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1. Introduction

1.1. Purpose

This document presents a Feasibility Study (FS) for a portion of the Three Star Anodizing Site (Three Star Site, Site #314058) that was completed by O'Brien & Gere Engineers, Inc. (O'Brien & Gere) on behalf of the New York State Department of Environmental Conservation (NYSDEC). The portion of the Three Star Site that is addressed by this FS is the Main Plant Site (including the Former Raceway) and the MGP Site (Figure 1). Wappingers Creek adjacent to and downstream of the Three Star Site is addressed in a separate document (O'Brien & Gere 2007a).

The FS process consists of development and screening of remedial action alternatives followed by a development of a detailed analysis of options to establish a basis for selecting a remedy for the Three Star Site. The FS was completed according to guidance provided by the United States Environmental Protection Agency (USEPA) for the evaluation of Sites under Comprehensive Emergency Response, Compensation, and Liability Act (CERCLA) (USEPA 1988). NYSDEC's Department of Environmental Restoration (DER)-10 draft guidance entitled *Technical Guidance for Site Investigation and Remediation* (NYSDEC 2002) was also considered for this analysis.

1.2. Conceptual Site Model

The Conceptual Model presented below summarizes the results of the Remedial Investigation (RI) and the Supplemental Remedial Investigation (SRI) of the Three Star Site (Site RI and Site SRI, respectively). Additional background information is provided in the Three Star Site RI Report (O'Brien & Gere 2007b). Supporting information associated with the evaluation of former metal plating vats that were exposed to the environment after a fire that occurred at the Three Star Site in May 2004 is presented in the Three Star Site SRI Report (O'Brien & Gere 2007c).

- The Three Star Site has been the location of industrial and commercial activities since the 1830s. Past industrial activities include dye manufacturing, metal plating, felt hat and leather manufacturing, ammunition production, and plastic mold injection. Currently, uses of the Three Star Site include a commercial warehouse and an area used for tractor trailer storage (NYSDEC 2003). For the RI, the Three Star Site was subdivided into three areas consisting of the Main Site, the manufactured gas plant (MGP) Site, and the Three Star lagoon.

- The Main Site is occupied by the Axton-Cross Building and four additional buildings designated as buildings 17, 21, 12, and Page Print. Three additional buildings (buildings 15, 16, and 22) were destroyed by a fire at the Three Star Site in 2004. Other areas of the Main Site include paved parking areas and a grassed area adjacent to Wappingers Creek. A retaining wall borders the Main Site along the creek, except bordering the Axton-Cross Building and the MGP Site where there is soil exposed along the creek bank. A former raceway borders the Main Site to the south and drains toward the Three Star lagoon.

- The 2004 fire exposed to the environment twenty-three former metal plating vats (the vats) that were formerly contained in Building 16. The vats contain miscellaneous materials including wood, metal, insulation, and shingles. Liquids that were in the vats following the fire were primarily non-hazardous, although chromium was detected as a characteristic hazardous waste in an aqueous sample collected from Vats 1, 7, and 8. Sludge in the bottoms of the vats is presumed to consist of non-hazardous and hazardous wastes. Mastic adhesives used to affix foam glass insulation material to the walls of the vats included non-friable asbestos containing materials (ACM). Both the glass foam scattered around the vat area and some of the vat walls contained the mastic adhesives with ACM. Roof shingles intermingled with the debris associated with the fire were presumed to be non-friable ACM. The west and north walls of Building 16 remain in place. However, the heat from the fire and the loss of the rest of the building has destabilized those walls.

- The Three Star lagoon historically received industrial discharges. The sediment in the Three Star lagoon ranges from approximately 2 to 11 feet thick with concentrations of volatile organic compounds (VOCs), semi-volatile organic compounds (SVOCs), and inorganic constituents above sediment screening values but below levels that would classify it as a characteristically hazardous waste. The Three Star lagoon is located at the terminal end of the former raceway and it drains to Wappingers Creek.

- The MGP Site is undeveloped with ruins of two gas holders and miscellaneous debris scattered on portions of it. Concrete debris is located on the MGP Site. The creek bank bordering the MGP Site is exposed soil.

- There is a widespread presence of fill material throughout the Three Star Site containing inorganic constituents and polyaromatic hydrocarbons (PAHs). Historical accounts indicate coal cinders from the MGP were used to fill portions of the Three Star Site. Fill materials extend to at least 10 ft below grade. Test pits excavated during the Three Star Site RI identified the presence of coal cinders in fill materials.

- On the Main Site, two primary areas of contaminated soil were identified as potential sources. These areas, consisting of the lower portion of the former raceway and the drywell area, were identified by the link between concentrations detected in shallow ground water, associated soil, and site history. The lower portion of the former raceway exhibits inorganic constituents and PAHs (primarily consisting of naphthalene) that appear to be associated with the documented discharge of industrial wastes to the ground surface in this area of the Three Star Site. The soil and ground water samples collected in the vicinity of the drywell located in the former drum storage area next to the south side of the Axton-Cross Building, exhibited chlorinated VOCs that appear to be associated with past industrial uses. The VOC plume likely extends under the Axton-Cross building.

- Deep ground water also contains inorganic constituents at elevated levels. Although the source of these constituents may be the concentrated material observed in the lower portion of the former raceway or the vats, the mechanism for vertical migration of inorganic constituents to deep ground water is unknown. Furthermore, transport of inorganic constituents to deep ground water from the former raceway or the vats may not be currently active.

- The presence of elevated concentrations of inorganic constituents in deep ground water adjacent to the creek suggests that the creek channel may provide a migration pathway with the potential for ground water to emerge into Wappingers Creek or the Hudson River down gradient of the Three Star Site. The loading of constituents from ground water seepage to the creek or river may not be detected in creek and river due to relative flows that reduce the ability to observe these interactions.

- Sporadic detections of constituents above 6 NYCRR Part 375 Soil Cleanup Objectives for Unrestricted Use (considered for the RI and SRI), as well as sporadic detections of constituents above 6 NYCRR Part 375 Restricted Use Soil Cleanup Objectives for Commercial Use (considered for the FS) in individual samples of soil may be associated with heterogeneous fill material and do not appear to represent source areas. Comparison of data from such samples with samples of soil and ground water collected from nearby locations were used to corroborate this inference.

- Current and future uses of the Three Star Site are expected to be commercial. Potential human exposure pathways are primarily associated with the inhalation of indoor air by workers inside the Axton-Cross Building due to the VOC plume located in the vicinity of it and indoor air of other buildings on the Three Star Site. Additional pathways include potential human contact with surface soil and fugitive dust at the Three Star Site, and surface water and sediment of the Three Star lagoon. The potential for contact with surface soil on the Main Site is limited by the size of the soil area and uses of the Three Star Site. Surface water and sediment of the Three Star lagoon are potential exposure routes for trespassers, site workers, or recreational visitors. Exposure to subsurface materials is a potential pathway for construction workers. Potable water use of ground water is prohibited by the village due to the availability of a public water supply. Other potential uses of the Three Star Site are recreational uses primarily associated with the proximity to the creek, and future residential uses, if they were permitted.

- The Three Star Site contains limited ecological habitat. Most of the Main Site is occupied by buildings, ruins of buildings, and paved parking areas that represent poor quality ecological habitat. However, wildlife that may be present on the Main Site may be exposed to metals, PAHs, and VOCs that were detected in surface soil above ecological screening values. The Three Star lagoon provides limited aquatic habitat on the Three Star Site. Aquatic receptors that visit the Three Star lagoon may be exposed to metals, PAHs, and chlorobenzene concentrations that were detected in surface water or sediment above ecological screening values. The MGP Site consists primarily of vegetated areas with grasses, trees, and shrubs that may be suitable habitat for wildlife. Wildlife that may be present on the MGP Site may be exposed to PAHs and metals concentrations that were detected in surface soil above ecological screening values.

1.3. Summary of Exposure Assessment

The following exposure pathways associated with the Three Star Site represent potentially complete pathways, as presented in the Exposure Pathway Analysis Report (O'Brien & Gere 2007b):

- Current and future dermal contact and incidental ingestion of Three Star Site surface soil for adult, adolescent, and child human receptors

- Current and future dermal contact and incidental ingestion of Three Star Site subsurface soil for adult construction workers

- Current and future inhalation of site-wide outdoor ambient air for adult, adolescent, and child human receptors

- Current (Main Site) and future (Main and MGP sites) inhalation of fugitive dust for adult site workers

- Current (Main Site) inhalation of indoor air for adult site workers

- Future (Main Site and MGP Site) inhalation of indoor air for adult site workers, adult commercial workers, and residents

- Current and future dermal contact and incidental ingestion of lagoon sediment for adult, adolescent, and child human receptors

In addition, the Fish and Wildlife Impact Analysis identified the following potentially complete exposure pathways (O'Brien & Gere 2002):

- Current and future direct contact and incidental ingestion of soil and lagoon surface water and sediment for ecological receptors, and associated food chain exposures.

1.4. Feasibility Study Approach

The FS was completed in two steps. Section 2 presents the development of remedial alternatives consisting of the development of remedial action objectives, identification of general response actions, evaluation of areas and volumes of media, and identification and screening of remedial technologies. Section 3 presents the detailed analysis of alternatives that consists of individual and comparative analyses.

2. Development of Remedial Alternatives

The objective of this phase of the FS was to develop a range of remedial alternatives for the Three Star Site. The process of development of alternatives included the development of remedial action objectives; development of general response actions; identification of volumes or areas of media; identification and screening of remedial technologies and process options; evaluation of remedial technologies and process options; and the assembly of remedial alternatives.

2.1. Development of Remedial Action Objectives

Remedial action objectives are media-specific goals for protecting human health and the environment. These remedial action objectives form the basis of the FS by providing overall goals for site remediation. The remedial action objectives are considered to identify appropriate remedial technologies and formulate alternatives for the Three Star Site, and later to evaluate remedial alternatives.

Remedial action objectives are based on engineering judgement, risk-based information established in the qualitative risk assessments (Section 1.6), and potentially applicable or relevant and appropriate standards, criteria and guidance (SCGs).

2.1.1. Identification of Potential Standards, Criteria and Guidance (SCGs)

There are three types of SCGs, consisting of 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 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 Three Star 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.

2.1.2. Physical and Technical Limits to Remediation

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

- The interaction between the surface water and ground water at the Three Star Site complicates remediation options. Wappingers Creek, adjacent to the Three Star Site, interacts with the ground water under the Three Star Site. It is difficult to pump and treat ground water without treating excessive quantities of extracted water. Although a cutoff wall is typically useful to control plume migration, the thickness of the aquifer (50 to 70 ft) and the presence of cobbles would make construction of a wall difficult.

- The high permeability of the soil and fill coupled with the proximity of the surface water body makes it difficult to remove potential sources located below the ground water table because of the extensive pumping required for dewatering.

- The site-wide presence of fill material at the Main Site (the presence of cinders, particularly along the north portion of the Main Site) and MGP Site (cinders prevalent in fill) make PAH and inorganic constituent source removal impracticable and thereby remediation to ground water standards impracticable. Inorganic contamination in shallow ground water at the Main Site correlates to the general presence of surface and subsurface contamination. Furthermore, the fill material itself is likely a contributor to the impacts observed. This fill was historically placed at the Three Star Site to raise the ground surface above the creek level to facilitate construction of the structures at the Three Star Site. It is impractical to remove this fill without demolition of the existing structures and devising significant structures to keep the creek water from flooding the property. As discussed above, extensive pumping would be required to dewater the area to address the removal of fill material.

- For the potential source of chlorinated VOCs in the shallow ground water in the Axton-Cross building area, the potential source material is not completely accessible due to the presence of the currently occupied building over a portion of the primary suspected source area. Although *in situ* technologies can be used to reduce concentrations of source material, they have not demonstrated the ability to remediate sources to meet ground water standards (Fountain 1998; ITRC 2002; and USEPA 2004).

2.1.3. Technical Impracticability Evaluation

USEPA's September 1993 *Guidance for Evaluating the Technical Impracticability of Ground Water Restoration* recognizes that some sites will not attain chemical-specific SCGs and provides for implementation of Technical Impracticability (TI) waivers. Under CERCLA, a "…TI waiver must be invoked when either of the following specific criteria are met:

- Engineering feasibility. The current engineering methods necessary to construct and maintain an alternative that will meet the SCGs cannot reasonably be implemented.

- Reliability. The potential for the alternative to continue to be protective into the future is low, either because the continued reliability of technical and institutional controls is doubtful, or because of inordinate maintenance costs."

Similarly, under NYSDEC environmental regulations (6 NYCRR 375-1.10 (1) (i) a-d) "…conformity with an SCG can be dispensed with if a good cause such as the following exists:

- The proposed action is only part of a complete program that will conform to such standard or criterion [of *[sic]* guidance] upon completion;

- Conformity with such standard or criterion will result in greater risk to the public health or to the environment than alternatives; or

- Conformity with such standard or criterion is technically impracticable from an engineering perspective; or

- 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."

At the Three Star Site, a TI waiver is applicable to the NYSDEC Class GA ground water standards due to technical impracticability from an engineering perspective. Engineering options to address ground water contamination typically consist of source removal, plume concentration reduction, or plume migration control. The first two have the potential to reduce concentrations to the ground water standards.

As discussed above, it is technically impracticable at this Site to restore ground water to NYSDEC Class GA ground water standards for inorganic constituents in shallow and deep ground water, and for chlorinated VOCs and PAHs in shallow ground water.

2.1.4. Remedial Action Objectives

Given this information, the following remedial action objectives have been established:

- Minimize to the extent practicable potentially unacceptable human health risks associated with direct contact and incidental ingestion of soil, ground water, and lagoon sediment

- Minimize to the extent practicable potentially unacceptable human health risks associated with current and future inhalation of outdoor ambient air and indoor air

- Mitigate to the extent practicable existing and potential adverse impacts to wildlife resources

- Mitigate to the extent practicable sources of VOCs, PAHs, and inorganic constituents to Wappingers Creek sediment and surface water.

2.2. Identification of General Response Actions

General response actions are media-specific actions that may be combined into alternatives to satisfy the remedial action objectives. General response actions that address the remedial action objectives related to the Three Star Site media include institutional controls, containment, removal, disposal, reuse, and treatment.

2.3. Identification of Areas and Volumes of Media

Site conditions, the nature and extent of contamination, and preliminary remediation goals were taken into consideration to estimate the volumes and areas of media to be addressed by the general response actions. The aerial extent of the areas described below is depicted in Figure 2.

Lower Portion of the Former Raceway. As identified in Section 1.2, one potential source area is the lower portion of the former raceway. The lower portion of the former raceway is characterized by concentrations of inorganic constituents greater than 6 NYCRR Part 375 Restricted Use Soil Cleanup Objectives for Commercial Use to an approximate depth of 22 ft below ground surface (bgs). The footprint of the lower portion of the former raceway is approximately 31,000 square ft (0.7 acres). The estimated volume is approximately 25,000 cubic yards.

Drywell Area. As identified in Section 1.2, the second potential source area is the drywell area. The drywell area is characterized by elevated VOC concentrations to an approximate depth of 22 ft bgs.

The footprint of the drywell area is approximately 9,500 square ft. The estimated volume is approximately 7,800 cubic yards.

Surface Soil at Concentrations Greater than 6 NYCRR Part 375 Restricted Use Soil Cleanup Objectives for Commercial Use. The estimated footprint of surface soil exhibiting concentrations of site-related constituents greater than 6 NYCRR Part 375 Restricted Use Soil Cleanup Objectives for Commercial Use is approximately 3.2 acres on the Main Site and the MGP Site. However, additional sampling is recommended to more accurately delineate the extent of surface soil areas at concentrations greater than 6 NYCRR Part 375 Restricted Use Soil Cleanup Objectives for Commercial Use. Specifically, additional information is required to fill in the following data gaps:

- the south border of the MGP Site,
- the area between buildings 15/16/17 and the raceway, the area adjacent to the eastern side of the lower half of the lagoon, and
- the area along the creek bank north of the Axton-Cross Building.

Lagoon Sediment. Sediment thickness was measured in the Three Star lagoon. The total volume of sediment continuously under water in the Three Star lagoon is approximately 2,100 cubic yards.

Former Gas Holders. Two former gas holders constructed of brick are present at the MGP Site. Based on the exposed brick structures, an estimated 15 cubic yards of brick would result from demolition of these structures to approximately 2 ft below grade.

Former Metal Plating Vats. Twenty-three vats constructed of poured concrete or concrete block are present in the ruins of Building 16 at the Main Site that contain varying amounts of contaminated liquid and sludge. Based on field measurements taken September 20, 2006, an estimated 62,000 gallons of liquid and 100 cubic yards of sludge (assuming 75% liquid and 25% sludge) would result from decommissioning these structures. However, since these vats are exposed to the environment, the amount of liquid may vary considerably due to precipitation and evaporation. The total capacity of the vats is approximately 245,000 gallons. As part of the vat decommissioning, an estimated 550 cubic yards of asbestos-containing material (AMC) will also be generated.

2.4. Identification and Screening of Remedial Technologies and Process Options

Potentially applicable remedial technology types and process options for each general response action 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 Three Star Site are presented in Table 2. Process options that were viewed as not implementable for the Three Star Site were not considered further in the FS. Following are descriptions of technologies that were considered potentially implementable for the Three Star Site.

2.4.1. Soil

<u>No Action.</u> The no action general response action must be considered in the FS, as specified in the National Contingency Plan (NCP) (40 CFR Part 300.430).

Institutional Actions. The remedial technology associated with the institutional general response action that was identified for the Three Star Site was access restrictions. Access restrictions identified consist of an environmental easement and fencing. The process options considered potentially applicable are described as follows.

Environmental Easement. With respect to the soil, land use restrictions would be reflected in the property deed. An environmental easement would preclude activities which would potentially expose contaminated materials (and require health and safety precautions) or impair the integrity of a cover without prior review and approval by NYSDEC.

Fencing. A fence would be constructed to provide site security to limit access to the areas and thereby minimize contact, and protect against activities that might adversely affect the integrity of a remedy.

Containment Actions. The remedial technologies that were identified for the Three Star Site related to the containment general response action were capping and erosion control. Capping and erosion control process options that were considered potentially applicable were a vegetated soil cover, low permeability cover, and creek bank stabilization. These process options are described below.

Vegetated Soil Cover. A soil cover consisting of 24 inches of soil with vegetation is one technology that would address the objective of minimizing contact with impacted surface soil. Grading and cover installation would be performed such that drainage is promoted, erosion is minimized, and cover integrity is protected. Routine cover maintenance, consisting of mowing of vegetation and inspections for integrity, would be necessary. An asphalt cover (such as parking lots) and buildings would be functionally equivalent to a vegetated soil cover, and could be used to support alternative land uses.

Low Permeability Cover. A low permeability cover would minimize surface water infiltration, encourage runoff and control erosion, and isolate and contain soil. This would involve the construction of a low permeability layer over the impacted soil. Low permeability covers are typically constructed of clay and soil, or multi-media.

A clay and soil cover would be a three-layer system consisting of an upper topsoil layer for the support of vegetation, a barrier protection layer and a low permeability layer. The low permeability layer would consist of 18 inches of compacted clay with a maximum permeability of 1×10^{-7} cm/sec. The barrier protection layer would consist of 24 inches of soil. The upper layer would consist of 6 inches of topsoil for vegetative growth. The maximum allowable grade of the cap would be 33%, and the minimum grade would be 4%.

The multimedia cap would consist of a 6-inch vegetated topsoil layer, a 24-inch soil barrier protection layer, and a 40 mil geomembrane. The minimum final grade would be 4% and the maximum final grade would be no greater than 33%.

In addition to the low permeability cover, a cover system would include a drainage layer and drainage control structures. The drainage layer would be positioned above the low permeability layer. A layer of filter fabric would be placed between the two layers. Drainage control structures function to protect the cover from surface run-on and run-off.

Routine cover maintenance, consisting of mowing of vegetation and inspections for integrity, would be necessary.

Creek Bank Stabilization. Creek bank stabilization would involve consolidation of material on-site, placement of clean fill, and installation of a combination of vegetative or structural bank stabilization technology such as brush mattresses with a rock toe, or a retaining wall along Wappingers Creek. The technology selected would be highly dependent on the velocity of Wappingers Creek. Creek bank stabilization is necessary to reduce potential erosion of fill material and Site soil into the creek.

<u>Removal Actions.</u> The remedial technology related to the removal general response action that was identified for the Three Star Site was excavation.

Excavation. Excavation would involve the removal of soil using construction equipment such as backhoes and front-end loaders.

<u>Disposal Actions.</u> The remedial technology related to the disposal general response action that was identified for the Three Star Site was off-site commercial landfill. The off-site commercial landfill process option is described below.

Off-site Commercial Landfill. Excavated soil would be transported to a NYSDEC-approved permitted commercial landfill for disposal, provided the soil meets land disposal restrictions (LDRs). Based on sample results, soil excavated at the Three Star Site may be hazardous waste.

<u>Treatment Actions.</u> The remedial technologies related to the treatment of soil at the Three Star Site were physical, chemical, biological, and thermal treatment technologies. The process options considered potentially applicable are both *in situ* and *ex situ*, and are described as follows. The effectiveness of *in situ* technologies may be limited if subsurface soil conditions are heterogeneous.

Soil Flushing. Soil flushing is a physical treatment process that involves the separation/segregation and volumetric reduction of contaminants in soil. The process involves high energy contacting and mixing of excavated soil with an aqueous-based washing solution in a series of mobile washing units. The soil washing process separates fine-grained soil, which constituents are typically concentrated in, from coarser-grained soil. Soil washing would likely be effective for soil containing VOCs and inorganic constituents. The aqueous-based washing solution would require further management.

In situ Soil Venting. In situ soil venting, or soil vapor extraction, 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. *In situ* soil venting would likely be an effective treatment technology for site-related VOCs. However, this technology would not treat inorganic constituents.

Dual Phase Extraction. Dual-phase extraction wells remove ground water and soil vapor, and in some cases, product that is present, simultaneously. A pumping test performed at the Three Star Site would be required to identify appropriate locations to place the extraction wells and evaluate appropriate pumping rates and/or levels to minimize migration of contaminated ground water from the potential source areas and maximize contaminant removal. Dual-phase extraction would likely be an effective treatment technology for site-related VOCs. However, this technology would not treat inorganic constituents.

Solidification/Stabilization. Solidification/stabilization is a process that involves the addition of cement or pozzolanic materials to soil to produce a stable and inert mass. This process renders constituents in the soil less leachable, but does not destroy or reduce the toxicity of contaminants. Encapsulation of contaminants via solidification could be accomplished through the addition of cement or lime, and mixing with soil. Bonding of the contaminant via stabilization could be accomplished through the addition of a modified clay or other binder, and mixing with soil. Solidification/stabilization would likely be effective for site-related inorganic constituents but may not be effective for VOCs. The solidified/stabilized matrix would require further management.

Chemical Dechlorination. Chemical reagents prepared from polyethylene gycol and potassium hydroxide have been demonstrated to dechlorinate chlorinated VOCs through a nucleophilic substitution process. The products of the reaction have been proven to be non-toxic, non-mutagenic, and non-bioaccumulative. In this process, regents are mixed with soil and heated in a reactor. Chemical dechlorination would not be effective for site-related inorganic constituents. Wash water management is required for this treatment. This treatment must be monitored carefully such that sufficient reaction time is allowed. The treated residuals would then be either placed at the Three Star Site or transported for off-site disposal.

In situ Chemical Oxidation. In situ chemical oxidation involves the injection of oxidation agents such as ozone or Fenton's Reagent (an iron catalyst combined with hydrogen peroxide) to destroy VOCs in the subsurface. These oxidants are effective for the VOCs and selected site-related inorganic constituents present at the Three Star Site.

Ex situ Biological Treatment. Ex situ biological treatment is a process in which excavated contaminated material is treated biologically in a reactor, composting system, or landfarming process. In this process, naturally occurring microorganisms are stimulated to degrade organic contaminants. Nutrients, oxygen, and co-metabolites are injected to enhance the process. This innovative technology allows the microorganisms to reduce the contaminant into a less toxic constituent. *Ex situ* biological treatment would likely be effective for selected VOCs. Inorganic constituents, however, would not be treated.

In situ Biological Treatment. In situ biological treatment involves the degradation of soil contaminants in place by naturally occurring microorganisms. *In situ* biological treatment of surface soil at the Three Star Site could consist of a modified landfarming process in which nutrients and/or enhanced naturally occurring microbial populations are applied to surface soil to enhance biodegradation. Tilling of surface soil could also be performed to enhance oxygen availability to microbes. *In situ* biological treatment would require a treatability study to evaluate its effectiveness to treat site related VOCs. Inorganic constituents would likely not be treated by *in situ* biological treatment.

Thermal Desorption. Thermal desorption 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 VOCs. Inorganic constituents, however, would not be treated by this technology.

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.

In situ Vitrification. In situ vitrification (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. The treated residuals could then be either placed at the Three Star Site or transported for off-site disposal. Dewatering activities must be employed for effective treatment of soil with a high moisture content.

2.4.2. Ground Water

No Action. The no action general response action must be considered in the FS, as specified in the NCP (40 CFR Part 300.430).

Institutional Actions. The remedial technologies associated with the institutional general response action that was identified for the Three Star Site were monitoring and access restrictions. Access restrictions identified consist of ground water use restrictions. Ground water monitoring was identified as the monitoring process option. The process options considered potentially applicable are described as follows.

Ground Water Monitoring. Ground water monitoring would involve periodic sampling and analysis of ground water at the Three Star Site to provide a means to detect changes in concentrations of VOCs and inorganic constituents in the ground water.

Ground Water Use Restrictions. Currently, ground water at Wappingers Falls is not permitted for potable use. Ground water use restrictions would include an environmental easement that would preclude the use of ground water at the Three Star Site as a potable source of water. In addition, an environmental easement would preclude the use of ground water from the Site without prior review and approval by NYSDEC.

Containment Actions. The remedial technology that was identified for the Three Star Site related to the containment general response action for ground water was a vertical barrier. The vertical barrier process options considered applicable were a slurry wall and sheet piles.

Slurry Wall. Slurry wall(s) can intercept ground water, thus minimizing migration off-site. A trench is excavated with construction equipment (*i.e.,* backhoe) from the ground surface to the hard till or bedrock layer. A low permeability wall, constructed of cement/bentonite or soil/bentonite, replaces the native soil from the excavated trench. Ground water collection is necessary to maintain ground water levels within the slurry wall.

Sheet Piles. Sheet piles could be used to construct walls to intercept ground water, thus minimizing migration off-site. The sheet piles would be installed from the ground surface to the hard till or bedrock layer. Ground water collection is necessary to maintain ground water levels within the sheet piles.

Collection Actions. The remedial technology that was identified for the Three Star Site related to the collection general response action for ground water was ground water extraction. The ground water extraction process options considered applicable were recovery wells and interceptor trenches.

Recovery Wells. As part of the potential source area removal, contaminated ground water would be collected by pumping from recovery wells. A pumping test performed on the Three Star Site would be required to identify appropriate locations to place the extraction wells and evaluate appropriate pumping rates and/or levels to minimize migration of contaminated ground water from the potential source areas.

Interceptor Trenches. Interceptor trenches are buried conduits that would intercept and/or collect ground water at the Three Star Site. Interceptor 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.

In situ Treatment Actions. The remedial technologies that were identified for the Three Star Site related to *in situ* treatment general response action for ground water were physical and biological. The *in situ* ground water treatment process options considered applicable were air sparging and bioremediation.

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 an *in situ* air stripping 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 an *in situ* air stripping system. Air sparging is not effective for treating inorganic constituents.

Bioremediation. Natural microbial degradation of organic contaminants *in situ* can be enhanced through injection of necessary nutrients and/or cometabolites to the subsurface. Injection wells can be used to supply the needed nutrients and/or cometabolites to the indigenous microbial organisms in the subsurface which are capable of destroying the contaminants. A treatability study would likely be necessary to evaluate the effectiveness of biological treatment on site-related VOCs. Biological treatment is not effective in treating inorganic constituents.

Ex situ Treatment Actions. The remedial technologies that were identified for the Three Star Site related to *ex situ* treatment general response action for ground water were physical, chemical and biological. The ground water extraction process options considered applicable are described below.

Air Stripping. Air stripping involves the contact of ground water with air in a countercurrent packed column or tray or bulk reactor to transfer volatile contaminants from the ground water to the air. Air stripping would be effective to treat site-related VOCs. Inorganic constituents, however, are often oxidized and foul air strippers; hence organics are generally pretreated. Depending on the resulting characteristics of the discharging air stream, air pollution controls may be required.

Carbon Adsorption. Activated carbon can adsorb organic contaminants from ground water onto its surfaces during contact. Carbon adsorption would likely be an effective treatment for site-related VOCs. Inorganic constituents, however, would not be treated effectively. The carbon must be periodically replaced, regenerated, treated and/or disposed. Regeneration may be accomplished at the Three Star Site or off-site at a permitted commercial hazardous waste carbon regeneration facility. Carbon disposal would be off-site at a permitted commercial hazardous waste facility.

Adsorptive Resins. Commercial resins are available which can adsorb organic contaminants from the ground water during contact. Adsorptive resins would likely be an effective treatment for site-related VOCs. Inorganic constituents, however, would not be treated effectively. Such resins are typically regenerated on the Three Star 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. A trickling filter is a biological treatment technology which involves passing water over a bed of media which supports microbial film growth. The filter bed typically consists of media with large surface area to sustain an environment suitable for biological growth. Contaminated water is percolated through the media and comes in contact with the microbial film before discharge. A treatability study would likely be necessary to evaluate the effectiveness of biological treatment on site-related VOCs. Biological treatment is not effective in treating inorganic constituents. Sludge management would be required.

Chemical Oxidation. Chemical oxidation involves the addition of oxidation agents such as hydrogen peroxide or ozone to the ground water in the presence of ultraviolet light to oxidize organic contaminants to non-toxic byproducts. Chemical oxidation would likely be an effective treatment for site-related VOCs. Site-related inorganic constituents, however, would not be treated effectively. 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. Site-related VOCs would not be treated effectively. 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. Ion exchange would not treat site-related VOCs effectively.

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

2.4.3. Lagoon Sediment

No Action. The no action general response action must be considered in the FS, as specified in the NCP (40 CFR Part 300.430).

Containment Actions. Filling in the Three Star lagoon with sand and other granular backfill was identified as a remedial action for the containment of sediment. The process option considered potentially applicable is described as follows.

Containment. Sediment would be covered with sand and granular backfill using a backhoe and a culvert would be installed along the former lagoon to convey storm water from the Three Star Site to Wappingers Creek.

Removal Actions. Excavation was identified as the remedial technology for the removal of sediment at the Three Star Site. The process option considered potentially applicable is described as follows.

Excavation. Sediments would be removed in the dry following lagoon drainage using construction equipment such as backhoe excavators.

Treatment Actions. Physical treatment was identified as the remedial technology for the treatment of sediment at the Three Star Site. The process option considered potentially applicable is described as follows.

Stabilization. Solidification/stabilization is a process that involves the addition of cement or pozzolanic materials to the sediment to produce a solid, stable and inert mass. This process renders constituents in the sediment less leachable, but does not destroy or reduce the toxicity of contaminants. Sediment stabilization can be accomplished *in situ* or *ex situ*. Stabilized mass would require additional management.

Disposal Actions. Off-site commercial landfill was identified as the remedial technology for the disposal of sediment at the Three Star Site. The off-site commercial landfill process option is described below.

Off-site Commercial Landfill. Excavated sediment would be transported to a NYSDEC-approved permitted commercial landfill for disposal, provided the soil meets LDRs. Excavated sediment may require dewatering, depending on the excavation method. Testing of sediment from the Three Star lagoon indicated that the sediment is non-hazardous. Disposal of sediment in a non-hazardous waste landfill is anticipated.

2.4.4. Soil Vapor

Control Actions. Vapor control was identified as the remedial technology for control actions for soil vapor in the vicinity of the Axton-Cross Building. The process option considered potentially applicable is described as follows.

Pumping/Ventilation. Pumping/ventilation would consist of the installation of suction points and ventilation fans to mitigate sub-slab and indoor vapor.

2.5. 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;
- 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 operation and maintenance (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.

2.6. Assembly of Remedial Alternatives

Four remedial alternatives were developed for the Three Star Site by assembling the general response actions and applying combinations of the process options chosen to represent the various technology types. A summary of the alternatives and their components is presented in Table 4. A description of each alternative is included in the following subsections.

2.6.1. Common Components of Alternatives

Ground water monitoring and a Site Management Plan are common elements to each of the active alternatives being evaluated for the Three Star Site. Vapor control, erosion control, removal and disposal of surface debris, demolition and off site disposal of the former gas holders, decommissioning of the former metal holding vats, and soil containment are common elements of Alternatives 3 and 4. A description of these elements is included below.

Ground Water Monitoring. Ground water monitoring would be implemented to track concentrations of VOCs and inorganic constituents in ground water and would be instrumental in detecting changes in concentrations. Ground water monitoring would consist of quarterly sampling of wells with analysis of VOCs and inorganic constituents.

Site Management Plan. Since impacted soil would remain onsite, each alternative would include periodic site management reviews as part of a Site Management Plan. The periodic reviews would focus on evaluating the Three Star Site with regard to the continuing protection of human health and the environment as provided by information such as ground water monitoring results and documentation of field inspections.

In addition to the elements described above, vapor control, erosion control, removal and off-site disposal of surface debris, demolition and off-site disposal of the former gas holders, decommissioning of the vats, and removal of sediment from the Three Star lagoon are common components of Alternatives 3 and 4. A description of these elements is provided below.

Vapor Control. Due to the presence of a chlorinated VOC plume under and in the vicinity of the currently occupied Former Axton-Cross Building, a vapor control system has been included as a component of each active remedial alternative. Prior to installation of such a vapor control system, an assessment of sub-slab and indoor air conditions would be performed. Following this, a vapor control system would be installed, if warranted. The vapor control system would consist of ventilation fans and suction points aimed at depressurizing sub-slab vapor conditions.

Erosion Control. Due to the presence of cinder-containing site soil along the banks of Wappingers Creek, erosion control measures are included in each active remedial alternative. Presently, a portion of the bank is protected from erosion by a retaining wall. The balance of the bank (approximately 850 ft in length) would be stabilized to provide erosion control from Wappingers Creek, which has documented mean velocities over 6 feet per second (fps) (USGS 2007) dating back to 1973 with two particularly high peak flow events in 1939 and 1955 where velocities were not recorded that had peak flows of 15,900 and 18,600 cubic feet per second. The average mean velocity estimated from the available mean velocity from the United States Geological Survey (USGS), which is measured upstream of Wappingers Lake by USGS, is approximately 2 fps. These velocities were considered in selection of the bank stabilization technology.

For cost estimation purposes it was assumed that, a 850 ft bank section of Wappingers Creek would be covered in an approximately 2.5-ft thick layer of embankment material supplemented with a brush mattress with rock toe and 6 inches of topsoil with selective live stake/whip placement and plantings to prevent erosion. Prior to the placement of the embankment material, and brush mattress sections with rock toe and topsoil, a silt curtain would be installed within the creek.The creek bank (approximately 13 feet in length to the creek bed with 3 feet submerged) would then be excavated to remove a 3-ft thick layer of cinder-containing site soil. The excavated site soil would be disposed off-site. A 2.5ft layer of embankment material would be placed over the exposedexcavated site soil , with the exception of a three foot wide section at the toe of the slope that would only receive 1.5 ft of embankment material. Following placement of the embankment material, a 1.5 ft thick layer of rip-rap, underlain with a geotextile, would be placed in a 3 foot wide section at the toe of the slope to provide protection from wave action, undercutting, and scouring of the embankment material, brush mattress, and topsoil. Above the rock toe, brush mattress sections would be placed on the remaining 10-ft section of the bank from the bottom of the slope up. The brush mattress sections would be filled with a minimum of 6 inches of topsoil. The brush mattress sections would consist of live brush that would act as an immediate sediment trap and mature into a shrubby protective barrier for the bank. Live stakes/whips and other native wetland and riparian plants (tolerant to salinity due to tidal influence of Wappingers Creek) would be planted within the brush mattress sections at varying locations to provide vegetative diversity for restoration of the creek bank. A monitoring plan would be developed outlining inspection and stabilization/restoration success criteria and invasive species management for the stabilized and restored area of the creek bank.

Removal and Disposal of Surface Debris. Miscellaneous debris is present on the ground surface at the MGP Site. Removal of this debris is included as a component in each of the active remedial alternatives. Removal would consist of gathering the material and consolidating it for off-site disposal. It is anticipated that this debris would be disposed in a Construction & Demolition (C&D) debris landfill.

Demolition and Off-site Disposal of the Former Gas Holders. The ruins of two former gas holders are present on the MGP Site consisting of two circular brick structures that are approximately 40 ft in diameter and extend approximately 8-ft above ground surface. Removal of these former gas holders is anticipated to be completed using an excavator. The brick debris would be disposed in a C&D landfill.

Decommissioning of Former Metal Plating Vats. Twenty-three vats are present within the footprint of the original Building 16, which was burned during the fire that occurred at the Three Star Site in May 2004. The vats consist of poured concrete or concrete block structures extending approximately 9 ft deep, with approximately 7 ft below existing grade and 2 ft above grade, each having an approximate footprint of 5 ft by 38 ft. As a result of the fire, a brick wall associated with Building 16 would require stabilization. The debris left from the fire primarily consists of bricks and wood timbers, but it also contains other miscellaneous debris such as roof shingles, tar paper, mortar, and metal. Roof shingles and tar paper present across the Three Star Site, including within vats, are presumed to be non-friable ACM. It is anticipated that the debris will be containerized, transported, and disposed in a C&D debris landfill. Removal of the liquid would be performed with a vac truck. Sludge would be removed from the vats using a specialty excavator (*e.g.*, long stick excavator). Based on existing data, it is anticipated that the liquid and sludge would be disposed of off-site as hazardous waste and non-hazardous waste at a NYSDEC-approved landfill. Following liquid and sludge removal, the vats will have non-friable ACM mastic spots that can be removed and then the vats can be pressure washed. Following pressure washing, the soil under the vats and the vat concrete would be investigated to identify if metals detected in the vats have impacted the subsurface soil or vat concrete. For this FS, it was assumed that the soil under the vats has not been impacted to an extent that would require excavation and removal. Following the subsurface investigation, the vat walls will be demolished to grade and the vats will be filled with sand and capped with concrete.

Soil Containment. A vegetated soil cover would be used to contain surface soil areas with concentrations of constituents greater than 6 NYCRR Part 375 Restricted Use Soil Cleanup Objectives for Commercial Use. The soil cover would consist of a 24-inch thick soil vegetated layer. Based on the concentrations detected in soil samples collected across the Three Star Site, it is anticipated that the vegetated soil cover would cover approximately 3.2 acres of the Three Star Site, including areas of the MGP Site and Main Site. However, additional sampling is recommended to more accurately delineate the extent of surface soil areas at concentrations greater than 6 NYCRR Part 375 Restricted Use Soil Cleanup Objectives for Commercial Use. Specifically, additional information is required to fill in data gaps for the south border of the MGP Site, the area between buildings 15/16/17 and the raceway, the area adjacent to the eastern side of the lower half of the Three Star lagoon, and the area along the creek bank north of the Axton-Cross Building.

As indicated on the Three Star Site map (Figure 2), surface soil sample SS-4 was the only isolated location exhibiting concentrations above 6 NYCRR Part 375 Restricted Use Soil Cleanup Objectives for Commercial Use that would not be included in the soil cover area. This location would not be included in the soil cover area because it only slightly exceeded 6 NYCRR Part 375 Restricted Use Soil Cleanup Objectives for Commercial Use for Cadmium (the Cadmium concentration was 11 mg/kg compared to the Part 375 screening value of 9.3 mg/kg) and because the neighboring surface soil sample location SS-3 did not exceed the screening values. Presently, SS-4 is isolated from surface contact by debris associated with the fire.

Prior to installation of the vegetated soil cover, the ground surface would be graded and surface debris would be removed. The vegetated soil cover would be graded to promote drainage and minimize erosion of the cover. The vegetated soil cover would be routinely inspected to verify integrity.

Because the MGP Site is currently a heavily vegetated area with value as a natural resource, the soil cover would incorporate a 100-ft wide buffer area along Wappingers Creek on the MGP Site. This portion of the soil cover would be constructed by excavating the soil to a depth of approximately 6.5 ft.The excavated cinder-containing fill material would be disposed off site. The excavation would be backfilled with clean fill. The ground surface would be restored using appropriate native plantings.

2.6.2. Alternative 1

Alternative 1 is the no further action alternative. The no further action alternative is required by the NCP and serves as a benchmark for the evaluation of action alternatives. This alternative provides for an assessment of the environmental conditions if no remedial actions are implemented.

2.6.3. Alternative 2

Alternative 2 is the institutional and engineering controls, and ground water monitoring alternative. Alternative 2 consists of ground water monitoring, an environmental easement, and a Site Management Plan, as described in Section 2.6.1. In addition, this alternative incorporates access restrictions, as described below.

Access Restrictions. Fencing would be installed around the perimeter of the Three Star Site to restrict access. An environmental easement would consist of land use restrictions and ground water use restrictions. Land use restrictions would preclude the conduct of activities that would potentially disturb or expose contaminated materials or impair the integrity of a cover over contaminated materials without prior notification and approval from the NYSDEC. Ground water use restrictions would preclude the use of ground water at the Three Star Site without prior notification and approval from the NYSDEC.

2.6.4. Alternative 3

Alternative 3 is the on-site treatment and containment alternative. Alternative 3 consists of the following passive remedial actions: ground water monitoring, an environmental easement, and a Site Management Plan. Alternative 3 also consists of the following active remedial actions that are common to remedial alternatives 3 and 4: vapor control, erosion control, removal and off-site disposal of surface debris, demolition and off-site disposal of the former gas holders, decommissioning of the vats, and soil containment as described in Section 2.6.1. In addition, this alternative considers on-site treatment and containment of soil and the containment of lagoon sediment as active remedial actions, as described separately below.

On-site treatment and containment of soil
The on-site treatment and containment of soil would consist of treatment of soil from the lower portion of the former raceway and the drywell area and containment of soil in the MGP Site and areas of the Main Site. These elements are described below. Figure 3 depicts the approximate limits of the common and alternative-specific elements for this alternative.

Treatment of Potential Source Areas. Soil treatment in Alternative 3 would consist of treatment of the lower portion of the former raceway and the former drywell area:

- An estimated 25,000 cubic yards of soil in the lower portion of the former raceway would be treated *in situ* for metals under Alternative 3 by stabilization through the addition of a stabilizing agent, such as a sulfide-based reagent, into the subsurface.

- An estimated 7,800 cubic yards of soil from the former drywell area would be treated *in situ* for VOCs under Alternative 3 by chemical oxidation through the injection of ozone into the subsurface.

On-site Containment of Lagoon Sediment /Decommissioning of Lagoon
Lagoon sediment would be left in place and contained using granular material stabilized with a geotextile layer. An estimated 700 cubic yards of sand will be used to mix with the lagoon sediment to increase material stability for placement of geotextile and backfill. Approximately 9,000 square feet of lagoon area would be capped using geotextile, various depths of backfill, and 6-inches of topsoil (from sediment surface to new cap surface). A 500 foot long, 24-inch diameter culvert would be installed along the eastern edge of the former lagoon to convey stormwater to the Creek from the former raceway. A swale would be established along the centerline of the capped area to convey storm water from the cap area to the creek. The entire cap area will be re-vegetated with grasses and the existing inlet culvert from the raceway would be rehabilitated and connected to the new piping.

2.6.5. Alternative 4

Alternative 4 is the limited excavation and off-site disposal, and containment alternative. Alternative 4 consists of the following passive remedial actions: ground water monitoring, an environmental easement, and a Site Management Plan. Alternative 4 also consists of the following active remedial actions that are common to each active remedial alternative: vapor control, erosion control, removal and off-site disposal of surface debris, demolition and off-site disposal of the former gas holders, decommissioning of the vats, and soil containment as described in Section 2.6.1.

In addition to the common elements listed above, Alternative 4 consists of sediment removal from the Three Star lagoon, limited soil excavation, and off-site disposal. These elements are described below. Figure 4 depicts the approximate limits of the common and alternative-specific elements for this alternative.

Sediment Removal and Restoration of the Lagoon. The Three Star lagoon contains sediment with site-related constituents that varies from approximately 2 to 11 ft in thickness and has an estimated total volume of approximately 2,100 cubic yards. The sediment has the consistency of pudding. Removal of the sediment would be accomplished using excavators to apply and mix portland cement to solidify sediment material *in situ* then remove the solidified material. The existing lagoon would be pumped dry, and well points would be installed to draw down the water table locally such that excavation work can be performed “in the dry” to the target depths which are below the observed water table. Solidification and excavation would then proceed incrementally across the lagoon to remove soft sediments unsuitable for support of excavation equipment. Following sediment removal, the sediments would be staged for dewatering as necessary. Following dewatering, the sediment would be characterized and transported off-site for disposal at a NYSDEC-approved landfill.

Restoration of the Three Star lagoon would consist of replacing the contaminated sediment with clean backfill to establish a maximum water depth of approximately 8 ft at along the midsection of the lagoon. Along the shorelines, clean sand would be added to a 10-ft width to develop a shallow water maximum depth of approximately 2 ft at average conditions next to the shore sloping toward the midsection. The outlet to the Three Star lagoon would be maintained at the current elevation which would allow discharge during storm events, but would not be connected to Wappingers Creek at low water conditions. Native wetland and riparian plants would be planted along soil banks and in the shallow area along the shorelines. A monitoring plan would be developed for the Three Star lagoon that outlines success criteria and invasive species management.

Subsurface Soil Excavation and Off-Site Disposal. Soil excavation in Alternative 4 would consist of excavation of the lower portion of the former raceway and the former drywell area:

- Based on analytical results, it is anticipated that excavation of the soil from the lower portion of the former raceway would extend to approximately 22 ft below grade and would encompass an approximately 0.7 acre area. An estimated 25,000 cubic yards of soil from the lower portion of former raceway would be removed under Alternative 4.

- Based on analytical results, it is anticipated that excavation of the former drywell area soil would extend to approximately 22 ft below grade and would encompass an approximately 0.2 acre area. An estimated 7,800 cubic yards of soil from the drywell area would be removed under Alternative 4.

Excavation would be accomplished using excavators. Due to the depth of the excavations, it is anticipated that shoring would be necessary. In addition, due to the presence of ground water at depths of less than 24 ft, it is anticipated that dewatering would be necessary during excavation. In order to minimize excessive dewatering, it was assumed that shoring would extend to bedrock. Based on concentrations of constituents present in ground water collected from the Three Star Site, it is anticipated that the water generated from dewatering activities would require treatment prior to discharge to Wappingers Creek. Following characterization, excavated soil would be transported off-site for disposal in a NYSDEC-approved landfill.

3. Detailed Analysis of Alternatives

This section documents the detailed evaluation of the alternatives developed for the Three Star 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 evaluation of alternatives also included a comparative evaluation designed to consider the relative performance of the alternatives and identify major trade-offs among them. The eight evaluation criteria are listed below:

- 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
- Community acceptance.

The preamble to the NCP (Federal Register 1990) indicates that, during remedy selection, these eight 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; implemetability; and cost are primary balancing criteria that are used to balance the trade-offs between alternatives. The modifying criterion is community acceptance, which is formally considered after public comment is received on the Proposed Remedial Action Plan. The NYSDEC Environmental Remedation Programs 6 NYCRR Part 375 (NYSDEC 2006) 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 evaluation criteria. A summary of the individual analysis of alternatives is presented in Table 4.

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 achieves and maintains adequate protection and a description of how site risks are eliminated, reduced, or controlled through treatment, engineering, or institutional controls. The individual analysis of each remedial alternative with respect to this criterion is presented in Table 5.

3.1.2. Compliance with SCGs

Potential SCGs for the Three Star Site are presented in Table 1 and the individual analysis of each remedial alternative with respect to this criterion is presented in Table 5.

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 Three Star Site. The adequacy and reliability of controls used to manage untreated material or treatment residuals are also evaluated. The individual analysis of each remedial alternative with respect to this criterion is presented in Table 5.

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

The evaluation of this criterion addressed the expected performance of treatment technologies in each alternative. The individual analysis of each remedial alternative with respect to this criterion is presented in Table 5.

3.1.5. Short-Term Effectiveness

The evaluation of short-term effectiveness addressed the protection of workers and the community during construction and implementation of each alternative, and potential environmental effects resulting from implementation of each alternative. The time required to achieve remedial objectives was also evaluated under this criterion. The individual analysis of each remedial alternative with respect to this criterion is presented in Table 5.

3.1.6. Implementability

The analysis of implementability involved 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 was also assessed. The individual analysis of each remedial alternative with respect to this criterion is presented in Table 5.

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 operation and maintenance costs, and present worth cost. The present worth cost for these alternatives was calculated for the expected duration of the remedy at a 7% discount rate. The individual cost estimates for the remedial alternatives are included in Tables 6 through 9.

3.1.8. Community Acceptance

Community acceptance will be addressed during the preferred alternative public comment period prior to the Record of Decision (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, Alternatives 3 and 4 satisfy the threshold criteria by providing protection to human health and the environment and by complying with the identified SCGs; therefore, each active alternative is 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; implemetability; and cost) were used for balance in the comparative evaluation of alternatives.

3.2.1. Overall Protection of Human Health and the Environment

Each alternative would be protective of human health with respect to potential soil and ground water exposure pathways. Alternatives 3 and 4 would provide for protection of the environment through isolation of soil and sediment, and erosion control from ecological receptors. None of the alternatives would be expected to restore ground water to NYS Class GA ground water standards. As described in Section 2.1.3, a waiver of the NYS Class GA ground water standards may be applicable due to technical impracticability for this Site.

3.2.2. Compliance with SCGs

None of the alternatives would likely attain the NYS Class GA ground water standards. As described in Section 2.1.2, it is technically impracticable to achieve ground water standards at this Site. As described in Section 2.1.3, a waiver of the NYS Class GA ground water standards may be applicable due to technical impracticability for this Site.

Alternatives 3 and 4 would achieve 6 NYCRR Part 375 Restricted Use Soil Cleanup Objectives for Commercial Use for portions of the Three Star Site. Soil present above 6 NYCRR Part 375 Restricted Use Soil Cleanup Objectives for Commercial Use on other portions of the Three Star Site would be addressed through risk management (containment). Each of the alternatives would be implemented in such a manner that location and action-specific SCGs would be met.

Alternatives 3 and 4 would address the NYS Sediment Criteria through containment or removal of the sediments.

3.2.3. Long-Term Effectiveness and Permanence

For each of the alternatives residual risk to human health would be adequately managed. Residual risk to the potential ecological receptors would be adequately managed in alternatives 3 and 4. Controls to be implemented as part of each of the alternatives are considered adequate and reliable controls for Site hazards.

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

Alternative 3 would include containment of the impacted volume of lagoon sediment and would provide a reduction in mobility for constituents present in soil through irreversible treatment. Alternative 4 would include the removal of the impacted volume of sediment in the lagoon and the reduction of the volume of impacted soil would be accomplished through soil removal.

3.2.5. Short-Term Effectiveness

Each of the alternatives would be implemented in such a manner that adverse impacts to the community, workers, and the environment would be minimized. With the exception of Alternatives 1 and 2, each alternative would achieve the remedial action objectives upon implementation. Alternatives 1 and 2 would not achieve protectiveness of ecological receptors.

3.2.6. Implementability

Each of the alternatives is readily constructable, operable, and consists of reliable technologies. For each of the alternatives, additional remedial actions, if necessary, would be readily implementable. Each remedy can be effectively monitored for effectiveness. Coordination with other agencies would be necessary to implement each alternative.

3.2.7. Cost

Alternative 1 is the least cost alternative, followed by Alternatives 2, 3, and 4, respectively.

3.2.8. Community Acceptance

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

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