatives available for remediation of ground water at the site. Specifically, the following physical and hydrogeologic conditions limit the technical practicability of ground water remediation technologies at this site:

- Chlorinated VOC concentrations in site ground water suggest the presence of DNAPL or residual source material. Although DNAPL was observed historically, none was identified as part of the RI. The location of DNAPL or residual source material is therefore unknown.
- Soil exceedances on the former Duso property may not be completely accessible due to the presence of occupied buildings.
- Although *in situ* technologies can be used to reduce concentrations of the source material, they

have not demonstrated the ability to remediate sources to meet ground water standards (Fountain 1998; ITRC 2002; and USEPA 2004).

Under NYSDEC environmental regulations (6 NYCRR 375-1.8 (f) (2) (i) a-d), conformity with an SCG can be dispensed with if a good cause such as any of the following exists:

The proposed action is only part of a complete program that will conform to such standard or criterion upon completion.

- Conformity with such standard or criterion will result in greater risk to the public health or to the environment than alternatives.
- Conformity with such standard or criterion is technically impracticable from an engineering perspective.
- The program will maintain a level of performance that is equivalent to that required by the standard or criterion through the use of another method or approach.

2.4. Development of Remedial Action Objectives (RAOs)

RAOs are goals set for environmental media, such as soil, ground water, surface water, and soil vapor/indoor air, that are intended to provide protection for human health and the environment. RAOs form the basis for the FS by providing overall goals for site remediation. The RAOs are considered during the identification of appropriate remedial technologies and formulation of alternatives for the site, and later during the evaluation of remedial alternatives.

RAOs are based on engineering judgement, risk-based information established in the risk assessment, and potentially applicable or relevant and appropriate SCGs. Documentation of the rationale employed in the development of the RAOs for the site is presented in the following sections.

2.4.1. RAOs for Soil

Potentially complete exposure pathways related to soil at the site are:

Human health

- Ingestion and dermal contact of surface soil by adult construction, industrial, or maintenance worker or trespasser
- Ingestion and dermal contact of subsurface soil by adult construction worker
  Inhalation of airborne particles and vapors from surface soil on undeveloped areas of the site by adult construction, industrial, or maintenance worker or trespasser
- Inhalation of airborne particles and vapors from subsurface soil by adult construction worker.

Ecological

- Potentially complete exposure pathways for wildlife and plants likely exist in surface soil and subsurface soil on-site.

In December 2006, NYSDEC promulgated SCOs in 6 NYCRR Part 375-6 for various site uses. The SCOs in 6 NYCRR Part 375-6, which are potential SCGs for the site, are:

- restricted use SCOs for the protection of public health, commercial use (6 NYCRR Part 375-6.8(b))
- restricted use SCOs for the protection of ecological resources (6 NYCRR Part 375-6.8(b))
- restricted use SCOs for the protection of ground water (6 NYCRR Part 375-6.8(b))
- unrestricted use SCOs (6 NYCRR Part 375-6.8(a)).

Comparison to unrestricted use SCOs was required for the purpose of evaluating restoration to pre-disposal conditions.

Based on the potential exposure pathways and comparison to SCGs, the following RAOs were developed for soil:

- Minimize, to the extent practicable, unacceptable human health risks associated with on-site (former Duso property) surface soil and subsurface soil and off-site (MHBP property) subsurface soil
- Minimize, to the extent practicable, unacceptable human health and ecological risks associated with surface soil in the former railroad bed area.

It is anticipated that the former railroad bed trail area will be paved, thereby addressing potential unacceptable human health and ecological risks associated with surface soil.

2.4.2. RAOs for Ground Water

Analytical results indicate the presence of site-related constituents in samples collected from both on-site and off-site ground water monitoring wells. Potentially complete exposure pathways related to ground water at the site, the MHBP property, and other off-site areas are:

Human health

- Current and future ingestion and dermal contact of on-site and off-site ground water by adult construction worker
- Current and future inhalation of ground water vapors from exposed on-site and off-site ground water by adult construction worker
- Current and future inhalation of on-site and off-site ground water vapors due to VI into closed space by adult industrial worker or office worker
- Future ingestion and dermal contact of on-site or off-site ground water as potable water by adult industrial worker, office worker, or adult, adolescent, and child residents.

Ecological

- A potentially complete exposure pathway for wildlife likely exists where ground water expresses itself as surface water at the site.

The NYS Class GA ground water standards are identified as a potential SCG. Exceedances of the NYS Class GA ground water standards for site related contaminants of concern (COCs) were observed both on-site and off-site. It is noted that the Town of Poughkeepsie provides a water supply for potable water use, and ground water in the area is not relied upon for this purpose.

Based on the potential exposure pathways and comparison to SCGs, the following RAOs were developed for ground water:

- Minimize off-site migration of ground water in exceedence of ground water standards or guidance values to the extent practicable.
- Minimize migration of ground water to surface water runoff at concentrations which present an unacceptable risk to human and/or ecological receptors.
- Minimize, to the extent practicable, unacceptable human health risks associated with on-site and off-site ground water.

2.4.3. RAOs for Surface Water

Analytical results indicate the presence of site-related constituents in samples collected from off-site surface water sample locations. Potentially complete exposure pathways related to surface water are:

Human health

- Ingestion and dermal contact of surface water by adult construction, industrial, or maintenance worker or trespasser
- Inhalation of surface water vapors by adult construction, industrial, or maintenance.

Ecological

- Evidence of wildlife use suggests complete pathways of exposure via surface water.

The NYS Class D surface water standards are identified as a potential SCG. Exceedances of the NYS Class D surface water standards for site related contaminants of concern (COCs) were observed. It is noted that the Town of Poughkeepsie provides a water supply for potable water use, and surface water in the area is not relied upon for this purpose.

Based on the potential exposure pathways and comparison to SCGs, the following RAOs were developed for surface water:

- Minimize, to the extent practicable, unacceptable human health risks associated with surface water.
  Minimize, to the extent practicable, unacceptable ecological risks associated with surface water.

2.4.4. RAOs for Indoor Air

Potentially complete exposure pathways related to indoor air at the site are:

Human health

- Current and future inhalation of on-site ground water vapors due to VI into closed space by adult industrial worker or office worker (Star Gas mitigation system in place)
- Current inhalation of ground water vapors due to off-site VI into closed space by adult industrial worker or office worker
- Future inhalation of ground water vapors due to off-site VI into closed space by adult industrial worker, office worker, and adult, adolescent, and child residents.

NYSDOH guidelines for evaluating VI are summarized *in Guidance for Evaluating Soil Vapor Intrusion in the State of New York* (NYSDOH 2006), which is an SCG. Based on detected concentrations of VOCs from the sub-slab and indoor air at the Star Gas Facility and the NYSDOH air decision matrices, VI mitigation was necessary. A sub-slab depressurization system was installed in February 2006 as an interim remedial measure (IRM) to decrease the concentrations of TCE and PCE in the air. After this system was installed, post mitigation confirmation air sampling showed that the system is effective in reducing the concentrations of VOCs detected in this structure, and that concentrations of both contaminants had decreased significantly. The approved IRM Work Plan (O'Brien & Gere 2005b) required a maintenance inspection be performed within 18 months of system commission. This inspection was performed in early September 2007 and indicated continued effective system operation.

VOCs were detected in sub-slab and indoor air samples collected at both the abandoned building and Staples, both located on the MHBP property. Carbon tetrachloride, PCE, TCE and 1,1,1-TCA were detected at concentrations below which mitigation would be recommended, based upon the NYSDOH air decision matrices.

Based on the potential exposure pathways and comparison to SCGs, the following RAOs were developed for indoor air:

- Achieve, to the extent practicable, conformance with the NYSDOH VI guidance for the Star Gas property.
  Minimize, to the extent practicable, inhalation exposures of on-site indoor air that would result in unacceptable health risks.

2.5. Identification of General Response Actions (GRAs)

GRAs are medium-specific actions that may be combined into alternatives to satisfy the RAOs. The GRA related to indoor air and surface water is institutional controls. The GRAs related to the soil are institutional controls, *in situ* treatment, containment, removal, *ex situ* treatment, and disposal. The GRAs related to the ground water are institutional controls, containment, collection, collection enhancement, *in situ* treatment, *ex situ* treatment, and discharge. GRAs applicable to the site are included in Table 2.

2.6. Identification of Areas and Volumes of Media

Site conditions, the nature and extent of contamination, and RAOs were taken into consideration to estimate the volumes and areas of media to be addressed by the GRAs.

Based upon the data presented in the RI Report, it was estimated that approximately 1,300 cubic yards (cu. yd.) of unsaturated soil over an approximate 6,100 sq. ft. area at the Former Duso Facility exceed VOC and metal SCOs for unrestricted use in 6 NYCRR Part 375.6.8(a). Of this area and volume, approximately 300 cu. yd. over an approximate 1,400 sq. ft. area is located under a building and is inaccessible for excavation.

Soil on a portion of the MHBP property (approximately 3,700 sq. ft) exceeds Part 375 restricted use SCOs for the protection of ground water. Based on data from the RI, depth of contamination extends to at least 24 ft bgs.

In the RI Report, it was estimated that the extent of VOCs in ground water in excess of Class GA standards is an approximately 91,500 sq. ft. area and includes portions of the former Duso Chemical property, the Conrail property, and the MHBP property. VOCs in excess of Class GA standards are present at screen depths ranging from 3 to 48 ft bgs. Based on historic and RI observations, DNAPL or residual source material may be present at the MHBP property. For the purposes of this evaluation, DNAPL and residual source material are assumed to not be present at the former Duso Chemical property.

It is anticipated that the former railroad bed area will be paved, thereby addressing potential unacceptable human health and ecological risks associated with surface soil in that area. Therefore, the former railroad bed area is not addressed in the FS.

2.7. Identification and Screening of Remedial Technologies and Process Options

Potentially applicable remedial technology types and process options for each GRA were identified during this step. Process options were screened on the basis of technical implementability. The technical implementability of each identified process option was evaluated with respect to site contaminant information, site physical characteristics, and areas and volumes of affected media.

Descriptions and screening comments for technologies and process options identified for the site are presented in Table 2. Process options that were viewed as not implementable for the site were not considered further in the FS. Following are descriptions of technologies that were considered potentially implementable for the site.

2.7.1. Indoor Air

No action. The no action GRA must be considered in the FS, as specified in the NYSDEC Draft DER-10, *Technical Guidance for Site Investigation and Remediation* (2002).

Institutional controls. An environmental easement and a site management plan were identified as the potentially implementable remedial technologies associated with the institutional GRA for indoor air.

- **Environmental easement.** An environmental easement would be recorded for the Star Gas property documenting building use restrictions. Restrictions would preclude the use of a building influenced by VI unless the building is proven to be in compliance with recommendations set forth in applicable guidance. Compliance status would be subject to review and approval by NYSDOH.

- **Site management plan.** A site management plan would be developed to describe the environmental easement and provide for continued operation and maintenance (O&M) of IRM components. The site management plan would also present the requirement for periodic inspection of the IRM system.

2.7.2. Surface Water

No action. The no action GRA must be considered in the FS, as specified in the NYSDEC Draft DER-10 (2002).

Institutional controls. An environmental easement and a site management plan were identified as the potentially implementable remedial technologies associated with the institutional GRA for surface water.

- **Environmental easement.** An environmental easement would be recorded for the impacted properties documenting surface water use restrictions. Restrictions would preclude the use of surface water without prior review and approval by NYSDEC.

- **Site management plan.** A site management plan would be developed to describe the environmental easement and provide for continued operation and monitoring of its components. The site management plan would also include a provision for periodic site reviews.

2.7.3. Soil

No action. The no action GRA must be considered in the FS, as specified in the NYSDEC Draft DER-10 (2002).

Institutional controls. An environmental easement and a site management plan were identified as the potentially implementable remedial technologies associated with the institutional GRA for soil.

- **Environmental easement.** An environmental easement would be recorded for the property documenting land use restrictions precluding activities that would potentially expose contaminated materials (and require health and safety precautions) without prior review and approval by NYSDEC.

- **Site management plan.** A site management plan would be developed to describe the environmental easement and provide for continued O&M of remedy components. The site management plan would also include a provision for periodic site reviews.

In situ treatment. Physical and thermal *in situ* treatment technologies were considered for the site and the MHBP property. Potentially applicable process options are described as follows.

- **Soil vapor extraction (SVE).** SVE involves removal of VOCs in the unsaturated zone. The soil is decontaminated in place by pulling air through the soil. Air removed from the soil by an extraction vent and vacuum blower may be resupplied passively via infiltration from the surface, or through injection vents, either passively or by pumping. The air flow displaces the soil gas, disrupting the equilibrium existing between VOCs that are (1) sorbed on the soil, (2) dissolved in soil-pore water, (3) present in a separate hydrocarbon phase, and (4) present as vapor. This air causes volatilization and subsequent removal of the contaminants in the air stream. Depending on the flow rate, contaminant type and concentration, as well as federal, state, and local environmental regulations, the extracted gas stream may be discharged directly to the atmosphere or sent to an emissions-control device. For application at the site, where the majority of VOCs have been detected in the saturated zone, SVE could be used in conjunction with another technology for treatment of soil and/or ground water in the saturated zone.

- **Multi-phase extraction (MPE).** MPE wells remove ground water and soil vapor, and in some cases, free product that is present, simultaneously. A pumping test would be required to identify appropriate locations to place the extraction wells and evaluate appropriate pumping rates for maximum contaminant removal. MPE would likely be an effective treatment technology for site-related VOCs.

- **Electrical resistance heating.** This method would heat the aquifer using six-phase alternating current connected to an array of electrodes placed in vertical wells. A neutral electrode would be placed at the center of the array. A contaminant-laden steam would be generated *in situ* and would be drawn to vapor extraction wells for subsequent treatment. The addition of heat to the subsurface would increase the transfer of VOCs and residual DNAPL, if present, to the gas phase by lowering the viscosity and increasing the vapor pressure of the contaminants, thereby increasing mobility.

- **Steam injection and extraction.** Steam injection is a thermal process that could be used to volatilize and mobilize the organic contaminants. Steam would be injected in injection wells at the boiling point of water under the depth being treated. Condensed steam plus contaminant would be recovered at the extraction wells. The addition of heat to the subsurface would increase the transfer of VOCs and residual DNAPL, if present, to the gas phase by lowering the viscosity and increasing the vapor pressure of the contaminants, thereby increasing mobility.

- **Conductive heating.** Conductive heating uses an array of vertical heater/heater-vacuum wells to heat the surrounding soil by thermal conductance. Heat propagates in a cylindrical fashion from the well outward and the heating is fairly even through all types of soil. Vacuum wells contain the same steel pipe and heating element components as a standard heater well, but are placed within a larger screened well to which a vacuum can be applied for recovery of vapors. Depending on the flow rate, contaminant type and concentration, as well as federal, state, and local environmental regulations, the extracted gas stream may be discharged directly to the atmosphere or sent to an emissions-control device. The addition of heat to the subsurface would increase the transfer of VOCs and residual DNAPL, if present, to the gas phase by lowering the viscosity and increasing the vapor pressure of the contaminants, thereby increasing mobility.

- ***In situ* vitrification (ISV).** ISV is a thermal process that transforms the chemical and physical characteristics of soil in place such that it becomes a glassy solid matrix, which is resistant to leaching. Soil reaction time is allowed. Dewatering activities must be employed for effective treatment of soil with high moisture content. The addition of heat to the subsurface would increase the transfer of VOCs and residual DNAPL, if present, to the gas phase by lowering the viscosity and increasing the vapor pressure of the contaminants, thereby increasing mobility.

Containment. Capping was identified as the remedial technology associated with the containment GRA. The process options considered potentially applicable are described below.

- **Soil cover**. A soil cover would consist of a layer of soil and vegetation to minimize contact with contaminated soil.

- **Low permeability cover**. A low permeability cover would include layers of low permeability material (*i.e.*, low permeable soils or geocomposites) to minimize infiltration and vegetative cover material to minimize contact with contaminated soil.

Removal. Excavation was identified as the remedial technology associated with the removal GRA.

- **Excavation.** Construction equipment, such as backhoes or excavators, would be used to remove contaminated soil.

Ex situ treatment. Thermal biological, and physical treatment were identified as the remedial technologies associated with the *ex situ* treatment GRA. The process options considered potentially applicable are described below.

- **Low temperature thermal desorption (LTTD).** LTTD is an *ex situ* process that uses either direct or indirect heat exchange to volatilize organic contaminants from soil. Thermal desorption is a physical separation (volume reduction) process and not an organic decomposition (incineration) process. Operating temperatures are in the 200 to 1000 degrees Fahrenheit range. The relatively low operating temperatures tend to make thermal desorption less energy intensive and thus, less costly, than incineration. The primary technical factors affecting thermal desorption performance are the contaminant concentration, the maximum soil temperature achieved, total soil residence time, and soil moisture content. The volatilized contaminants from the thermal desorption process are typically directed to a secondary system for incineration (*i.e.*, an afterburner), adsorption on activated carbon, or recovery by condensation. If the volatilized contaminants are incinerated, an air emissions control system is employed to remove acid gases and particulates in the exhaust gas. Thermal desorption would likely treat site-related VOCs.

- **Incineration.** Incineration is a thermal destruction treatment method which uses high temperature oxidation under controlled conditions to combust organic substances into products that generally include carbon dioxide (CO_2), water vapor, sulfur dioxide (SO_2), nitrogen oxides (NO_x), hydrochloric acid (HCl), and ash. Products of thermal destruction/incineration such as particulates, SO_2, NO_x, HC1, and products of incomplete combustion require air pollution control equipment to prevent release of undesirable species into the atmosphere. Ash disposal is also required. Incineration methods can be used to effectively destroy VOCs in soil. Inorganic constituents would be contained in the ash, which may require stabilization prior to disposal.

- **Anaerobic biocells.** In this process, naturally occurring microorganisms are stimulated to degrade organic contaminants in excavated soil in a constructed biocell. Soil would likely be amended with substrates and bacteria to enhance the process. This innovative technology allows the microorganisms to reduce the contaminant into a less toxic constituent.

- **Soil vapor extraction.** Excavated soils are placed on a network of aboveground piping to which a vacuum is applied to encourage volatilization of organics. Soil piles are generally covered with a geomembrane to prevent volatile emissions and to prevent the soil from becoming saturated by precipitation. The process would include a system for handling off-gases.

Disposal. Land disposal was identified as the remedial technology associated with the disposal general response action. The process option considered potentially applicable is described below.

- **Off-site commercial landfill.** Excavated soil would be transported off-site and disposed of at a commercial landfill.

2.7.4. Ground Water

No action. The no action GRA must be considered in the FS, as specified in the NYSDEC Draft DER-10 (2002).

Institutional controls. Monitoring and an environmental easement were identified as the potentially implementable remedial technologies associated with the institutional GRA for ground water.

- **Monitoring.** Ground water monitoring would involve periodic sampling and analysis of ground water. Ground water monitoring would provide a means of detecting changes in constituent concentrations in the ground water.

- **Environmental easement.** An environmental easement would be recorded for the impacted properties documenting ground water use restrictions. Restrictions would preclude the use of ground water at, and adjacent to, the site as a potable source of water without proper treatment activities and would preclude activities which could expose contaminated ground water (and require health and safety precautions) without prior review and approval by NYSDEC.

- **Site management plan.** A site management plan would be developed to describe the environmental easement and provide for continued O&M of remedy components. The site management plan would also present the requirements for periodic sampling and analysis of ground water to detect changes in constituent concentrations, as well as include a provision for periodic site reviews.

Collection. Ground water extraction was identified as the potentially implementable remedial technology associated with the collection GRA for ground water. The process options are described below.

- **Recovery wells.** Contaminated ground water would be collected by pumping from extraction wells. An aquifer performance test would be required to identify optimum locations for extraction wells and evaluate appropriate pumping rates to remove the contaminated ground water plume.

  Recovery trench. Recovery trenches are buried conduits that would intercept and/or collect ground water. Recovery trenches are installed perpendicular to ground water flow and generally consist of pipe drains, gravel, backfill material and low permeability membranes on the downgradient side. Excavation of an interceptor trench requires the use of construction equipment (*i.e.*, front end loader or backhoe). Temporary sheet piling and dewatering would likely be required.

- **Multi-phase extraction (MPE).** MPE wells remove ground water and soil vapor, and in some cases, free product that is present, simultaneously. A pumping test would be required to identify appropriate locations to place the extraction wells and evaluate appropriate pumping rates for maximum contaminant removal. MPE would likely be an effective treatment technology for site-related VOCs.

Collection enhancement. Chemical enhancement was identified as the potentially implementable technology associated with collection enhancement.

- **Surfactant/cosolvent flushing enhancement.** Surfactant/cosolvent flushing would involve the injection, and subsequent extraction, of surfactants or cosolvents into a contaminated aquifer. The injected solution would interact with the contaminants by lowering the interfacial tension between DNAPLs in the aqueous phase and/or enhancing contaminant solubility. The flushing or flooding could be utilized to remove contaminants by mobilizing or solubilizing the DNAPL, so that it could be more readily extracted with the ground water.

In situ treatment. Physical, chemical, and biological treatment were identified as the potentially implementable remedial technologies associated with the *in situ* treatment GRA for ground water. The potentially implementable process options are described below.

- **Air sparging.** Air sparging is an *in situ* technology used primarily to treat VOCs in the saturated zone. Air sparging, when used in conjunction with a SVE system, enables ground water to be stripped of VOCs. Contaminant-free air is introduced into the affected aquifer system in the form of minute bubbles utilizing microporous bubblers (or sparge points). VOCs below the water table are removed by volatilization, and often, biodegradation, as the air percolates through the water column and into the unsaturated zone. The movement of the air bubbles tends to facilitate the transfer of VOCs into soil pore spaces in the unsaturated zone where they can be removed by a SVE system.

- **In-well air stripping.** In-well air stripping involves the injection of air into the water column to volatilize constituents. Air injected into the bottom of the well casing establishes a ground water circulation cell within the well, with ground water entering the well at one screen and being discharged through a second screen. The recirculation cell continuously draws ground water into the well such that contaminants can be stripped from the aqueous to gaseous phase. Treated ground water is discharged back to the aquifer. Depending on the resulting characteristics of the effluent air stream, air pollution controls may be required.

- **Monitored natural attenuation (MNA).** MNA relies on the naturally occurring *in situ* biotic and abiotic processes to degrade organic constituents in the saturated zone. Baseline and ongoing monitoring is required to evaluate the effectiveness of this process option.

- **Enhanced bioremediation**. For a chlorinated solvent site, enhanced *in situ* biodegradation (EISB) would supplement natural attenuation by enhancing conditions in ground water to promote contaminant biodegredation, subsequently minimizing contaminant migration and accelerating contaminant mass removal. Electron donors, nutrients and/or beneficial microorganisms would be added to the subsurface to facilitate the anaerobic dechlorination of COCs. They are injected by wells to the required depth. The basic requirements for successful enhanced bioremediation implementation would include: appropriate subsurface geochemical conditions, sufficient nutrient dose, a capable microbial population and the effectiveness of delivering electron donors, nutrients, and/or beneficial microorganisms to the impacted ground water.

- **Chemical oxidation.** *In situ* chemical oxidation (ISCO) would involve the injection of oxidants, such as permanganate, hydrogen peroxide, sodium persulfide and/or ozone, directly into the contaminant source zone and downgradient plume. For chlorinated VOCs, the oxidants would react with the contaminants to eventually form neutral by-products including inorganic chloride. ISCO would involve a reaction between the applied oxidant and the target contaminant. Successful ISCO treatment, therefore, would be a function of the effectiveness of delivering oxidants to the impacted ground water and the subsequent transport of the oxidant within the aquifer to further treat contaminants not initially reacted.

- **Permeable reactive barrier (PRB).** A PRB would be a subsurface treatment wall constructed of reactive material for treatment of chlorinated VOCs within ground water. Zero valent iron (ZVI) is a widely used reactive material for the treatment of chlorinated VOCs, which are dechlorinated when they are oxidized by the ZVI as ground water flows through the wall area, however, other reactive media, such as activated carbon, surfactant-modified zeolites, and biological materials may also be used. PRBs are typically suitable for long-term treatment and control of contaminated ground water, but are limited to depths achievable by conventional trenching equipment, unless injection techniques, such as vertical hydrofracturing, are utilized. PRBs are an innovative technology that offer a passive alternative to conventional pump and treat systems for addressing long term ground water contamination problems.

Ex situ treatment actions. The remedial technologies that were identified for the site, related to the *ex situ* treatment general response action for ground water, were physical, chemical, and biological treatment. The potentially implementable process options considered applicable are described below.

- **Air stripping**. Air stripping involves the contact of ground water with air in a countercurrent packed column, tray, or bulk reactor to transfer VOCs from the ground water to the air. Depending on the resulting characteristics of the effluent air stream, air pollution controls may be required.

- **Carbon adsorption**. Activated carbon can readily adsorb organic contaminants from ground water onto its surfaces during contact. The carbon must be periodically replaced, regenerated, treated, and/or disposed. Spent carbon would be regenerated or disposed of off-site at a permitted commercial hazardous waste facility.

- **Adsorptive resin.** Commercial resins are available which can adsorb organic contaminants from the ground water during contact. Such resins are typically regenerated on-site on a periodic basis.

- **Settling.** Settling would involve pumping of ground water into a holding tank to settle solids, if present, in the extracted ground water. Separation of solids from ground water improves the effectiveness of subsequent treatment. Solids would be transported off-site for treatment and/or disposal at a permitted commercial hazardous waste facility.

  Filtration. Filtration would involve the separation of solids and liquids using a semipermeable filter medium.

- **Chemical/ultraviolet (UV) oxidation**. Chemical oxidation involves the addition of an oxidation agent, such as hydrogen peroxide, permanganate, or ozone, to the ground water to oxidize organic contaminants to non-toxic byproducts. UV light is often used in conjunction with oxidants to promote faster and more complete destruction of organic compounds. Chemical oxidation is typically performed in a closed reactor system.

- **Precipitation.** Precipitation is a chemical treatment technology, which alters the pH of ground water in order to separate contaminants from the water particles. This technology would effectively remove site-related inorganic constituents from the ground water stream. The precipitate residue would require further management.

- **Ion exchange.** Ion exchange is a chemical treatment technology for ground water. Contaminants, particularly heavy metals, would be chemically altered on a molecular level into non-hazardous material.

- **Biological reactor**. A biological reactor could be used to enhance conditions for co-metabolic degradation of chlorinated organics. Nutrients, cometabolities, and aeration would be provided as necessary to optimize degradation. Sludge management would be required.

Discharge. The discharge process options considered applicable are presented below:

- **Discharge to surface water.** Extracted and treated ground water would be discharged to surface water pursuant to a State Pollutant Discharge Elimination System (SPDES) permit.

- **Discharge to Publicly Owned Treatment Works (POTW) facility.** Extracted and treated ground water would be released to municipal sanitary sewers, ultimately treated and discharged by a municipal treatment plant pursuant to a POTW discharge permit.

- **Discharge to storm sewer.** Extracted and treated ground water would be discharged to the storm sewer pursuant to a SPDES permit.

- **Discharge to ground water.** Extracted and treated ground water would be re-injected to the aquifer pursuant to a reinjection permit.

2.8. Evaluation of Remedial Technologies

The process options remaining after the initial screening were evaluated further according to the criteria of effectiveness, implementability, and cost. The effectiveness criterion included the evaluation of potential effectiveness of the process options in meeting remedial objectives and handling the estimated volumes or areas of media; potential effects on human health and the environment during construction and implementation; and experience and reliability of the process options for site contaminants and conditions. Technical and institutional aspects of implementing the process options were assessed for the implementability criterion. The capital and O&M costs of each process option were evaluated as to whether they were high, medium, or low relative to the other process options of the same technology type.

Based on the evaluation, the more favorable process options of each technology type were chosen as representative process options. The selection of representative process options simplifies the assembly and evaluation of alternatives, but does not eliminate other process options. The process option actually used to implement remediation may not be selected until the remedial design phase. A summary of the evaluation of process options and selected representative process options is presented in Table 3. Representative process options are marked with an asterisk.

2.9. Assembly of Remedial Alternatives

Remedial alternatives were developed by assembling GRAs and representative process options into combinations that address the site. Four alternatives were developed for the site. A summary of the alternatives and their components is presented in Table 4. A description of each alternative is included in the following subsections.

2.9.1. Alternative 1 – No Action

Alternative 1 is the no action alternative. The no action alternative is required by NYSDEC Draft DER-10 (2002) and serves as a benchmark for the evaluation of action alternatives. This alternative provides for an assessment of the environmental conditions if no active remedial actions are implemented.

2.9.2. Common Components of Alternatives

An environmental easement, a site management plan, and ground water monitoring are common elements to the remaining alternatives being evaluated for the site. A description of these elements is included below.

Environmental easement. An environmental easement would consist of land use, ground water, surface water, and building use restrictions for the contaminated properties. Land use restrictions would restrict activities that could result in unacceptable exposure to contaminated soil. Ground water and surface water use restrictions would preclude the use of ground water and surface water without prior notification and approval from NYSDEC. Building use restrictions would preclude building uses and site activities that result in unacceptable exposures to contaminated vapors. An environmental easement would also include requirements that remediation systems be operated, maintained, and monitored to maintain protectiveness.

Site management plan. A site management plan would guide future activities at the site by addressing use restrictions and by developing requirements for periodic site management reviews and ground water monitoring. The periodic site management reviews would focus on evaluating the on-site and off-site conditions with regard to the continuing protection of human health and the environment as evidenced by information such as ground water monitoring and documentation of field inspections.

Ground water monitoring. Ground water monitoring would be implemented to track COC concentrations in ground water both on-site and off-site and would be instrumental in detecting changes in concentrations. Ground water monitoring would consist of sampling approximately nineteen wells with analyses for VOCs using USEPA SW-846 Methods 8021 or 8260. Table 5 provides a summary of the sampling locations (monitoring well identification numbers) and the corresponding sampling frequency.

2.9.3. Alternative 2 –Monitored Natural Attenuation (MNA)

Alternative 2 consists of an environmental easement, site management plan, and MNA of VOCs in ground water.

The premise of an MNA alternative is to demonstrate with periodic ground water monitoring that natural conditions are decreasing VOC concentrations via physical, chemical, and biological processes. Natural attenuation processes include advection, dispersion, sorption, dilution, volatilization, biodegradation, and chemical stabilization, transformation, or destruction. Much of the current focus of MNA programs is on biodegradation although it is only one of the processes. Evaluation of MNA parameters analyzed during the RI shows evidence to support that subsurface conditions conducive to reductive dechlorination of contaminants exist at the site. A summary of the evaluation follows:

- Concentrations of ethane and ethene, daughter products of the site COCs, were detected in source area and downgradient wells.
- Field measurements of DO concentrations in source area wells were lower than concentrations measured at upgradient wells. The concentrations were less than 0.5 mg/l in source area wells, which indicate oxygen deficient concentrations that allow for reductive dechlorination.
- Chloride concentrations detected in the most highly contaminated source area well, MHC-29, are two to three times the detected chloride concentrations in the upgradient well, indicating that reductive dechlorination has occurred.
- The ORP of ground water is a measure of electron activity and is an indicator of the relative tendency of a solution to accept or transfer electrons. The ORP readings at source area wells ranged from -15 to –153 mV, indicating that reducing conditions are probable.
- Methane was detected in source area wells at concentrations from 0.0045 to 1 mg/L. The presence of methane in ground water is indicative of reducing conditions.
- The range of alkalinity, from 98 mg/L to 570 mg/L, and pH, from 6.2 to 7.8, indicate conditions, which are conducive to microbial growth.

MNA would initially comprise a quarterly ground water monitoring program to collect spatial and temporal VOC and MNA data from approximately twelve existing monitoring wells. Ground water samples would be analyzed for redox field parameters (ORP, DO, and ferrous iron); VOCs and associated daughter products; dissolved hydrocarbon gases (methane, ethane, and ethene); standard anion redox indicators (*e.g.*, nitrate, nitrite, sulfate, and sulfide); dissolved hydrogen; alkalinity; pH, temperature, and conductivity; chloride; and, potentially, quantitative polymerase chain reaction (qPCR). Quarterly monitoring for these parameters would proceed for a minimum of one year to establish ground water quality data and to estimate a VOC attenuation rate. Semi-annual sampling would be implemented after the requisite baseline data was attained.

Given the concentrations of on-site and off-site contaminants in ground water and the potential presence of DNAPL or residual source material, it would likely take more than 30 years to reach NYSDEC Class GA ground water standards using monitored natural attenuation. This alternative relies on natural attenuation to control plume migration.

2.9.4. Alternative 3 – *In Situ* Treatment Technologies
Two *in situ* treatment technologies were considered for the FS. The first consisted of *in situ* treatment via enhanced *in situ* biodegradation (EISB). The second consisted of *in situ* treatment via EISB and *in situ* thermal conduction.

2.9.4.1. Alternative 3a – *In Situ* Biological Treatment
Alternative 3a consists of an environmental easement, site management plan, ground water monitoring, and *in situ* biological treatment of ground water via EISB.

EISB involves creating and/or optimizing ground water geochemical conditions required for the microorganisms that facilitate the biodegradation reactions. This is achieved through the subsurface injection of carbon-based electron donors, nutrients (biostimulation) and/or bacterial consortia (bioaugmentation).

The degradation of TCA can occur via reductive dechlorination or abiotic transformation. The reductive dechlorination process is mediated by microorganisms that release hydrogen, which replaces the chlorine on a chlorinated organic compound molecule. These microorganisms are termed halorespiring bacteria. In the reductive dechlorination reaction, TCA is sequentially dechlorinated to 1,1-DCA, chloroethane, and sometimes ethane (Mohn and Tiedje 1992). Chloroethane has been observed to be the dominant end product of TCA degradation in most laboratory and field studies (Fogel 2005). Abiotic transformation of TCA also occurs regardless of redox conditions. TCA can be hydrolyzed (abiotically) to acetic acid or 1,1-DCE in an elimination reaction, which removes a single chloride.

The predominant biodegradation reaction of chlorinated ethenes is reductive dechlorination. Under reducing conditions, PCE serves as an electron acceptor and is dechlorinated sequentially to TCE, cis-1,2-DCE, vinyl chloride, and finally to ethene and/or ethane.

Based on the DO measurements collected throughout the site investigative history, site ground water redox is generally anaerobic, and is thus favorable for EISB. Evidence of intrinsic biodegradation of VOCs at the site includes the presence of chlorinated ethene daughter products including cis-1,2-DCE and vinyl chloride, as well as the presence of chlorinated ethane daughter products, 1,1-DCA, and CA. Given these conditions, the potential to enhance the intrinsic biodegradation occurring at the site is favorable. The approach would involve biostimulation and may also include bioaugmentation.

The conceptual approach for implementing EISB for Alternative 3a involves the following:

- Characterization of ground water geochemistry (inorganic and organic), the oxidation-reduction (redox) conditions, and bacterial populations in site ground water. Ground water samples would be collected from representative wells and analyzed for VOCs, dissolved light hydrocarbons (methane, ethane, ethene), dissolved carbon dioxide gas, volatile fatty acids, sulfide, sulfate, nitrate, nitrite, total iron, DO, ORP, *Dehalococcoides ethenogenes*, and *Dehalobacter* via qPCR.

- Bench scale testing to evaluate surfactant properties associated with biological processes. The objective of the bench scale tests would be to evaluate whether it would be possible to make potential residual DNAPL more bio-available.

- Implementation of a laboratory microcosm study to compare candidate electron donors and to select a single donor, based on its performance in site ground water. The microcosm study would evaluate other geochemical conditions (*e.g.*, natural bacteria, potential TCA inhibition, donor metabolism) that would benefit the design.

- Based on the microcosm study, a decision would be made if bioaugmentation is necessary or advantageous to accelerate biodegradation, and if development a TCA/TCE degrading culture should proceed. The culturing step would be necessary to develop sufficient culture volume with appropriate cell densities for bioaugmentation during the implementation phases.

- Installation of injection wells to deliver soluble electron donors in to the ground water beneath the site. Conceptually, 28 wells would be installed in five transects oriented perpendicular to ground water flow. The wells are anticipated to be spaced assuming a 20-foot radius of influence.

- Deployment of selected electron donor for biostimulation, optimizing the use of existing wells. Biostimulation would be implemented in a batch approach initially, through the direct application of soluble electron donors through the injection wells on a bimonthly basis for the first year.

- Evaluation of the performance of EISB through post-injection geochemical and biological ground water monitoring via interpretation of biweekly sampling results from ten wells for the first two months and monthly thereafter through the end of the first year.

- Use of a semi-soluble (*i.e.*, longer lasting) electron donor, such as emulsified soybean oil, for annual injections in years 2, 4, and 6, in conjunction with annual geochemical and biological ground water monitoring from ten wells.

- Ground water monitoring as described in Section 2.9.2.

Given the concentrations of on-site and off-site contaminants, it would likely take more than 30 years to reach NYSDEC Class GA ground water standards using *in situ* biological treatment due to the potential presence of DNAPL and/or residual source material. While *in situ* biological treatment would be effective for reducing concentrations of dissolved COCs in ground water at both on-site and off-site, it would not completely treat residual source material, or DNAPL, if present. *In situ* biological treatment relies on enhanced natural attenuation to control plume migration.

2.9.4.2. Alternative 3b – *In Situ* Biological and Thermal Treatment

Alternative 3b consists of an environmental easement, site management plan, ground water monitoring, *in situ* thermal treatment of soil and ground water on MHBP property, and *in situ* biological treatment of ground water on the former Duso property.

In situ biological treatment on former Duso property

The conceptual approach for implementing EISB for Alternative 3b is the same as for Alternative 3a, however the number of injection wells would be approximately 14 wells to treat the former Duso property. EISB is further described in Section 2.9.4.1.

In situ thermal treatment on MHBP property

The *in situ* thermal treatment would consist of a conductive heating technology, *in situ* thermal desorption (ISTD), to treat a portion of the MHBP property where soil concentrations exceed Part 375 restricted use SCOs for the protection of ground water. Prior to implementation, the extent of the contamination would have to be further delineated vertically and horizontally, as the current extent of contamination is based on limited sample data to a depth of 24 ft below grade. Thermal treatment would be effective for treating both soil and ground water to SCGs in the designated treatment zone. If present in the treatment zone, DNAPL would also be treated and source reduction would be achieved.

Based on the information available, the following conceptual approach was developed for the MHBP property by TerraTherm. An area of approximately 3,700 sq. ft. would be treated from 0 to 24 ft below grade with 46 heater wells spaced 15 ft apart. The water table is this area ranges from 5 to 12 ft below the ground surface. For energy demand calculations, an average water saturation of 80% was assumed. A target temperature of 100 Celsius (steam distillation temperature) would be established. As the soil is heated, COCs would be vaporized and/or destroyed by a number of mechanisms, including: (1) evaporation into the subsurface air stream; (2) steam distillation; (3) boiling; and (4) hydrolysis. A subset of heater wells would have vapor recovery screens to capture vapors generated when boiling potential DNAPL and water. Vapors (steam, air, and COCs) and water would be extracted from the vertical extraction screens and treated using cooling, condensation, and GAC. The ISTD system would be operated for approximately 170 days.

Given the concentrations of on-site and off-site contaminants in ground water, it could potentially take less than 30 years to reach NYSDEC Class GA ground water standards for the *in situ* thermal conduction and *in situ* biological treatment combination due to the ability for *in situ* thermal conduction to treat potential residual source material. However, because the location of potential residual source material is unknown and site-specific biological parameters are unknown, a specific timeframe cannot be established. *In situ* thermal treatment would effectively reduce concentrations of COCs in soil and ground water in an estimated 1-year period on the MHBP property, while *in situ* biological treatment will reduce concentrations of COCs on the former Duso property at a relatively slower pace.

2.9.5. Alternative 4 –Soil Removal and Ground Water Collection/Treatment/Discharge

Alternative 4 consists of an environmental easement, site management plan, ground water monitoring, excavation of accessible unsaturated soil exceeding unrestricted SCOs in 6 NYCRR Part 375 and site background concentrations, off-site landfill disposal of excavated soil, and ground water extraction, treatment, and storm sewer discharge.

Unsaturated soil exceeding unrestricted SCOs in 6 NYCRR Part 375, which is accessible (*i.e.*, not underneath site buildings and utilities), would be excavated and transported to an off-site commercial landfill. The excavation would be backfilled with clean soil and resurfaced. For the purposes of the FS, it is assumed that the excavated soil would not require treatment in accordance with the Land Disposal Restrictions (LDRs; 6 NYCRR Part 376 and 40 CFR Part 268) prior to land disposal. Based on contaminant concentrations in the area of soil to be excavated, it is anticipated that excavated soil would not exhibit the characteristics of a hazardous waste. If excavated soil was considered a listed waste, contaminant concentrations are lower than the LDR treatment standards for U listed wastes. For cost estimates, it is assumed that excavated soil would be disposed of in a hazardous waste landfill.

Ground water exceeding Class GA standards would be extracted, treated, and discharged to the storm sewer. A pump test would be conducted prior to remedial design to evaluate pumping rates and areas of influence. The criteria for extraction well design, the extraction system, treatment, and discharge are dependent on the physical site characteristics, contaminant concentrations and the geochemistry of the ground water at the site, which can affect the ground water treatment system utilized to treat the extracted ground water. Ground water treatment would include the design of processes, such as settling, metals pretreatment (if necessary), filtration, air stripping, and carbon adsorption. Treated ground water would be discharged to nearby storm sewers.

For the purposes of the FS, it is assumed that three pumping wells would be installed. Pumping wells on the northern and southern edges of the prospective treatment area would be approximately 20 feet deep constructed of 6-inch diameter riser pipe with 5 feet of 0.010-inch slot well screen, and the center pumping well would be approximately 40 feet deep with 10 feet of 0.010-inch slot well screen. Based on the proposed well construction details and the estimated discharge of the prospective treatment area, a total pumping rate for the ground water recovery system (all three wells combined) of 15 to 60 gpm was estimated. A maximum flow of 60 gpm through the treatment system was assumed for cost estimate purposes.

The estimated discharge of the prospective treatment area (discharge of ground water within the unconsolidated hydrogeologic unit along the western edge of the former Duso property) ranged from approximately 20,000 to 65,000 gallons per day (gpd). These discharge rates are based on Darcy's Law, as follows:

$$Q = KIA$$

where Q is discharge (gpd), K is hydraulic conductivity [30.6 and 102.7 gallons per day per square foot (gpd/sq. ft.) averaged for all wells on-site and a subset of wells along the western edge of the former Duso property, respectively], I is hydraulic gradient (0.0283 feet per feet (ft/ft), calculated from ground water elevations measured March 26, 2007) and A is the cross-sectional area of the prospective treatment area (22,200 sq. ft.).

Given the concentrations of on-site and off-site contaminants in ground water and the potential presence of DNAPL or residual source material, it would likely take more than 30 years to reach NYSDEC Class GA ground water standards using ground water extraction/treatment/discharge. While this technology will be effective for reducing concentrations of dissolved COCs in ground water at both on-site and off-site and preventing plume migration, effective treatment of residual source material, or DNAPL (if present), would not be achieved. Thus, attainment of ground water standards is not likely within 30 years.

3. Detailed Analysis of Alternatives

The following section documents the detailed analysis of the alternatives developed for the site. The objective of the detailed analysis of alternatives was to analyze and present sufficient information to allow the alternatives to be compared and a remedy selected. The analysis consisted of an individual assessment of each alternative with respect to nine evaluation criteria that encompass statutory requirements and overall feasibility and acceptability. The detailed analysis of alternatives also included a comparative evaluation designed to consider the relative performance of the alternatives and identify major trade-offs among them. The nine evaluation criteria are:

- Overall protectiveness of human health and the environment
- Compliance with SCGs
- Long-term effectiveness and permanence
- Reduction of toxicity, mobility, or volume through treatment
- Short-term effectiveness
- Implementability
- Cost
- Support agency acceptance
- Community acceptance

The preamble to the NCP (Federal Register 1990) indicates that, during remedy selection, these nine criteria should be categorized into three groups: threshold criteria, primary balancing criteria, and modifying criteria. The two threshold criteria, overall protection of human health and the environment, and compliance with SCGs, must be satisfied in order for an alternative to be eligible for selection. Long-term effectiveness and permanence; reduction of toxicity, mobility, or volume through treatment; short-term effectiveness; implementability; and cost are primary balancing criteria that are used to balance the trade-offs between alternatives. The modifying criteria are state and community acceptance, which are formally considered after public comment is received on the Proposed Remedial Action Plan (PRAP). The New York State TAGM entitled *Selection of Remedial Actions at Inactive Hazardous Waste Sites*, (NYSDEC 1990) and NYSDEC's Department of Environmental Restoration (DER)-10 draft guidance entitled *Technical Guidance or Site Investigation and Remediation* were also considered during this evaluation (NYSDEC 2002).

3.1. Individual Analysis of Alternatives

In the individual analysis of alternatives, each of the remedial alternatives was evaluated with respect to the above-listed evaluation criteria. A summary of this analysis is presented in Table 6.

3.1.1. Overall Protection of Human Health and the Environment

The analysis of each alternative with respect to this criterion provides an evaluation of whether the alternative would achieve and maintain adequate protection and a description of how site risks would be eliminated, reduced, or controlled through treatment, engineering, or institutional controls.

3.1.2. Compliance with SCGs

Potential SCGs for the site are presented in Table 1.

3.1.3. Long-Term Effectiveness and Permanence

This criterion assesses the magnitude of residual risk remaining from untreated material or treatment residuals at the site. The adequacy and reliability of controls used to manage untreated material or treatment residuals are also evaluated.

3.1.4. Reduction of Toxicity, Mobility, or Volume though Treatment

The evaluation of this criterion addresses the expected performance of treatment technologies in each alternative.

3.1.5. Short-Term Effectiveness

The evaluation of short-term effectiveness addresses the protection of workers and the community during construction and implementation of each alternative and potential environmental effects that would result from implementation of each alternative. The time required to achieve remedial objectives was also evaluated under this criterion.

3.1.6. Implementability

The analysis of implementability involves an assessment of the ability to construct and operate the technologies, the reliability of the technologies, the ease of undertaking additional remedial action, the ability to monitor the effectiveness of each remedy, and the ability to obtain necessary approvals from other agencies. Additionally, the availability of services, capacities, equipment, materials, and specialists necessary for implementation of the alternative is also assessed.

3.1.7. Cost

For the cost analysis, cost estimates were prepared for each alternative based on vendor information and quotations, cost estimating guides, and experience. Cost estimates were prepared for the purpose of alternative comparison and were based on information currently known about the study area. The cost estimates include capital costs, annual O&M costs, and present worth cost. The present worth cost for these alternatives was calculated for the expected duration of the remedy at a 3% discount rate.

The individual cost estimates for the remedial alternatives are included in Tables 7 through 11.

3.1.8. Support Agency Acceptance

Support agency acceptance will be addressed during development of the PRAP.

3.1.9. Community Acceptance

Community acceptance will be addressed during the public comment period prior to the ROD.

3.2. Comparative Analysis of Alternatives

In the comparative analysis of alternatives, the performance of each alternative relative to the others was evaluated for each criterion. As discussed in the following subsections, with the exception of Alternative 1, each alternative would satisfy the threshold criteria by providing protection to human health and the environment, and by addressing the identified SCG. Therefore, each active alternative would be eligible for selection as the final remedy. The primary balancing criteria (long-term effectiveness and permanence; reduction of toxicity, mobility, or volume through treatment; short-term effectiveness; implementability; and cost) were used in the comparative evaluation of alternatives.

3.2.1. Overall Protection of Human Health and the Environment

With respect to protection of human health, Alternatives 2 through 4 would provide equal protectiveness for ground water and soil potential impacts through institutional controls. Each of Alternatives 2 through 4 would be equally protective by addressing trail surface soil risks to human health and the environment through planned paving. Each alternative would be protective of human health and the environment by addressing potential future exposures to VOCs in ground water through natural attenuation or active treatment of ground water. Ground water monitoring included in Alternatives 2, 3, and 4 would provide a means of evaluating the protectiveness of the alternatives. Alternatives 2, 3, and 4 would be more protective to human health and the environment than Alternative 1, which relies solely on natural attenuation and does not include institutional controls or monitoring. Alternative 4 would provide increased protection by minimizing off-site ground water migration upon implementation and removing accessible soil exceeding SCGs. Alternative 3b would provide increased protection through potential source reduction and faster reduction of the highest concentrations of COCs (relative to the other alternatives).

3.2.2. Compliance with SCGs

As summarized in Table 1, chemical-specific SCGs were identified for ground water, soil, surface water and indoor air. Each alternative would provide a means of reducing ground water concentrations, but attainment of ground water SCGs is likely technically impracticable due to the likely presence of residual source material. Ground water monitoring included in Alternatives 2, 3, and 4 would provide a means of evaluating the progress toward attainment of ground water SCGs. Reductions in ground water concentrations would provide for potential future attainment of surface water SCGs for Alternatives 1, 2 and 3. Ground water extraction would provide for attainment of surface water SCGs in Alternative 4. Alternative 4 would attain soil SCGs for accessible soil in the unsaturated zone on the former Duso property; Alternatives 2, 3a, and 3b would rely on institutional controls to restrict contact with soil exceeding SCGs. Alternatives 2, 3, and 4 would achieve compliance with the indoor air SCG with continued O&M of the VI IRM system. Alternative 1 would not attain chemical-specific SCGs for soil or indoor air.

Each alternative would comply with location-specific SCGs related to endangered or threatened species. Action-specific SCGs related to Occupational Safety and Health Administration (OSHA) requirements during construction activities were identified for Alternatives 2, 3, and 4, and would be met during construction. Action-specific SCGs related to subsurface injection of biological treatment amendments in Alternative 3 would be met during remedy implementation. Action-specific SCGs related to air emissions, storm sewer discharge, waste management, transportation, and disposal identified for Alternative 4 and would be met during remedy implementation.

3.2.3. Long-Term Effectiveness and Permanence

Alternatives 2 through 4 would provide for minimal residual risk through adequate and reliable institutional controls for impacts from ground water, soil, surface water, and indoor air; continued O&M of the VI IRM system; and trail paving for surface soil impacts. Residual risk would be further reduced in Alternatives 3 and 4 through treatment and removal. Alternative 1 would not provide for protection with regard to soil, ground water, surface water, or indoor air. Ground water monitoring included in Alternatives 2, 3, and 4 would provide a means of evaluating the expected reliability of controls.

3.2.4. Reduction of Toxicity, Mobility, or Volume though Treatment

Each alternative, through natural attenuation or active treatment would attain reduction in VOC contamination of the ground water plume. Accelerated reduction of VOCs in ground water are expected with active treatment in Alternatives 3 and 4. Reduction of VOCs in soil provided with Alternative 3b. Natural attenuation and active treatment are irreversible processes. Residual contamination is possible if residual source material is present.

3.2.5. Short-Term Effectiveness

Each alternative would be protective of workers and the community during implementation through the use of appropriate controls. Environmental impacts are not anticipated from the implementation of the alternatives. Alternative 1 would not provide for attainment of remedial objectives. Alternatives 2 and 3 would provide for attainment of remedial objectives for soil, indoor air, surface water, and ground water risk mitigation immediately upon implementation of institutional controls, and through trail paving and VI IRM O&M. The estimated timeframe for attainment of the remedial objective related to minimization of off-site migration of ground water exceeding SCGs is unknown for Alternatives 2, 3a, and 3b (expected to be greater than 30 years), but is expected to be longest for Alternative 2 and shortest for Alternative 3b. Minimization of off-site migration of ground water exceeding SCGs would be attained in Alternative 4 immediately following implementation of the ground water extraction system.

3.2.6. Implementability

Each alternative would be implementable. Alternatives 3 and 4 would involve agency approvals related to injection and discharge, respectively. The technologies being used in each alternative are reliable and readily available technologies. Each alternative would allow for additional remedial actions to be implemented, if necessary, and would be readily monitored for effectiveness of the remedy. Coordination with off-site property owners would be required for treatment and extraction in Alternatives 3 and 4, and for the environmental easement and monitoring in Alternatives 2, 3, and 4. Disposal facilities are readily available for treatment residuals in Alternatives 3 and 4, and soil in Alternative 4.

3.2.7. Cost

Detailed cost estimates for Alternatives 1 through 4 are included as Tables 7 through 11.

Alternative 1, the no action alternative, is the least cost alternative with an estimated present worth value of approximately $40,000.

Alternative 2, the monitored natural attenuation alternative, has an estimated present worth of approximately $1,300,000.

Alternative 3a, the *in situ* ground water treatment alternative, has an estimated present worth of approximately $1,730,000.

Alternative 3b, the *in situ* soil and ground water treatment alternative, has an estimated present worth of approximately $2,480,000.

Alternative 4, the soil excavation and ground water extraction/treatment/discharge alternative, has an estimated present worth of approximately $5,850,000.

3.2.8. Support Agency Acceptance

Support agency acceptance will be addressed during development of the preferred alternative.

3.2.9. Community Acceptance

Community acceptance will be addressed during the preferred alternative public comment period prior to the ROD.

4. Conclusions and Recommendations

Alternative 3b is the recommended alternative (see Figure 3 for the conceptual plan). Alternative 3b would achieve the remedial objectives. Remedial objectives would be achieved under Alternative 3b through the following remedy components:

- Treatment of ground water at the former Duso Facility via enhanced *in situ* biological treatment
- Treatment of ground water and soil at the MHBP facility via *in situ* thermal treatment
- Environmental easement
- Site management plan
- Ground water monitoring.

As documented in Section 3.2, Alternative 3b would achieve protectiveness of human health and the environment and would address SCGs (a waiver on attainment of the Class GA ground water standards may be applicable for the site due to technical impracticability). Alternative 3b would provide protection to human health and the environment because it would substantially reduce the highest concentrations of COCs in a short amount of time (relative to the other alternatives). Furthermore, Alternative 3b would provide for potential residual source reduction. Additionally, by substantially reducing concentrations of COCs in a short period of time (approximately one year for *in situ* thermal treatment), Alternative 3b would reduce the likelihood for plume migration.

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Table 1. *Evaluation of Potential SCGs*

Medium/Location/ Action	Citation	Requirements	Comments	Potential SCG	Alternative
		Potential chemical-specific SCGs			
Ground water	6 NYCRR 703 - Class GA ground water quality standards	Promulgated state regulation that requires that fresh ground waters of the state must attain Class GA standards.	Potentially applicable to site ground water.	Yes	All
Surface Water	6 NYCRR Part 703.5 - Class D surface water standards	Promulgated state regulation that requires that surface waters of the state must attain appropriate standards based on water body classification.	Potentially applicable to site surface water.	Yes	All
Indoor Air	NYSDOH - Guidance for Evaluating Soil Vapor Intrusion	Guidance that provides action levels for mitigation of indoor air influences	Potentially applicable for on-site and off-site buildings.	Yes	All
Soil	6 NYCRR Part 375-6 Remedial Program Soil Cleanup Objectives	Regulation that provides guidance for soil cleanup objectives for various property uses.	Potentially applicable to site soil.	Yes	All
	NYSDEC TAGM HWR-94-4046 - Recommended soil cleanup objectives	Guidance that provides recommended soil cleanup objectives.	Potentially relevant and appropriate to site soil for constituents that are not addressed in Part 375.	Yes	All
		Potential location-specific SCGs			
Wetlands	6 NYCRR 663 - Freshwater wetland permit requirements	Actions occurring in a designated freshwater wetland (within 100 ft) must be approved by NYSDEC or its designee. Activities occurring adjacent to freshwater wetlands must: be compatible with preservation, protection, and conservation of wetlands and benefits; result in no more than insubstantial degradation to or loss of any part of the wetland; and be compatible with public health and welfare.	Not applicable or relevant and appropriate. No wetlands located at Site, and no remedial actions expected to impact wetlands near Site.	No	None
	Executive Order 11990 - Protection of Wetlands	Activities occurring in wetlands must avoid, to the extent possible, the long- and short-term adverse impacts associated with the destruction or modification of wetlands. The procedures also require USEPA to avoid direct or indirect support of new construction in wetlands wherever there are practicable alternatives or minimize potential harm to wetlands when there are no practicable alternatives.	Not applicable or relevant and appropriate. No wetlands located at Site, and no remedial actions expected to impact wetlands near Site.	No	None
100-year flood plain	6 NYCRR 373-2.2 - Location standards for hazardous waste treatment, storage, and disposal facilities -100-yr floodplain	Hazardous waste treatment, storage, or disposal facilities located in a 100-yr floodplain must be designed, constructed, operated and maintained to prevent washout of hazardous waste during a 100-yr flood.	Not applicable or relevant and appropriate. Site is not located in the 100-year floodplain.	No	None
	Executive Order 11988 - Floodplain Management	EPA is required to conduct activities to avoid, to the extent possible, the long- and short- term adverse impacts associated with the occupation or modification of floodplains. The procedures also require EPA to avoid direct or indirect support of floodplain development wherever there are practicable alternatives and minimize potential harm to floodplains when there are no practicable alternatives.	Not applicable or relevant and appropriate. Site is not located in the 100-year floodplain.	No	None
Within 61 meters (200 ft) of a fault displaced in Holocene time	40 CFR Part 264.18	New treatment, storage, or disposal of hazardous waste is not allowed.	Not applicable or relevant and appropriate. Site is not located within 200 ft of a fault displaced in Holocene time, as listed in 40 CFR 264 Appendix VI.	No	None
River or stream	16 USC 661 - Fish and Wildlife Coordination Act	Requires protection of fish and wildlife in a stream when performing activities that modify a stream or river.	Not applicable or relevant and appropriate. On-site surface water not considered significant surface water resource (e.g., stream) in FWIA..	No	None

Table 1. *Evaluation of Potential SCGs*

Medium/Location/ Action	Citation	Requirements	Comments	Potential SCG	Alternative
		Potential location-specific SCGs (cont.)			
Habitat of an endangered or threatened species	6 NYCRR 182	Provides requirements to minimize damage to habitat of an endangered species.	Potentially applicable. NYSDEC Natural Heritage Program identified 19 endangered or threatened species within 2 mile radius of site, 6 within 0.5 mile radius of Site.	Yes	All
Habitat of an endangered or threatened species	Endangered Species Act	Provides a means for conserving various species of fish, wildlife, and plants that are threatened with extinction.	Potentially applicable. US Fish and Wildlife Service identified four endangered species and one species of concern within 2 mile radius of Site.	Yes	All
Historical property or district	National Historic Preservation Act	Remedial actions are required to account for the effects of remedial activities on any historic properties included on or eligible for inclusion on the National Register of Historic Places.	Not applicable or relevant and appropriate. Site not identified as a historic property .	No	None
		Potential action-specific SCGs			
Treatment actions	6 NYCRR 373 - Hazardous waste management facilities	Provides requirements for managing hazardous wastes.	Likely applicable to extracted ground water based on contaminant concentrations in monitoring wells. Potentially applicable to excavated soil.	Yes	4
Construction	29 CFR Part 1910 - Occupational Safety and Health Standards - Hazardous Waste Operations and Emergency Response	Remedial activities must be in accordance with applicable OSHA requirements.	Applicable for construction and monitoring phase of remediation.	Yes	2, 3, 4
	29 CFR Part 1926 - Safety and Health Regulations for Construction	Remedial construction activities must be in accordance with applicable OSHA requirements.	Applicable for construction phase of remediation.	Yes	2, 3, 4
Transportation	6 NYCRR 364 - Waste Transporter Permits	Hazardous waste transport must be conducted by a hauler permitted under 6 NYCRR 364.	Potentially applicable to excavated soil.	Yes	4
	49 CFR 172-174 and 177-179 - Department of Transportation Regulations	Hazardous waste transport to offsite disposal facilities must be conducted in accordance with applicable DOT requirements	Potentially applicable to excavated soil.	Yes	4
	6 NYCRR Part 372 - Hazardous Waste Manifest System and Related Standards for Generators, Transporters, and Facilities	Substantive hazardous waste generator and transportation requirements must be met when hazardous waste is generated for disposal. Generator requirements include obtaining an EPA Identification Number and manifesting hazardous waste for disposal.	Potentially applicable to excavated soil.	Yes	4
Disposal	6 NYCRR Part 376 - Land Disposal Restrictions	Land disposal of hazardous waste must be conducted in accordance with land disposal restrictions, including treatment standards.	Potentially applicable to excavated soil.	Yes	4
Generation of air emissions	NYS Air Guide 1	Provides annual guideline concentrations (AGCs) and short-term guideline concentrations (SGCs) for specific chemicals. These are property boundary limitations that would result in no adverse health effects.	Potentially applicable.	Yes	4
	NYS TAGM 4031 - Dust Suppressing and Particle Monitoring at Inactive Hazardous Waste Disposal Sites	Provides limitations on dust emissions.	Potentially applicable to excavation.	Yes	4
Discharge to surface water and injection to ground water	6 NYCRR Parts 750 through 758 - SPDES Regulations	Substantive requirements associated with discharge to a water body (limitations and monitoring requirements) would be set by NYSDEC.	Applicable for treated ground water discharge to storm sewers and injection of biological treatment amendments.	Yes	3, 4
Injection to ground water	40 CFR 144 - Underground Injection Control Program	Permit not required for Class V wells, which are approved by rule under federal UIC program. Subtantial compliance with Class V permit requirements must be demonstrated.	Applicable for injection of biological treatment amendments.	Yes	3

Table 1. *Evaluation of Potential SCGs*

Medium/Location/ Action	Citation	Requirements	Comments	Potential SCG	Alternative
		Potential action-specific SCGs (cont.)			
Construction storm water management	NYSDEC General permit for storm water discharges associated with construction activities. Pursuant to Article 17 Titles 7 and 8 and Article 70 of the Environmental Conservation Law.	The regulation prohibits discharge of materials other than storm water and all discharges that contain a hazardous substance in excess of reportable quantities established by 40 CFR 117.3 or 40 CFR 302.4, unless a separate NPDES permit has been issued to regulate those discharges. A permit must be acquired if activities involve the disturbance of 5 acres or more. If the project is covered under the general permit, the following are required: development and implementation of a storm water pollution prevention plan; development and implementation of a monitoring program; all records must be retained for a period of at least 3 years after construction is complete.	Not applicable. Construction disturbances will not exceed the limits.	No	None

Table 2. *Screening of Remedial Technologies and Process Options*

General Response Action	Remedial Technology	Process Option	Description	Screening Comments
Indoor Air				
No Action	None	Not applicable	No action.	Required for consideration by NYSDEC Draft DER-10 (Technical Guidance for Site Investigation and Remediation) for baseline comparison.
Institutional Controls	Use restrictions	Environmental easement	Restrictions of building uses and site activities that result in unacceptable exposures to contaminated vapors. Requires that mitigation systems be operated and monitored to maintain protectiveness from unacceptable exposures to contaminated vapors.	Potentially applicable.
		Site management plan	Documentation of restrictions and provisions for continued operation and monitoring of the remedy.	Potentially applicable.
Surface Water				
No Action	None	Not applicable	No action.	Required for consideration by NYSDEC Draft DER-10 (Technical Guidance for Site Investigation and Remediation) for baseline comparison.
Institutional Controls	Use restrictions	Environmental easement	Restriction of surface water uses where surface water exceeds NYSDEC surface water quality standards.	Potentially applicable.
		Site management plan	Documentation of restrictions and provisions for continued operation and monitoring of the remedy.	Potentially applicable.

Table 2. *Screening of Remedial Technologies and Process Options*

General Response Action	Remedial Technology	Process Option	Description	Screening Comments
Soil				
No Action	None	Not applicable	No action.	Required for consideration by NYSDEC Draft DER-10 (Technical Guidance for Site Investigation and Remediation) for baseline comparison.
Institutional Controls	Use restrictions	Environmental easement	Restrictions on land uses and site activities that result in unacceptable exposures to contaminated soils. Requires compliance with site management plan.	Potentially applicable.
		Site management plan	Documentation of restrictions and provisions for continued operation and maintenance of the remedy components.	Potentially applicable.
In Situ Treatment	Physical	Soil vapor extraction (SVE)	Vacuum is applied through extraction wells to create a pressure/concentration gradient that induces gas-phase volatiles to be removed from soil through extraction wells. Extracted vapors are treated *ex situ*.	Not applicable as standalone technology for this Site because VOCs are concentrated in the saturated zone. Potentially applicable for use in conjunction with another technology.
		Multi-phase extraction (MPE)	A high-pressure vacuum is applied through extraction wells to simultaneously extract ground water and vapors from the subsurface. Extracted ground water and vapors are separated and treated *ex situ*.	Potentially applicable to VOCs in saturated soil.
	Physical/Chemical	Solidification/stabilization	Contaminants are physically bound or enclosed within a stabilized mass (solidification), or chemical reactions are induced between the stabilizing agent and contaminants to reduce their mobility (stabilization).	Not applicable for treatment of VOCs.

Table 2. *Screening of Remedial Technologies and Process Options*

General Response Action	Remedial Technology	Process Option	Description	Screening Comments
In Situ Treatment (continued)	Thermal	Electrical resistance heating	Electrical current is used to heat soil and ground water such that contaminants are vaporized and ready for vacuum extraction. Extracted vapors are treated *ex situ.*	Potentially applicable for VOCs in saturated soil.
		Radio frequency (electromagnetic) heating	Electromagnetic energy is used to heat soil and ground water such that contaminants are vaporized and ready for vacuum extraction.	Not applicable to VOCs in saturated soil without extensive dewatering.
		Steam injection and extraction	Steam is applied though injection wells to the subsurface soil and ground water to volatilize contaminants. Vapors are extracted and treated *ex situ.*	Potentially applicable for VOCs in saturated soil.
		Conductive heating	Electrical heaters within thermal wells or thermal blanket apply heat to soil and ground water. Heat is transferred via conduction and vaporized contaminants are collected within thermal vacuum wells. Vapors are treated *ex situ.*	Potentially applicable for VOCs in saturated soil.
		In situ vitrification	Electric current is used to melt soil or other earthen materials at extremely high temperatures (1,600 to 2,000 °C or 2,900 to 3,650 °F) and thereby immobilize most inorganics and destroy organics by pyrolysis.	Potentially applicable for metals in unsaturated soil. Not applicable to VOCs in saturated soil without extensive dewatering.
Containment	Capping	Soil cover	Installation of layer of clean soil over contaminated soil.	Potentially applicable for minimizing contact.
		Low permeability cap	Installation of clay or multi-media cover system over contaminated soil.	Potentially applicable for minimizing contact and infiltration.

Table 2. *Screening of Remedial Technologies and Process Options*

General Response Action	Remedial Technology	Process Option	Description	Screening Comments
Removal	Excavation	Excavation	Use of construction equipment, such as backhoes, bulldozers, clamshells, draglines, or conveyors to remove site soils.	Identified as a "conventional remedial method" by NYSDEC. Excavation of some site soil may not be practical due to depths of contamination up to 24 ft and locations beneath buildings and in vicinity of utilities.
Ex Situ Treatment	Thermal	Low temperature thermal desorption	Use of direct or indirect heat to volatilize organic contaminants. Further treatment of vapor phase potentially required.	Potentially applicable to VOCs.
		Incineration	Thermal oxidation of organic contaminants.	Potentially applicable to VOCs.
	Biological	Anaerobic biocells	Excavated soils are mixed with soil amendments and placed on a constructed treatment area to promote degradation.	Potentially applicable.

Table 2. *Screening of Remedial Technologies and Process Options*

General Response Action	Remedial Technology	Process Option	Description	Screening Comments
Ex Situ Treatment (continued)	Physical	Soil vapor extraction	Excavated soils are placed on a network of aboveground piping to which a vacuum is applied to encourage volatilization of organics. Soil piles are generally covered with a geomembrane to prevent volatile emissions and to prevent the soil from becoming saturated by precipitation. The process would include a system for handling off-gases.	Potentially applicable.
Disposal	Landfill disposal	Off-site commercial landfill	Transport and disposal of excavated soil in off-site permitted landfill.	Potentially applicable.
Ground Water				
No Action	None	Not applicable	No action.	Required for consideration by NYSDEC Draft DER-10 (Technical Guidance for Site Investigation and Remediation) for baseline comparison.
Institutional Controls	Monitoring	Ground water monitoring	Periodic sampling and analyses of ground water.	Potentially applicable.
	Use restrictions	Environmental easement	Restriction of ground water use at the site and off-site where ground water exceeds Class GA standards.	Potentially applicable.
		Site management plan	Documentation of restrictions and provisions for continued operation and monitoring of the remedy.	Potentially applicable.
Containment	Vertical barrier	Slurry wall	Soil- or cement-bentonite slurry wall placed around the area of contamination to contain ground water.	Not feasible due to ground water flow patterns at the site and the presence of fractured bedrock (no confining layer).

Table 2. *Screening of Remedial Technologies and Process Options*

General Response Action	Remedial Technology	Process Option	Description	Screening Comments
Containment (continued)	Vertical barrier (continued)	Sheet piles	Sheet piles installed around the area of contamination to contain ground water.	Not feasible due to ground water flow patterns at the site and the presence of fractured bedrock (no confining layer).
Collection	Ground water extraction	Recovery wells	Removal of ground water by pumping from recovery wells for hydraulic containment or mass removal.	Potentially applicable.
		Recovery trench	Removal of ground water by pumping from recovery trenches for hydraulic containment or mass removal.	Potentially applicable, although complex due to ground water flow patterns at the site.
		Multi-phase extraction (MPE)	Simultaneous extraction of VOCs from ground water and soil.	Potentially applicable.
Collection Enhancement	Chemical	Surfactant/cosolvent flushing	Injection, and subsequent extraction, of surfactants or cosolvents into the aquifer to mobilize or solubilize DNAPL, so that it can be more readily extracted with the ground water.	Potentially applicable.
In Situ Treatment	Physical	Air sparging	Injection of air into the saturated zone to volatilize constituents, which are collected in the unsaturated zone by an SVE system.	Potentially applicable.
		In-well air stripping	Injection of air into the water column within a well to volatilize constituents. Ground water circulation is performed *in situ*, with ground water entering the well at one screen and being discharged through a second screen. Air is collected and treated if necessary.	Potentially applicable.

Table 2. *Screening of Remedial Technologies and Process Options*

General Response Action	Remedial Technology	Process Option	Description	Screening Comments
In Situ Treatment (continued)	Monitored natural attenuation	Monitored natural attenuation	Long-term monitoring of the natural biotic and abiotic degradation of organic constituents.	Potentially applicable.
	Biological	Enhanced bioremediation	Injection of microbial populations, nutrient sources, and electron donors into ground water to enhance biological degradation of organic constituents.	Potentially applicable.
	Chemical	Chemical oxidation	Injection of oxidation agents such as hydrogen peroxide, ozone, or permanganate into ground water to oxidize/destroy organic contaminants.	Potentially applicable.
		Permeable reactive barrier wall	Construction of an iron wall, biobarrier, or carbon wall to treat ground water as it flows through the treatment zone.	Potentially applicable, although complex due to ground water flow patterns at the site.
Ex Situ Treatment	Physical	Air stripping	Contact of air with water in countercurrent column or bulk reactor to transfer VOCs from water to air.	Potentially applicable.
		Carbon adsorption	Adsorption of organic constituents from water to activated carbon.	Not applicable for vinyl chloride. Potentially applicable for use in conjunction with another technology.
		Adsorptive resin	Adsorption of organic constituents from water to commercial adsorptive resin.	Potentially applicable.
		Settling	Retention of aqueous stream in tank to settle/separate solids, or light or heavy components.	Potentially applicable.
		Filtration	Separation of solids from water phase using semipermeable filter medium.	Potentially applicable.

Table 2. *Screening of Remedial Technologies and Process Options*

General Response Action	Remedial Technology	Process Option	Description	Screening Comments
Ex Situ Treatment (continued)	Chemical	Chemical oxidation	Addition of oxidation agents such as hydrogen peroxide and ultraviolet light to water to oxidize/destroy organic contaminants.	Potentially applicable.
		Precipitation	pH adjustment of ground water to separate out dissolved metal contaminants.	Potentially applicable.
		Ion exchange	Removal of dissolved metal ions from the aqueous phase by the exchange of cations or anions between the contaminants and the exchange medium.	Potentially applicable.
	Biological	Biological reactor	Addition of microbial populations, nutrient sources, and electron donors into ground water in a reactor to enhance biological degradation of organic constituents.	Potentially applicable.
Discharge	Treated water discharge	Discharge to surface water	Discharge of treated ground water to off-site stream.	Potentially applicable.
		Discharge to POTW	Discharge of treated ground water to sanitary sewer system.	Potentially applicable.
		Discharge to storm sewer	Discharge of treated ground water to storm sewer system.	Potentially applicable.
		Discharge to ground water	Discharge of treated ground water to aquifer.	Potentially applicable.

Table 3. ***Evaluation of Process Options***

General Response Action	Remedial Technology	Process Option	Effectiveness	Implementability	Costs
Indoor Air					
No Action	None	Not applicable	Not applicable.	Implementable.	No capital No O&M
Institutional Actions	Use restrictions	Environmental easement*	Effective means of legally documenting site use restrictions.	Implementable.	Low capital No O&M
		Site management plan*	Effective means of communicating site restrictions to affected parties and documenting operation and monitoring of the remedy.	Implementable.	Low capital. Low O&M
Surface Water					
No Action	None	Not applicable	Not applicable.	Implementable.	No capital No O&M
Institutional Controls	Use restrictions	Environmental easement*	Effective means of legally documenting site use restrictions.	Implementable.	Low capital No O&M
		Site management plan*	Effective means of communicating site restrictions to affected parties and documenting operation and monitoring of the remedy.	Implementable.	Low capital. Low O&M
Soil					
No Action	None	Not applicable	Not applicable.	Implementable.	No capital No O&M
Institutional Controls	Use restrictions	Environmental easement *	Effective means of legally documenting site use restrictions.	Implementable.	Low capital No O&M

* Indicates process option was selected as a representative process option and included in at least one of the remedial alternatives.

Table 3. ***Evaluation of Process Options***

General Response Action	Remedial Technology	Process Option	Effectiveness	Implementability	Costs
Institutional Controls (continued)	Use restrictions (continued)	Site management plan *	Effective means of communicating site restrictions to affected parties and documenting operation and monitoring of the remedy.	Implementable.	Low capital Low O&M
In Situ Treatment	Physical	Soil vapor extraction (SVE)	Not effective for removal of VOCs from saturated soils, but may be effective for vapor recovery when used in conjunction with other technologies.	Implementable.	Low capital Low O&M
		Multi-phase extraction (MPE)	Effective for removal of VOCs from saturated soils.	Implementable.	Low capital Medium O&M
	Thermal	Electrical resistance heating	Effective for removal of VOCs. Potential exists for uncontrolled horizontal and vertical migration of mobilized DNAPL, if present.	Implementable.on the MHBP property. Not implementable on the Duso property due to safety issues with the use of thermal technologies at a propane facility.	High capital Medium O&M
		Steam injection and extraction	Effective for removal of VOCs. Potential exists for uncontrolled horizontal and vertical migration of mobilized DNAPL, if present.	Implementable.on the MHBP property. Not implementable on the Duso property due to safety issues with the use of thermal technologies at a propane facility.	Medium capital Medium O&M
		Conductive heating*	Effective for removal of VOCs. Potential exists for uncontrolled horizontal and vertical migration of mobilized DNAPL, if present.	Implementable.on the MHBP property. Not implementable on the Duso property due to safety issues with the use of thermal technologies at a propane facility.	High capital Medium O&M
		In situ vitrification	Effective for treatment of metals in unsaturated soil. Potential exists for uncontrolled horizontal and vertical migration of mobilized DNAPL, if present.	Not implementable due to safety issues with the use of extremely high temperature thermal technologies near a propane facility. Not applicable to VOCs in saturated soil without extensive dewatering.	High capital High O&M

* Indicates process option was selected as a representative process option and included in at least one of the remedial alternatives.

Table 3. *Evaluation of Process Options*

General Response Action	Remedial Technology	Process Option	Effectiveness	Implementability	Costs
Containment	Capping	Soil cover	Effective for limiting human and ecological exposure to contaminated soil.	Implementable.	Medium capital Low O&M
		Low permeability cap	Effective for limiting human and ecological exposure to contaminated soil and for reducing infiltration.	Implementable.	High capital Low O&M
Removal	Excavation	Excavation*	Effective for removing contaminated soil.	Implementable for unsaturated soil. Dewatering required for saturated soil.	High capital No O&M
Ex Situ Treatment	Thermal	Low temperature thermal desorption (LTTD)	Effective for removal of VOCs.	Implementation may be difficult due to limited space availability for siting an LTTD unit on the former Duso property. Safety concerns are also an issue for thermal technologies given that the property is currently a propane facility.	Medium capital Medium O&M
		Incineration	Effective for removal of VOCs.	Implementation may be difficult due to limited space availability for siting an incineration unit on the former Duso property. Safety concerns are also an issue for thermal technologies given that the property is currently a propane facility. Residuals will require off-site disposal.	High capital No O&M
	Biological	Anaerobic biocells	Effective for removal of CVOCs.	Implementation may be difficult due to limited space availability for siting biocells on the former Duso property.	Medium capital Low O&M

* Indicates process option was selected as a representative process option and included in at least one of the remedial alternatives.

Table 3. *Evaluation of Process Options*

General Response Action	Remedial Technology	Process Option	Effectiveness	Implementability	Costs
Ex Situ Treatment (continued)	Physical	Soil vapor extraction	Effective for removal of CVOCs.	Implementation may be difficult due to limited space availability for siting biocells on the former Duso property.	Medium capital Low O&M
Disposal	Landfill disposal	Off-site commercial landfill*	Effective method of disposal. Minimizes on-site and off-site constituent migration.	Implementable.	High capital No O&M
Ground Water					
No Action	None	Not applicable	Not applicable	Implementable.	No capital No O&M
Institutional Controls	Monitoring	Ground water monitoring*	Effective method for monitoring changes in ground water concentrations. Useful for evaluating remedy effectiveness.	Implementable.	Low capital Low O&M
	Use restrictions	Environmental easement*	Effective means of legally documenting site use restrictions.	Implementable.	Low capital No O&M
		Site management plan*	Effective means of communicating site restrictions to affected parties.	Implementable.	Low capital Low O&M
Collection	Ground water extraction	Recovery wells*	Effective collection method.	Implementable.	Low capital Medium O&M
		Recovery trench	Effective collection method.	Difficult to implement due to site geology, ground water flow patterns, and fractured bedrock.	Medium capital Medium O&M

* Indicates process option was selected as a representative process option and included in at least one of the remedial alternatives.

Table 3. *Evaluation of Process Options*

General Response Action	Remedial Technology	Process Option	Effectiveness	Implementability	Costs
Collection (continued)	Ground water extraction (continued)	Multi-phase extraction (MPE)	Effective removal method for VOCs in ground water.	Implementable.	Medium capital High O&M
Collection Enhancement	Chemical	Surfactant/cosolvent flushing	Low permeablity soils, subsurface heterogeneity and the presence of manmade subsurface conduits could cause uneven distribution of the cosolvent or surfactant, resulting in pockets of untreated contaminants. Potential exists for uncontrolled horizontal and vertical migration of mobilized DNAPL. Could potentially disrupt natural attenuation processes.	Implementable.	High Capital High O&M
In Situ Treatment	Physical	Air sparging	Low permeablity soils, subsurface heterogeneity and the presence of manmade subsurface conduits could prevent adequate collection of vapors in a SVE system.	Implementable.	Medium capital Medium O&M
		In-well air stripping	Effective for removal of chlorinated VOCs. Frequent mainentance potentially required to address fouling.	Implementable.	Medium capital Medium O&M
	Monitored natural attenuation	Monitored natural attenuation*	Likely effective for destruction of chlorinated VOCs in saturated zone.	Implementable.	Low capital No O&M

* Indicates process option was selected as a representative process option and included in at least one of the remedial alternatives.

Table 3. *Evaluation of Process Options*

General Response Action	Remedial Technology	Process Option	Effectiveness	Implementability	Costs
In Situ Treatment (continued)	Biological	Enhanced bioremediation	Low permeablity soils, subsurface heterogeneity and the presence of subsurface conduits could cause uneven distribution of electron donors, nutrients and/or microorganisms, resulting in pockets of untreated contaminants. Biological treatment can move with the contaminant plume.	Implementable.	Medium Capital Medium O&M
	Chemical	Chemical oxidation	Low permeablity soils, subsurface heterogeneity and the presence of manmade subsurface conduits could cause uneven distribution of the oxidant, resulting in pockets of untreated contaminants. Could potentially disrupt natural attenuation processes.	Implementable.	Medium Capital Medium O& M
		Permeable reactive barrier wall	Potentially effective treatment option. Ensuring and verifying hydraulic performance are the main design and monitoring challenges. Effectiveness of the technology is dependent upon design to prevent ground water flow bypass and/or inadequate residence time in the reactive media.	Difficult to implement due to site geology, ground water flow patterns, and fractured bedrock.	Medium Capital Medium O&M
Ex Situ Treatment	Physical	Air stripping*	Effective for removal of VOCs.	Implementable.	Medium capital Medium O&M
		Carbon adsorption*	Effective for removal of VOCs, with the exception of vinyl chloride.	Implementable.	Medium capital High O&M
		Adsorptive resin	Effective for removal of VOCs.	Implementable.	Medium capital High O&M

* Indicates process option was selected as a representative process option and included in at least one of the remedial alternatives.

Table 3. *Evaluation of Process Options*

General Response Action	Remedial Technology	Process Option	Effectiveness	Implementability	Costs
Ex Situ Treatment (continued)	Physical (continued)	Settling*	Effective for removal of solids or precipitated metals.	Implementable.	Medium capital Medium O&M
		Filtration*	Effective for removal of solids or precipitated metals.	Implementable.	Medium capital Medium O&M
	Chemical	Chemical oxidation	Effective for removal of VOCs.	Implementable.	Medium capital High O&M
		Precipitation	Effective for metals treatment.	Implementable.	Medium capital Medium O&M
		Ion exchange	Effective for metals treatment.	Implementable.	High capital High O&M
	Biological	Biological reactor	Potentially effective; limited applications for chlorinated organics; treatability study required.	Implementable.	Medium capital Medium O&M
Discharge	Treated water discharge	Discharge to surface water	Effective for discharge of treated water.	Implementable. SPDES permit required.	Low capital Low O&M
		Discharge to POTW	Effective for discharge of treated water.	Implementable. POTW approval required.	Low capital Medium O&M
		Discharge to storm sewer*	Effective for discharge of treated water.	Implementable. SPDES permit required.	Low capital Low O&M

* Indicates process option was selected as a representative process option and included in at least one of the remedial alternatives.

Table 3. *Evaluation of Process Options*

General Response Action	Remedial Technology	Process Option	Effectiveness	Implementability	Costs
Discharge (continued)	Treated water discharge (continued)	Discharge to ground water	Effective for discharge of treated water. Frequent mainentance potentially required to address fouling.	Not likely implementable. Injection permits required.	Medium capital Medium O&M

* Indicates process option was selected as a representative process option and included in at least one of the remedial alternatives.

Table 4. *Components of Remedial Alternatives*

General Response Actions	Remedial Technology / Process Option	1	2	3	4
Institutional Controls	Environmental Easement		x	x	x
	Site Management Plan		x	x	x
	Ground Water Monitoring		x	x	x
In Situ Treatment	Enhanced Bioremediation			x	
	Conductive Heating			x	
	Monitored Natural Attenuation		x		
Removal	Excavation				x
Disposal	Off-Site Landfill Disposal				x
Collection and Extraction	Recovery Wells				x
Ex Situ Treatment	Physical Treatment - Settling, Filtration, Air Stripping, Carbon Adsorption				x
Discharge	Discharge of Treated Ground Water to Storm Sewer				x

Alternative 1: No action
Alternative 2: Monitored Natural Attenuation
Alternative 3a: *In Situ* Biological Treatment
Alternative 3b: *In Situ* Biological and Thermal Treatment
Alternative 4: Soil Excavation and Ground Extraction/Treatment/Discharge

Table 5
Ground Water Monitoring Requirements

Former Duso Chemical
Poughkeepsie, New York

Monitoring Well ID/Sample Location	Sampling Frequency for VOCs				
	First Two Years		Following Second Year		
	Quarterly	Semi-Annually	Quarterly	Semi-Annually	Annually
Background Monitoring Wells					
OBG-1S		X			X
OBG-2S		X		X	
OBG-4S		X			X
OBG-5S		X		X	
OBG-14B		X			X
Plume Monitoring Wells					
OBG-10S	X			X	
OBG-11S	X		X		
OBG-11B	X			X	
MHC-24	X		X		
MHC-26	X		X		
MHC-27	X		X		
MHBP-12	X		X		
MHBP-13S	X		X		
MHBP-13D	X			X	
MHBP-15	X		X		
MHBP-28	X			X	
MHBP-29	X		X		
Down Gradient Monitoring Wells					
OBG-8S	X			X	
OBG-12S	X			X	

Notes:

1. Groundwater samples will be analyzed for VOCs using USEPA SW-846 Methods 8021 or 8260.
2. Water levels will be obtained from all accessible monitoring wells on a quarterly basis. Water levels will be measured manually in the field to the nearest 0.01 foot using an electronic water level probe.

Table 6. Detailed analysis of alternatives

Criterion	Alternative 1: No action	Alternative 2: Monitored Natural Attenuation	Alternative 3a: *In Situ* Biological Treatment	Alternative 3b: *In Situ* Thermal and Biological Treatment	Alternative 4 Soil Excavation and Ground Water Extraction/Treatment/Discharge
		• Environmenal easement • Site management plan • Natural attenuation of VOCs	• Environmenal easement • Site management plan • *In situ* biological treatment	• Environmenal easement • Site management plan • *In situ* thermal treatment • *In situ* biological treatment	• Environmenal easement • Site management plan • Soil excavation • Soil landfill disposal • Ground water extraction • Ground water treatment • Treated ground water discharge
Overall protection of human health and the environment					
Overall protection of human health	Would not provide means to mitigate potential risks associated with soil and ground water. Relies on natural attenuation to address potential risks associated with future ground water use.	Protection of human health is provided through institutional controls precluding ground water use and restricting land use and building use. Additional protection to human receptors provided by planned trail paving. Natural attenuation would reduce potential risks associated with future ground water use.	Protection of human health is provided through institutional controls precluding ground water use and restricting land use and building use. Additional protection to human receptors provided by planned trail paving. Active ground water remediation would reduce potential risks associated with future ground water use.	Protection of human health is provided through institutional controls precluding ground water use and restricting land use and building use. Additional protection to human receptors provided by planned trail paving. Active ground water remediation would reduce potential risks associated with future ground water use. Soil treatment would provide added protection by reducing potential risks associated with off-site soil.	Protection of human health is provided through institutional controls precluding ground water use and restricting land use and building use. Additional protection to human receptors provided by planned trail paving. Soil excavation and disposal would provide added protection of human health by reducing potential risks associated with on-site soil. Active ground water remediation would address potential risks associated with future ground water use.
Overall protection of the environment	Relies on natural attenuation to protect ground water and surface water. Protection to ecological receptors provided by planned trail paving.	Relies on natural attenuation to protect ground water and surface water. Protection to ecological receptors provided by planned trail paving.	Protection of the environment is provided through active remediation of ground water. Protection to ecological receptors provided by planned trail paving.	Protection of the environment is provided through active remediation of ground water and off-site soil. Protection to ecological receptors provided by planned trail paving.	Protection of the environment is provided through on-site soil removal and active remediation of ground water. Protection to ecological receptors provided by planned trail paving.
Compliance with standards, criteria, and guidance (SCGs)					
Compliance with chemical-specific SCGs	Relies on natural attenuation to achieve ground water and surface water SCGs. Reduction expected, but attainment of SCGs likely technically impracticable due to the likely presence of residual source material in unknown locations. Soil and indoor air SCGs not addressed.	Relies on natural attenuation to attain ground water and surface water SCGs. Reduction expected, but attainment of ground water SCGs likely technically impracticable due to the likely presence of residual source material in unknown locations. Achieves compliance with indoor air SCGs through VI IRM O&M. Soil SCGs addressed through institutional controls.	Achieves compliance with indoor air SCGs through VI IRM O&M. Significant reduction in ground water concentrations, and subsequently surface water concentrations, expected, but attainment of ground water SCGs likely technically impracticable due to the likely presence of residual source material in unknown locations. Soil SCGs addressed through institutional controls.	Achieves soil SCGs off-site with thermal treatment. Achieves compliance with indoor air SCGs through VI IRM O&M. Significant reduction in ground water concentrations, and subsequently surface water concentrations, expected, but attainment of ground water SCGs likely technically impracticable due to the likely presence of residual source material in unknown locations. On-site soil SCGs addressed through institutional controls.	Achieves soil SCGs through excavation. Achieves compliance with indoor air SCGs through VI IRM O&M. Significant reduction in ground water concentrations expected, but attainment of SCGs likely technically impracticable due to the likely presence of residual source material in unknown locations. Attainment of surface water SCGs expected with ground water extraction.
Compliance with location-specific SCGs	Would not damage habitat of endangered or threatened species, complying with SCGs.	Would not damage habitat of endangered or threatened species, complying with SCGs.	Would not damage habitat of endangered or threatened species, complying with SCGs.	Would not damage habitat of endangered or threatened species, complying with SCGs.	Would not damage habitat of endangered or threatened species, complying with SCGs.
Compliance with action-specific SCGs	No actions are included in this alternative.	Construction activities would be conducted consistent with OSHA safety requirements.	Construction activities would be conducted consistent with OSHA safety requirements.	Construction activities would be conducted consistent with OSHA safety requirements.	Construction activities would be conducted consistent with air quality standards and in accordance with OSHA safety requirements. Treatment systems would be operated consistent with applicable state and federal requirements. Wastes generated by the treatment process would be managed, transported and disposed of in accordance with applicable state and federal requirements.
Long-term effectiveness and permanence					

Table 6. Detailed analysis of alternatives

Criterion	Alternative 1: No action	Alternative 2: Monitored Natural Attenuation	Alternative 3a: *In Situ* Biological Treatment	Alternative 3b: *In Situ* Thermal and Biological Treatment	Alternative 4 Soil Excavation and Ground Water Extraction/Treatment/Discharge
		• **Environmenal easement** • **Site management plan** • **Natural attenuation of VOCs**	• **Environmenal easement** • **Site management plan** • ***In situ* biological treatment**	• **Environmenal easement** • **Site management plan** • ***In situ* thermal treatment** • ***In situ* biological treatment**	• **Environmenal easement** • **Site management plan** • **Soil excavation** • **Soil landfill disposal** • **Ground water extraction** • **Ground water treatment** • **Treated ground water discharge**
Magnitude of residual risk	Potential residual risk associated with soil, ground water, surface water, and indoor air.	Minimal residual risk of exposure to soil by land use controls and trail paving. Minimal residual risk of exposure to ground water by natural attenuation and use controls. Minimal residual risk of exposure to indoor air through use controls and VI IRM O&M.	Minimal residual risk of exposure to soil by land use controls and trail paving. Minimal residual risk of exposure to ground water by treatment and use controls. Minimal residual risk of exposure to indoor air through use controls and VI IRM O&M.	Minimal residual risk of exposure to soil by land use controls, trail paving, and off-site treatment. Minimal residual risk of exposure to ground water by treatment and use controls. Minimal residual risk of exposure to indoor air through use controls and VI IRM O&M.	Minimal residual risk of exposure to soil by removal, trail paving, and land use controls. Minimal residual risk of exposure to ground water by extraction and use controls. Minimal residual risk of exposure to indoor air through use controls and VI IRM O&M.
Adequacy and reliability of controls	No controls are included in this alternative.	Institutional controls are reliable means of managing potential risks associated with soil, ground water, surface water and indoor air. VI IRM O&M adequate and reliable means of controlling potential risks associated with indoor air. Monitoring of ground water provides effective means of evaluating potential risks. Paving of trail surface soil is an adequate control of exposures to surface soils.	Institutional controls are reliable means of managing potential risks associated with soil, ground water and indoor air. Active treatment of ground water provides added control of potential risks associated with ground water. VI IRM O&M adequate and reliable means of controlling potential risks associated with indoor air. Monitoring of ground water provides effective means of evaluating potential risks. Paving of trail surface soil is an adequate control of exposures to surface soils.	Institutional controls are reliable means of managing potential risks associated with soil, ground water and indoor air. Treatment of off-site soil provides added control of potential risks. Active treatment of ground water provides added control of potential risks associated with ground water. VI IRM O&M adequate and reliable means of controlling potential risks associated with indoor air. Monitoring of ground water provides effective means of evaluating potential risks. Paving of trail surface soil is an adequate control of exposures to surface soils.	Institutional controls are reliable means of managing potential risks associated with soil, ground water and indoor air. Excavation of on-site soil provides added mitigation of potential risks associated with soil. Active treatment of ground water provides added control of potential risks associated with ground water. VI IRM O&M adequate and reliable means of controlling potential risks associated with indoor air. Monitoring of ground water provides effective means of evaluating potential risks. Paving of trail surface soil is an adequate control of exposures to surface soils.
Reduction of toxicity, mobility, or volume through treatment					
Treatment process used and materials treated	Natural attenuation of VOCs in ground water.	Natural attenuation of VOCs in ground water.	*In situ* biological treatment would treat VOCs in ground water.	*In situ* thermal treatment would treat VOCs in off-site soil and *in situ* biological treatment would treat VOCs in ground water.	*Ex situ* air stripping and activated carbon would treat VOCs in ground water.
Amount of hazardous material destroyed or treated	An approximate 2-acre ground water plume would be treated by natural attenuation.	An approximate 2-acre ground water plume would be treated by natural attenuation.	An approximate 2-acre ground water plume would be treated by *in situ* biological treatment.	An approximate 2-acre ground water plume would be treated by *in situ* biological and thermal treatments. Approximately 1011 cu yd of soil would be treated by *in situ* thermal treatment.	An approximate 2-acre ground water plume would be treated by ground water extraction/treatment/discharge. Up to 54 gpm is anticipated to be extracted and treated (up to approximately 28 million gallons per year).
Degree of expected reduction in toxicity, mobility, or volume	Natural attenuation expected to continue to reduce chlorinated organic concentrations in ground water.	Natural attenuation expected to continue to reduce chlorinated organic concentrations in ground water.	*In situ* biological treatment expected to accelerate reduction of chlorinated organic concentrations in ground water.	*In situ* thermal treatment expected to reduce concentrations in MHBP saturated zone to SCGs. *In situ* biological treatment expected to accelerate reduction of chlorinated organic concentrations in ground water.	Ground water extraction expected to accelerate reduction of chlorinated organic concentrations in ground water.
Degree to which treatment is irreversible	Natural attenuation of ground water is irreversible. Residual source material presents a continuing source, thus is detrimental to degree of treatment achieved.	Natural attenuation of ground water is irreversible. Residual source material presents a continuing source, thus is detrimental to degree of treatment achieved.	*In situ* biological treatment of ground water is irreversible. Residual source material presents a continuing source, thus is detrimental to degree of treatment achieved.	*In situ* thermal treatment of soil and *in situ* biological treatment of ground water are irreversible. Effective treatment of residual source material is achieved in this alternative.	Treatment of ground water is irreversible. Residual source material presents a continuing source, thus is detrimental to degree of treatment achieved.

Table 6. Detailed analysis of alternatives

Criterion	Alternative 1: No action	Alternative 2: Monitored Natural Attenuation	Alternative 3a: *In Situ* Biological Treatment	Alternative 3b: *In Situ* Thermal and Biological Treatment	Alternative 4 Soil Excavation and Ground Water Extraction/Treatment/Discharge
		• **Environmenal easement** • **Site management plan** • **Natural attenuation of VOCs**	• **Environmenal easement** • **Site management plan** • ***In situ* biological treatment**	• **Environmenal easement** • **Site management plan** • ***In situ* thermal treatment** • ***In situ* biological treatment**	• **Environmenal easement** • **Site management plan** • **Soil excavation** • **Soil landfill disposal** • **Ground water extraction** • **Ground water treatment** • **Treated ground water discharge**
Type and quantity of residuals remaining after treatment	Residual chlorinated organics anticipated due to likely presence of residual source material.	Residual chlorinated organics anticipated due to likely presence of residual source material.	Residual chlorinated organics may be present in ground water following treatment, to be reduced further by natural attenuation.	Residual chlorinated organics may be present in ground water following treatment, to be reduced further by natural attenuation. Treatment processes result in treatment wastes that require proper management.	Residual chlorinated organics may be present in ground water following treatment, to be reduced further by natural attenuation. Treatment processes result in treatment wastes that require proper management.
Short-term effectiveness					
Protection of community during remedial actions	No remedial actions are considered under this alternative.	No remedial actions are considered under this alternative.	Proper health and safety measures will be established and implemented during remedial activities.	Proper health and safety measures will be established and implemented during remedial activities.	Dust, if any, will be controlled during excavation and construction. Air stripper emissions will be monitored and controlled if necessary.
Protection of workers during remedial actions	No remedial actions are considered under this alternative.	No remedial actions are considered under this alternative.	Proper health and safety measures will be established and implemented during remedial activities.	Proper health and safety measures will be established and implemented during remedial activities.	Proper health and safety measures will be established and implemented during remedial activities.
Environmental impacts	There are no environmental impacts expected as a result of implementation of this alternative.	There are no environmental impacts expected as a result of implementation of this alternative.	There are no environmental impacts expected as a result of implementation of this alternative.	There are no environmental impacts expected as a result of implementation of this alternative.	Dust, volatile emissions, and surface runoff controls will be instituted to minimize impacts to the environment during implementation of this alternative.
Time until remedial action objectives are achieved	Would not provide for attainment of remedial objectives.	Institutional actions, trail paving, and VI IRM O&M would provide for attainment of remedial objectives related to soil , indoor air, surface water, and ground water risk mitigation immediately following implementation. Estimated timeframe for minimization of off-site migration of ground water exceeding SCGs is unknown (greater than 30 yrs), but is expected to be longer than Alternatives 3 and 4.	Institutional actions, trail paving, and VI IRM O&M would provide for attainment of remedial objectives related to soil , indoor air, surface water, and ground water risk mitigation immediately following implementation. Estimated timeframe for minimization of off-site migration of ground water exceeding SCGs is unknown (greater than 30 years), but is expected to be shorter than Alternative 2, and longer than Alternatives 3b and 4.	Institutional actions, trail paving, and VI IRM O&M would provide for attainment of remedial objectives related to soil , indoor air, surface water, and ground water risk mitigation immediately following implementation. Concentrations of COCs would be reduced in the shortest time period with this alternative. Estimated timeframe for minimization of off-site migration of ground water exceeding SCGs is unknown (greater than 30 yrs), but is expected to be shorter than Alternatives 2 and 3a, and longer than Alternative 4.	Institutional actions, trail paving, and VI IRM O&M would provide for attainment of remedial objectives related to indoor air, surface water, and ground water risk mitigation immediately following implementation. Soil removal would provide for attainment of remedial objectives related to soil immediately following implementation. Ground water extraction would provide for attainment of remedial objective related to minimization of off-site migration of ground water exceeding SCGs immediately following implementation.
Implementability					
Ability to construct and operate the technology	There are no technologies in this alternative.	There are no technologies in this alternative.	Injection wells for *in situ* biological treatment could be readily constructed.	Injection wells for *in situ* biological treatment could be readily constructed. An *in situ* thermal treatment system could be readily constructed and operated.	A ground water extraction/treatment/discharge system could be readily constructed and operated. Soil could be readily excavated and disposed.

Table 6. Detailed analysis of alternatives

Criterion	Alternative 1: No action	Alternative 2: Monitored Natural Attenuation	Alternative 3a: *In Situ* Biological Treatment	Alternative 3b: *In Situ* Thermal and Biological Treatment	Alternative 4 Soil Excavation and Ground Water Extraction/Treatment/Discharge
		• **Environmenal easement** • **Site management plan** • **Natural attenuation of VOCs**	• **Environmenal easement** • **Site management plan** • ***In situ* biological treatment**	• **Environmenal easement** • **Site management plan** • ***In situ* thermal treatment** • ***In situ* biological treatment**	• **Environmenal easement** • **Site management plan** • **Soil excavation** • **Soil landfill disposal** • **Ground water extraction** • **Ground water treatment** • **Treated ground water discharge**
Reliability of technology	There are no technologies in this alternative. Based on historical data, natural attenuation resulting in reduction of VOC concentrations in ground water is occurring at the site. The presence of residual source material limits the ability of natural attenuation to attain ground water standards.	There are no technologies in this alternative. Based on historical data, natural attenuation resulting in reduction of VOC concentrations in ground water is occurring at the site. The presence of residual source material limits the ability of natural attenuation to attain ground water standards. Ground water sampling and analysis is a reliable means to monitor the effectiveness of ground water treatment.	*In situ* biological treatment is a reliable means of reducing VOC concentrations in ground water. Based on historical data, biological processes resulting in reduction of VOC concentrations in ground water are occurring at the site. The presence of residual source material limits the ability of biological treatment to attain ground water standards. Ground water sampling and analysis is a reliable means to monitor the effectiveness of ground water treatment.	*In situ* biological treatment is a reliable means of reducing VOC concentrations in ground water. Based on historical data, biological processes resulting in reduction of VOC concentrations in ground water are occurring at the site. The presence of residual source material limits the ability of biological treatment to attain ground water standards. Ground water sampling and analysis is a reliable means to monitor the effectiveness of ground water treatment. *In situ* thermal treatment is a reliable means of reducing VOCs in off-site ground water and soil.	Ground water extraction is a reliable means of reducing VOC concentrations in ground water. The presence of residual source material limits the ability of natural attenuation to attain ground water standards. Ground water sampling and analysis is a reliable means to monitor the effectiveness of ground water extraction. On-site soil excavation and disposal is a reliable approach for soil.
Ease of undertaking additional remedial actions, if necessary	Additional remedial actions, if necessary, would be readily implementable.	Additional remedial actions, if necessary, would be readily implementable.	Additional remedial actions, if necessary, would be readily implementable.	Additional remedial actions, if necessary, would be readily implementable.	Additional remedial actions, if necessary, would be readily implementable.
Ability to monitor effectiveness of remedy	Not applicable.	Effectiveness of remedy could be monitored through sampling of ground water.	Effectiveness of remedy could be monitored through sampling of ground water.	Effectiveness of remedy could be monitored through sampling of ground water.	Effectiveness of remedy could be monitored through sampling of ground water.
Coordination with other agencies and property owners	No coordination necessary.	Coordination with local authorities and off site property owners would be necessary to implement environmental easement and monitoring program.	Coordination with local authorities and off site property owners would be necessary to implement environmental easement and monitoring program. Coordination with off-site property owners required to implement *in situ* biological treatment. Agency approval of injection required.	Coordination with local authorities and off-site property owners would be necessary to implement environmental easement and monitoring program. Coordination with off-site property owners required to implement *in situ* thermal and biological treatment. Agency approval of injection required.	Coordination with local authorities and off-site property owners would be necessary to implement environmental easement and monitoring program. Coordination with off-site property owners required for extraction well installation and maintenance. Agency approval of air and water discharges required.
Availability of off-site treatment storage and disposal services and capacities	None required.	None required.	None required.	Disposal services would be readily available for management of treatment residuals.	Disposal services would be readily available for management of soil and treatment residuals.
Availability of necessary equipment, specialists, and materials	None required.	None required.	Readily available.	Readily available.	Readily available.
Costs					
Capital cost	$0	$200,000	$670,000	$1,610,000	$2,040,000
Present worth of operation and maintenance cost	$40,000	$1,100,000	$1,060,000	$870,000	$3,810,000
Approximate total net present worth cost	$40,000	$1,300,000	$1,730,000	$2,480,000	$5,850,000

Table 7
REMEDIAL ALTERNATIVE COST SUMMARY

Alternative #1 - No Action

O'BRIEN & GERE **COST ESTIMATE SUMMARY**

Site: Former Duso Chemical Facility
Location: 33 Fulton St. Poughkeepsie, New York
Phase: Feasibility Study (-30% to +50%)
Base Year: 2007

Description: Alternative #1 is the "No Action" alternative, as required by NYSDEC Draft DER-10 for baseline comparison, and consists only of periodic site reviews.

ITEM	UNIT	ESTIMATED QUANTITY	ESTIMATED UNIT COST	ESTIMATED COST		NOTES
Direct Capital Costs						
No direct capital costs.						
				TOTAL DIRECT CAPITAL COST:	$0	
Indirect Capital Costs						
No indirect capital costs.						
				TOTAL INDIRECT CAPITAL COSTS:	$0	
				TOTAL CAPITAL COSTS:	$0	
Operation & Maintenance Costs						
1) Periodic review	LS	1	$10,000	$10,000		Assumed to occur every 5th year
				PRESENT WORTH OF O&M COSTS:	$40,000	Assumes 30 years of O&M and discount rate of 3%.
				APPROXIMATE TOTAL PRESENT WORTH COST:	$40,000	

Table 8
REMEDIAL ALTERNATIVE COST SUMMARY

Alternative #2 - Monitored Natural Attenuation

O'BRIEN & GERE

COST ESTIMATE SUMMARY

Site: Former Duso Chemical Facility
Location: 33 Fulton St. Poughkeepsie, New York
Phase: Feasibility Study (-30% to +50%)
Base Year: 2007

Description: Alternative #2 consists of monitored natural attenuation, ground water monitoring for VOCs, a site management plan, and an environmental easement.

ITEM	UNIT	ESTIMATED QUANTITY	ESTIMATED UNIT COST	ESTIMATED COST		NOTES
Direct Capital Costs						
1) Site Management Plan	LS	1	$20,000	$20,000		
				SUBTOTAL:	$20,000	
2) Environmental Easement						
Ground water use restrictions	LS	1	$15,000	$15,000		
Building/property use restrictions	LS	1	$10,000	$10,000		
Institutional controls plan	LS	1	$20,000	$20,000		
Site information database	LS	1	$25,000	$25,000		
				SUBTOTAL:	$70,000	
3) Ground Water Monitoring - MNA Baseline	LS	1	$45,000	$45,000		Assumes quarterly monitoring
				SUBTOTAL:	$45,000	
				TOTAL DIRECT CAPITAL COST:	$135,000	
Indirect Capital Costs						
1) Contingency (30% of Direct Capital Costs)		1	$40,500	$40,500		
				SUBTOTAL:	$40,500	
2) Engineering (15% of Direct Capital Costs)		1	$20,250	$20,250		
				SUBTOTAL:	$20,250	
3) Legal Fees (5% of Direct Capital Costs)		1	$3,500	$3,500		
				SUBTOTAL:	$3,500	
				TOTAL INDIRECT CAPITAL COSTS (rounded):	$64,000	
				TOTAL CAPITAL COSTS (rounded):	$200,000	
Operation & Maintenance Costs						
1) Periodic review	LS	1	$10,000	$10,000		Required by site management plan; assumed to occur every 5th year
2) Ground Water Monitoring - VOCs Only - Years 1 and 2	LS	1	$33,000	$33,000		Assumes quarterly monitoring for 14 wells and semi-annual monitoring for 5 wells.
3) Ground Water Monitoring - VOCs Only - Years 3 to 30	LS	1	$29,000	$29,000		Quarterly monitoring for 8 wells, semi-annual monitoring for 8 wells, and annual monitoring for 3 wells.
4) Ground Water Monitoring - MNA - Years 1 to 30	LS	1	$22,000	$22,000		Assumes semi-annual monitoring of 12 wells.
5) Reserve Fund (1% of Direct Capital Costs)	LS	1	$1,350	$1,350		Annual expense; Years 1 through 30
6) Insurance (1% of Direct Capital Costs)	LS	1	$1,350	$1,350		Annual expense; Years 1 through 30
				PRESENT WORTH OF O&M COSTS (rounded):	$1,100,000	Assumes 30 years of O&M and discount rate of 3%.
				APPROXIMATE TOTAL PRESENT WORTH COST:	$1,300,000	

Table 9
REMEDIAL ALTERNATIVE COST SUMMARY

Alternative #3a - *In Situ* Biological Treatment

O'BRIEN & GERE

COST ESTIMATE SUMMARY

Site: Former Duso Chemical Facility
Location: 33 Fulton St. Poughkeepsie, New York
Phase: Feasibility Study (-30% to +50%)
Base Year: 2007

Description: Alternative #3a consists of *in situ* enhanced in situ biodegradation for treatment of VOCs on both the former Duso and MHBP properties, ground water monitoring, a site management plan, and an environmental easement.

ITEM	UNIT	ESTIMATED QUANTITY	ESTIMATED UNIT COST	ESTIMATED COST		NOTES
Direct Capital Costs						
1) Site Management Plan	LS	1	$20,000	$20,000		
				SUBTOTAL:	$20,000	
2) Environmental Easement						
Ground water use restrictions	LS	1	$15,000	$15,000		
Building/property use restrictions	LS	1	$10,000	$10,000		
Institutional controls plan	LS	1	$20,000	$20,000		
Site information database	LS	1	$25,000	$25,000		
				SUBTOTAL:	$70,000	
3) Enhanced *In Situ* Biodegradation System - Benchscale Testing						
Microcosm Study	LS	1	$30,000	$30,000		
Genetic Testing	LS	1	$20,000	$20,000		
				SUBTOTAL:	$50,000	
4) Enhanced *In Situ* Biodegradation System - Installation	LS	1	$100,000	$100,000		Installation of 28 injection wells.
				SUBTOTAL:	$100,000	
5) Enhanced *In Situ* Biodegradation System - Initial Injections						
Materials and Labor	LS	1	$100,000	$100,000		Assumes bimonthly injections.
Sampling and Laboratory Analysis	LS	1	$120,000	$120,000		Assumes biweekly sampling for the first two months and monthly sampling thereafter.
				SUBTOTAL:	$220,000	
			TOTAL DIRECT CAPITAL COST (rounded):		$460,000	
Indirect Capital Costs						
1) Contingency (30% of Direct Capital Costs)	LS	1	$138,000	$138,000		
				SUBTOTAL:	$138,000	
2) Engineering (15% of Direct Capital Costs)	LS	1	$69,000	$69,000		
				SUBTOTAL:	$69,000	
3) Legal Fees (5% of Direct Capital Costs)	LS	1	$3,500	$3,500		
				SUBTOTAL:	$3,500	
4) Construction Performance Bond (1.25% Direct Capital Construction Costs) (Based on capital installation costs)	LS	1	$1,000	$1,000		
				SUBTOTAL:	$1,000	
			TOTAL INDIRECT CAPITAL COSTS (rounded):		$210,000	
			TOTAL CAPITAL COSTS:		$670,000	

Table 9
REMEDIAL ALTERNATIVE COST SUMMARY

Alternative #3a - *In Situ* Biological Treatment

O'BRIEN & GERE

COST ESTIMATE SUMMARY

Site: Former Duso Chemical Facility
Location: 33 Fulton St. Poughkeepsie, New York
Phase: Feasibility Study (-30% to +50%)
Base Year: 2007

Description: Alternative #3a consists of *in situ* enhanced in situ biodegradation for treatment of VOCs on both the former Duso and MHBP properties, ground water monitoring, a site management plan, and an environmental easement.

ITEM	UNIT	ESTIMATED QUANTITY	ESTIMATED UNIT COST	ESTIMATED COST		NOTES
Operation & Maintenance Costs						
1) Periodic review	LS	1	$10,000	$10,000		Required by site management plan; assumed to occur every 5th year
2) Ground Water Monitoring - VOCs Only - Years 1 and 2	LS	1	$33,000	$33,000		Assumes quarterly monitoring for 14 wells and semi-annual monitoring for 5 wells.
3) Ground Water Monitoring - VOCs Only - Years 3 to 30	LS	1	$29,000	$29,000		Quarterly monitoring for 8 wells, semi-annual monitoring for 8 wells, and annual monitoring for 3 wells.
4) Enhanced *In Situ* Biodegradation Injections	LS	1	$100,000	$100,000		Assumes annual injections in Years 2, 4, & 6; Includes materials, labor, and analysis
5) Reserve Fund (1% of Direct Capital Costs)	LS	1	$4,600	$4,600		Annual expense; Years 1 through 30
6) Insurance (1% of Direct Capital Costs)	LS	1	$4,600	$4,600		Annual expense; Years 1 through 30
		PRESENT WORTH OF O&M COSTS (rounded):			**$1,060,000**	Assumes 30 years of O&M and discount rate of 3%.
		APPROXIMATE TOTAL PRESENT WORTH COST:			**$1,730,000**	

Table 10
REMEDIAL ALTERNATIVE COST SUMMARY

Alternative #3b - *In Situ* Biological and Thermal Treatment

O'BRIEN & GERE

COST ESTIMATE SUMMARY

Site: Former Duso Chemical Facility
Location: 33 Fulton St. Poughkeepsie, New York
Phase: Feasibility Study (-30% to +50%)
Base Year: 2007

Description: Alternative #3b consists of *in situ* thermal desorption for treatment of VOCs on the MHBP property and enhanced *in situ* biodegradation for treatment of VOCs on the former Duso property, ground water monitoring, a site management plan, and an environmental easement.

ITEM	UNIT	ESTIMATED QUANTITY	ESTIMATED UNIT COST	ESTIMATED COST		NOTES
Direct Capital Costs						
1) Site Management Plan	LS	1	$20,000	$20,000		
				SUBTOTAL:	**$20,000**	
2) Environmental Easement						
Ground water use restrictions	LS	1	$15,000	$15,000		
Building/property use restrictions	LS	1	$10,000	$10,000		
Institutional controls plan	LS	1	$20,000	$20,000		
Site information database	LS	1	$25,000	$25,000		
				SUBTOTAL:	**$70,000**	
3) *In Situ* Thermal Desorption System - Installation						Based on cost estimate provided by TerraTherm
Design and permitting	LS	1	$50,000	$50,000		
Procurement and mobilization	LS	1	$40,000	$40,000		
Installation of wells and heaters	LS	1	$160,000	$160,000		
Vapor cover and insulation	LS	1	$20,000	$20,000		
Electrical construction	LS	1	$55,000	$55,000		
Mechanical construction	LS	1	$35,000	$35,000		
Vapor and water treatment system	LS	1	$110,000	$110,000		
Commissioning	LS	1	$35,000	$35,000		
				SUBTOTAL:	**$505,000**	
4) *In Situ* Thermal Desorption System - Operation						Based on cost estimate provided by TerraTherm
Maintenance	LS	1	$20,000	$20,000		
	LS	1	$100,000	$100,000		
Sampling and analysis	LS	1	$10,000	$10,000		
Waste disposal	LS	1	$25,000	$25,000		
Rental and fees	LS	1	$15,000	$15,000		
Power	LS	1	$110,000	$110,000		
				SUBTOTAL:	**$280,000**	
5) *In Situ* Thermal Desorption System - Decommissioning						Based on cost estimate provided by TerraTherm
Demobilization	LS	1	$30,000	$30,000		
Reporting	LS	1	$10,000	$10,000		
				SUBTOTAL:	**$40,000**	
6) Enhanced *In Situ* Biodegradation System - Pilot Testing						
Microcosm Study	LS	1	$15,000	$15,000		
Genetic Testing	LS	1	$10,000	$10,000		
				SUBTOTAL:	**$25,000**	
6) Enhanced *In Situ* Biodegradation System - Installation	LS	1	$50,000	$50,000		Installation of injection 14 wells.
				SUBTOTAL:	**$50,000**	
7) Enhanced *In Situ* Biodegradation System - Initial Injections						
Materials, Labor, and Equipment	LS	1	$50,000	$50,000		Assumes bimonthly injections.
Laboratory Analysis	LS	1	$60,000	$60,000		Assumes biweekly sampling for the first two months and monthly sampling thereafter.
				SUBTOTAL:	**$110,000**	
				TOTAL DIRECT CAPITAL COST (rounded):	$1,100,000	

Table 10
REMEDIAL ALTERNATIVE COST SUMMARY

Alternative #3b - *In Situ* Biological and Thermal Treatment

O'BRIEN & GERE **COST ESTIMATE SUMMARY**

Site: Former Duso Chemical Facility
Location: 33 Fulton St. Poughkeepsie, New York
Phase: Feasibility Study (-30% to +50%)
Base Year: 2007

Description: Alternative #3b consists of *in situ* thermal desorption for treatment of VOCs on the MHBP property and enhanced *in situ* biodegradation for treatment of VOCs on the former Duso property, ground water monitoring, a site management plan, and an environmental easement.

ITEM	UNIT	ESTIMATED QUANTITY	ESTIMATED UNIT COST	ESTIMATED COST		NOTES
Indirect Capital Costs						
1) Contingency (30% of Direct Capital Costs)	LS	1	$330,000	$330,000		
				SUBTOTAL:	$330,000	
2) Engineering (15% of Direct Capital Costs)	LS	1	$165,000	$165,000		
				SUBTOTAL:	$165,000	
3) Legal Fees (5% of Direct Capital Costs)	LS	1	$3,500	$3,500		
				SUBTOTAL:	$3,500	
4) Construction Performance Bond (1.25% Direct Capital Construction Costs) (Based on capital installation costs)	LS	1	$7,000	$7,000		
				SUBTOTAL:	$7,000	
		TOTAL INDIRECT CAPITAL COSTS (rounded):			$510,000	
			TOTAL CAPITAL COSTS:		$1,610,000	
Operation & Maintenance Costs						
1) Periodic review	LS	1	$10,000	$10,000		Required by site management plan; assumed to occur every 5th year
2) Ground Water Monitoring - VOCs Only - Years 1 and 2	LS	1	$33,000	$33,000		Assumes quarterly monitoring for 14 wells and semi-annual monitoring for 5 wells.
3) Ground Water Monitoring - VOCs Only - Years 3 to 30	LS	1	$29,000	$29,000		Quarterly monitoring for 8 wells, semi-annual monitoring for 8 wells, and annual monitoring for 3 wells.
4) Enhanced *In Situ* Biodegradation Injections	LS	1	$50,000	$50,000		Assumes annual injections in Years 2, 4, & 6; Includes materials, labor, and analysis
5) Reserve Fund (1% of Direct Capital Costs), Year 1	LS	1	$11,000	$11,000		
6) Reserve Fund (1% of Direct Capital Costs without ISTD costs), Years 2 to 30	LS	1	$2,750	$2,750		
7) Insurance (1% of Direct Capital Costs), Year 1	LS	1	$11,000	$11,000		
8) Insurance (1% of Direct Capital Costs without ISTD costs), Years 2 to 30	LS	1	$2,750	$2,750		
		PRESENT WORTH OF O&M COSTS (rounded):			$870,000	Assumes 30 years of O&M and discount rate of 3%.
		APPROXIMATE TOTAL PRESENT WORTH COST:			$2,480,000	

Table 11
REMEDIAL ALTERNATIVE COST SUMMARY

Alternative #4 - *Ex Situ* Soil and Ground Water Treatment

O'BRIEN & GERE

COST ESTIMATE SUMMARY

Site: Former Duso Chemical Facility
Location: 33 Fulton St. Poughkeepsie, New York
Phase: Feasibility Study (-30% to +50%)
Base Year: 2007

Description: Alternative #4 consists of soil excavation and disposal on the former Duso property and ground water extraction/treatment/discharge system for ground water on both properties, ground water monitoring, a site management plan, and an environmental easement.

ITEM	UNIT	ESTIMATED QUANTITY	ESTIMATED UNIT COST	ESTIMATED COST		NOTES
Direct Capital Costs						
1) Site Management Plan	LS	1	$20,000	$20,000		
				SUBTOTAL:	**$20,000**	
2) Environmental Easement						
Ground water use restrictions	LS	1	$15,000	$15,000		
Building/property use restrictions	LS	1	$10,000	$10,000		
Institutional controls plan	LS	1	$20,000	$20,000		
Site information database	LS	1	$25,000	$25,000		
				SUBTOTAL:	**$70,000**	
3) Ground Water Extractio/Treatment/Discharge System - Pre-design Field Study	LS	1	$40,000	$40,000		
				SUBTOTAL:	**$40,000**	
4) Ground Water Extraction/Treatment/Discharge System - Installation						
Permitting	LS	1	$25,000	$25,000		
Extraction well installation	LS	1	$20,000	$20,000		Installation of 3 extraction wells.
Disposal	LS	1	$5,000	$5,000		
Treatment Train - Including well pumps, piping, and treatment equipment	LS	1	$300,000	$300,000		Based on information provided by Bisco Environmental.
				SUBTOTAL:	**$350,000**	
5) Soil Excavation and Off-Site Disposal						Assumes quarterly injections.
Mobilization	LS	1	$25,000	$25,000		
Soil excavation	CY	1,100	$15	$16,500		
Soil management and construction health and safety monitoring	LS	1	$40,000	$40,000		
Off-site disposal as hazardous waste (including transportation)	TON	2,100	$375	$787,500		
Backfill Material	CY	1,400	$20	$28,000		
Asphalt Replacement	SF	4,800	$5	$24,000		
				SUBTOTAL:	**$921,000**	
				TOTAL DIRECT CAPITAL COST (rounded):	**$1,400,000**	
Indirect Capital Costs						
1) Contingency (30% of Direct Capital Costs)	LS	1	$420,000	$420,000		
				SUBTOTAL:	**$420,000**	
2) Engineering (15% of Direct Capital Costs)	LS	1	$210,000	$210,000		
				SUBTOTAL:	**$210,000**	
3) Legal Fees (5% of Direct Capital Costs)	LS	1	$3,500	$3,500		
				SUBTOTAL:	**$3,500**	
4) Construction Performance Bond (1.25% Direct Capital Construction Costs) (Based on capital installation costs)	LS	1	$4,000	$4,000		
				SUBTOTAL:	**$4,000**	
				TOTAL INDIRECT CAPITAL COSTS (rounded):	**$640,000**	
				TOTAL CAPITAL COSTS:	**$2,040,000**	

Table 11
REMEDIAL ALTERNATIVE COST SUMMARY

Alternative #4 - *Ex Situ* Soil and Ground Water Treatment

O'BRIEN & GERE

COST ESTIMATE SUMMARY

Site: Former Duso Chemical Facility
Location: 33 Fulton St. Poughkeepsie, New York
Phase: Feasibility Study (-30% to +50%)
Base Year: 2007

Description: Alternative #4 consists of soil excavation and disposal on the former Duso property and ground water extraction/treatment/discharge system for ground water on both properties, ground water monitoring, a site management plan, and an environmental easement.

ITEM	UNIT	ESTIMATED QUANTITY	ESTIMATED UNIT COST	ESTIMATED COST		NOTES
Operation & Maintenance Costs						
1) Periodic review	LS	1	$10,000	$10,000		Required by site management plan; assumed to occur every 5th year
2) Ground Water Monitoring - VOCs Only - Years 1 and 2	LS	1	$33,000	$33,000		Assumes quarterly monitoring for 14 wells and semi-annual monitoring for 5 wells.
3) Ground Water Monitoring - VOCs Only - Years 3 to 30	LS	1	$29,000	$29,000		Quarterly monitoring for 8 wells, semi-annual monitoring for 8 wells, and annual monitoring for 3 wells.
4) Ground Water Treatment System Operation	LS	1	$135,000	$135,000		Includes labor, electricity, disposal, sampling, lab analysis, reporting. Operation for 30 yrs
5) Reserve Fund (1% of Direct Capital Costs)	LS	1	$14,000	$14,000		Annual expense; Years 1 through 30
6) Insurance (1% of Direct Capital Costs)	LS	1	$14,000	$14,000		Annual expense; Years 1 through 30
		PRESENT WORTH OF O&M COSTS (rounded):			**$3,810,000**	Assumes 30 years of O&M and discount rate of 3%.
		APPROXIMATE TOTAL PRESENT WORTH COST:			**$5,850,000**	