BASIS OF DESIGN REPORT FOR
IN-SITU SOLIDIFICATION

HEMPSTEAD INTERSECTION STREET
FORMER MANUFACTURED GAS PLANT SITE
VILLAGES OF HEMPSTEAD AND GARDEN CITY
NASSAU COUNTY, NEW YORK

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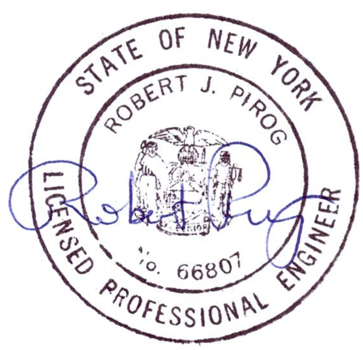
August 2011



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LIST OF ACRONYMS AND ABBREVIATIONS

amsl	above mean sea level
ANS	American Nuclear Society
ASTM	American Society for Testing and Materials
BOD	Basis of Design
bgs	below ground surface
BTEX	benzene, toluene, ethylbenzene, and xylenes
CAMP	Community Air Monitoring Plan
cm/sec	centimeters per second
cP	centipoise
DNAPL	dense non-aqueous phase liquid
DO	dissolved oxygen
DSM	deep soil mixing
DUSR	data usability summary report
ELAP	Environmental Laboratory Accreditation Program
ft	foot (feet)
FS/RAP	Feasibility Study/Remedial Action Plan
GGBFS	ground granulated blast furnace slag
HASP	Health and Safety Plan
IC	institutional control
IRM	interim remedial measure
ISS	in-situ solidification
kV	kilovolt
LILCO	Long Island Lighting Company
LIRR	Long Island Railroad
MGP	manufactured gas plant
mg/kg	milligrams per kilogram
MODFLOW	Modular Finite-difference Groundwater Flow Model
MT3DMS	Three-Dimensional Multi Species Transport Model
NAD	North American Datum
NAPL	non-aqueous phase liquid

NCDH	Nassau County Department of Health
NYSDEC	New York State Department of Environmental Conservation
NYSDOH	New York State Department of Health
NYSDOT	New York State Department of Transportation
PAH's	polycyclic aromatic hydrocarbons
PCB	polychlorinated biphenyl
PDI	Pre-Design Investigation
PDMS	polydimethylsiloxane
PVC	polyvinyl chloride
PM_{10}	particulate matter < 10 µm
psi	pounds per square inch
RI	Remedial Investigation
ROW	right-of-way
SC	soil-cement
SMP	Site Management Plan
SPT	Standard Penetration Test
TCB	Temporary Containment Building
TOC	Total Organic Carbon
UCS	unconfined compressive strength
URS	URS Corporation
USCS	Unified Soil Classification System
USEPA	United States Environmental Protection Agency
VMS	vapor management system
VU	VanderbiltUniversity
yd^3	cubic yards
µg/kg	micrograms per kilogram
µg/L	micrograms per liter
$µg/m^3$	micrograms per cubic meter

EXECUTIVE SUMMARY

Reason for the Basis of Design Report

This report presents the basis of design for remediation of manufactured gas plant (MGP) source material associated with the Hempstead Intersection Street former MGP Site located in the Villages of Hempstead and Garden City, Nassau County, New York (refer to Drawing 1). This report was prepared for National Grid by URS Corporation is accordance with an Order on Consent with the New York State Department of Environmental Conservation (NYSDEC).

The report documents the background, decision making process, and rationale behind the design of a remediation program that includes the excavation and off-Site treatment of MGP source materials and in-situ solidification (ISS) of MGP source materials. The report also presents the Site history, current Site conditions, the objectives of the remedial action, an overview of the remedial design, critical design parameters, how the remediation will be completed, monitoring activities that will be conducted during the remediation, and post-remediation monitoring and maintenance.

Site Description and History

MGP operations began in the early 1900's in the southern portion of the Site and expanded north as the demand for gas increased. The Long Island Lighting Company (LILCO) acquired the Site in the early 1930's. The on-site MGP was subsequently demolished by LILCO following the start of natural gas availability on Long Island in the early 1950's. In 1998, LILCO merged with Brooklyn Union Gas forming KeySpan Corporation. In 2007, KeySpan Corporation was purchased by National Grid.

A "cut and plug" interim remedial measure (IRM) Program was undertaken at the Site during the winter of 1999. The objective of that IRM was to locate underground piping associated with historic MGP operations so that each pipe could be cut, drained of any fluids and plugged in order to limit the potential for any off-site migration of MGP-related constituents. The IRM was completed in the summer of 2000.

A second IRM was implemented in 2008 for the excavation of shallow MGP source materials from the Site and for the recovery of non-aqueous phase liquid (NAPL) from the groundwater (refer to Drawing 3 for the IRM locations). The IRM was performed to remove MGP source materials from areas of the Site where no additional future remediation will be necessary and to support future site-wide remediation activities by providing clean areas for support facilities, vehicle parking, and the staging of equipment and materials. A total of 4,432 cubic yards of MGP source material (as contaminated soil) and construction / demolition debris was taken off-site for treatment and disposal. 9,493 gallons of liquid was also taken off-site for treatment and disposal.

Contamination associated with former MGP operations includes:

- MGP source material that includes soil saturated with NAPL or visibly impacted soil that contains total polycyclic aromatic hydrocarbons (PAH's) greater than 1,000 mg/kg or benzene, toluene, ethylbenzene, and xylenes (BTEX) greater than 50 mg/kg.
- A dissolved phase groundwater plume that extends approximately 3,800 feet south of the Site.

Groundwater treatment systems will be installed to provide treatment of the groundwater plume by creating zones of elevated dissolved oxygen (DO) that will stimulate and enhance aerobic bioremediation of contaminated groundwater as it flows through the treatment areas. Based on the dimensions and location of the groundwater contaminant plume, four separate groundwater oxygen treatment systems have been designed:

- System No. 1 – Installed and located in the vicinity of Smith Street, the inactive Long Island Railroad (LIRR) Right-of-Way(ROW), and the ROWs on Atlantic Avenue and Hilton Avenue (constructed).
- System No. 2 – Installed and located in MirschelPark, on private property at 158 Hilton Avenue, and in the road ROWs on Hilton Avenue and Kensington Court (constructed).
- Wydler Place – Planned to be located along Wydler Place (planned)
- Intersection Street – Planned to be located along Intersection Street, just east of the former MGP Site and partially within the LIRR ROW (planned).

The groundwater treatment systems incorporate a patented technology that supplies high-purity oxygen into groundwater at a rate low enough to avoid volatilization of the contaminants, but high enough to increase DO concentrations within the aquifer. The resulting zones of elevated DO will stimulate aerobic bioremediation of contaminated groundwater as it flows through the oxygenated areas.

Remediation Goals

The remediation goals for the ISS are:

- To remove shallow MGP source materials for off-Site treatment and disposal.
- To remove MGP infrastructure to support ISS using deep soil mixing.
- To reduce the mobility of NAPL by treatment, i.e. effective mixing with surrounding soils and addition of cementitious reagents, to reduce levels of organic contaminants below the residual saturation point of the site media.
- To control the effect of the remaining MGP source material by reducing its permeability to facilitate the flow of groundwater around, rather than through, the impacted media, and enhancing on-going bioremediation of the existing dissolved-phase plume.

These remediation goals are in accordance with the March 2008 Final Decision Document for the site (NYSDEC 2008)

Remedial Approach

The remedial action will be conducted at areas of the Site and adjacent properties that contain MGP source material. The remedial action will include the excavation of shallow MGP source material and former MGP structures from the Site for off-Site treatment and disposal. Most of the excavations where source material is present will be performed in a temporary enclosure that will incorporate a vapor management system.

ISS will be performed in areas that contain MGP source material that is too deep to be remediated by excavation and off-Site treatment/disposal. The solidification will be performed by using deep soil mixing.

Design Overview and Summary

The area to be remediated includes the former MGP Site and off-Site areas that include a Professional Office Building parking lot, Intersection Street, limited areas of the LIRR ROW, a portion of Wendell Street, a portion of a park owned by the Village of Garden City, and a portion of an adjacent oil storage terminal property, all of which are shown on the report drawings. ISS treatment will address MGP source materials as defined in the Pre-Design Investigation Report (URS 2010a):

- Soil saturated with NAPL if the total vertical thickness of a NAPL-saturated soil zone exceeds 6 inches.
- Visibly impacted soil zones exceeding six inches vertical thickness if the concentrations of PAH's were greater than 1,000 mg/kg or the concentrations of BTEX were greater than 50 mg/kg.

However, the limits of ISS treatment do not extend to areas with accessibility limitations such as under the Professional Office Building and near certain utilities such as high-voltage power lines along the LIRR ROW, and drainage/sewer lines located west of the site. These areas will instead be addressed via the planned oxygenation systems along Wydler Place and Intersection Street. The MGP source areas planned for ISS treatment are referred to below as the targeted MGP source material and are shown on Drawing 6.

The basic remediation approach to the areas shown on Drawing 6 is summarized below:

- Excavate shallow contaminated soil hotspots from the MGP Site and treat/dispose the excavated material off-Site.
- Excavate MGP structures and shallow targeted MGP source material from the MGP Site and treat/dispose off-Site. Excavate shallow clean soil and stockpile for later backfill.
- Solidify deeper targeted MGP source material beneath the former MGP Site using deep soil mixing.
- Cover solidified material with four or more feet of clean soil.
- After constructing a soil-crete retaining wall in the Professional Office Building (POB) parking lot, and in portions of Wendell St. and Intersection St., excavate and stockpile clean overburden soils to approximately 15 feet bgs and then solidify deeper targeted MGP source material.
- Solidify targeted MGP source material in the Village of Garden City Park and the adjacent oil storage terminal property.

- Restore the disturbed areas to existing (or better) condition. The Site will be restored to support future use or development.

Performance criteria for the solidification have been established for hydraulic conductivity reduction, compressive strength, and durability of the solidified soil, which are identified below.

- Hydraulic Conductivity $\leq 1 \times 10^{-6}$ cm/sec at 28 days
- Unconfined Compressive Strength (UCS) ≥ 50 psi and $\leq 1{,}000$ psi at 28 days

ISS will be performed using deep soil mixing, a process that creates approximately 4 to 12 feet diameter vertical solidified soil zones by physically mixing the soil with injected cementitious material using a rotating bit. A crane-mounted turntable or track-mounted drill rig are used to rotate the augers. Liquefied cementitious grout is injected through a hollow Kelly bar and the auger's injection ports. The auger is rotated upward or downward in the subsurface while grout is injected. When mixing cycles are complete, an in-situ column of solidified soil and groundwater is created. The process is repeated by installing a series of overlapping columns until the area is solidified.

Shallow soils on the MGP Site will be excavated to remove the former MGP structures and to provide a zone where clean, permeable backfill can be placed above the solidified material. These clean permeable soils will be placed over the top of the solidified soils and the disturbed areas will be restored to ground elevations that are similar to current conditions.

Bench-scale solidification testing was performed to demonstrate that grout mixtures can be formulated to be suitable for deep soil mixing. Examples of suitable mixes that have been identified include the following:

- Approximately 8 percent (dry weight basis) of reagent (Portland cement and ground granulated blast furnace slag [GGBFS]).
- Approximately 4.5 percent (dry weight basis) of Portland cement and GGBFS with bentonite (0.5 percent).

For these mixes, sufficient water was added to create a flowable grout, which when added to the soil allows production of a consistent, uniform, mix. Using this approach, the total dry weight to water ratios ranged from about 13:1 to 24:1.

Groundwater flow and solute transport modeling was performed to simulate the study area characteristics and to evaluate the remedial alternatives and their long-term effects on Site contaminants in groundwater. Groundwater modeling results indicate that the change in groundwater flow due to the solidified soil mass will be minimal and will occur only in the immediate vicinity of the solidified soil. Furthermore, the solidified soil mass will not increase the width or depth of the dissolved phase plume. Changes in hydrostatic head around the ISS mass were also evaluated with the model and showed minimal increases in hydraulic head of much less than a foot immediately north of the solidified monolith and essentially no changes in head side-gradient and down-gradient. These extremely small changes will not cause an adverse effect on adjacent structures in general and also because the water table surface is present at approximately 25 feet below ground surface which is well below the depth of foundations. Solute transport modeling has shown that the reduction of permeability from ISS will significantly improve groundwater quality over time.

1.0 INTRODUCTION

1.1 Scope

This Basis of Design (BOD) report provides data and assessments that were performed to establish the limits and methods that will be used to remediate manufactured gas plant (MGP) source material at the Hempstead Intersection Street former MGP site (Site). The document was prepared in accordance with an Order on Consent (Number D1-001-98-11) between National Grid and the New York State Department of Environmental Conservation (NYSDEC) and guidelines presented in NYSDEC Program Policy, *DER-10, Technical Guidance for Site Investigation and Remediation* (NYSDEC, 2010).

The project will be completed by National Grid. All activities identified in this report will be performed under the approval of the NYSDEC, the New York State Department of Health (NYSDOH), and the Nassau County Department of Health (NCDH).

1.2 Project Background

1.2.1 Site Location and Description

The Site, shown on Drawings 1 and 3, is located in the Villages of Hempstead and Garden City, Nassau County, New York. The majority of the approximately 8-acre Site is located within the Village of Garden City(Drawing3). The property is bordered to the north by Second Street, east by a Long Island Railroad (LIRR) inactive railroad right-of-way (ROW), south by Intersection Street, and west by a park owned by the Village of Garden City. The park contains a public parking lot, two public water supply wells, and a recharge basin for the wells. Residences and commercial businesses surround the Site, including a Professional Office Building to the southwest, an Active Oil Storage Terminal to the southeast, and an Inactive Petroleum Storage Facility to the southeast. An active National Grid natural gas regulator station is located within the northwestern portion of the Site.

The Site and surrounding area are generally flat with the ground surface gently sloping to the west, northwest, and southwest. The Site is predominantly covered with crushed stone and is secured with a perimeter fence. Limited grass, shrubs and trees serve as a buffer across the northern fence line. Other than gas piping in the regulator station and Site security fences, there are no permanent aboveground structures on the Site.

1.2.2 Site History

According to National Grid, the Nassau and Suffolk Lighting Company operated the plant starting in the early 1900s. The Long Island Lighting Company (LILCO) acquired an ownership share of the Site in the early 1930s and LILCO decommissioned the MGP in the early 1950s. In 1998, LILCO merged with Brooklyn Union Gas forming KeySpan Corporation. KeySpan was later acquired by National Grid in 2008. The facility originally produced coal gas but was converted to a carbureted water gas process sometime after 1910. Following the arrival of natural gas, the Site served as a peak/emergency facility to ensure gas supply until all MGP operations ceased in the mid-1950s. The plant was demolished shortly afterward.

Since demolition of the plant in the 1950s, the majority of the Site has been inactive except for vehicle parking in the southern and eastern portions of the Site and the ongoing operation of a National Grid natural gas regulator station in the northwestern portion of the Site. Currently, the Site is undeveloped and is secured by a perimeter fence.

A remedial investigation (RI) report prepared in 2006 (PS&S, 2006) described MGP Site-related impacts to soil and groundwater. The impacted materials are associated with coal tar and related constituents that are expected to be found at a former MGP site. The MGP impacts range from dissolved-phase contamination in the groundwater; to an immiscible fluid that is denser than water (dense non-aqueous phase liquid – DNAPL); to tarry material trapped in soils.

The typical MGP-related chemical constituents are principally benzene, toluene, ethylbenzene, and xylenes (BTEX) and polycyclic aromatic hydrocarbons (PAH’s) that are found in the soil, groundwater, and non-aqueous phase liquid (NAPL). The RI and PDI investigation results indicate that the majority of MGP impacts and/or DNAPL are located in two intervals beneath the Site, shallow soils in the upper 8 feet at locations near the former MGP structures or operations, and near the water table interface at approximately 24 to 34 feet.

The Site-related impacts have migrated south from the Site with the flow of groundwater. During the RI, DNAPL was found to extend approximately 450 feet south of the Site beneath a

Professional Office Building parking lot. The extent of a dissolved-phase BTEX and PAH plume is approximately 600 feet wide by approximately 3,800 feet long, as shown on Drawing 3. The concentrations of BTEX and PAH's decrease significantly as they migrate away from the Site. Downgradient migration of the dissolved-phase plume is retarded by naturally occurring organic carbon in the soil and attenuated by naturally occurring biodegradation.

Based on the RI, there are no current or potential exposure pathways through which individuals on or near the Site could be exposed to potentially hazardous materials related to the former MGP Site. The MGP contaminants have not adversely impacted drinking water supplies in the community. The previous investigations have determined that the Site is located outside of the groundwater capture zones for adjacent water supply wells operated by the Village of Garden City and water supply wells operated by the Village of Hempstead at Clinton Street. In addition, soil vapor intrusion testing did not identify volatile organic vapors related to the MGP Site in nearby buildings or in soil vapor monitoring points located in the vicinity of the dissolved phase groundwater plume.

Three interim remedial measures (IRMs) have been implemented at the Site, which are summarized below.

1. A "cut and plug" IRM was conducted in 1999 and 2000.
2. Shallow impacted soils from the Site were excavated and taken off-Site for treatment and disposal during 2008.
3. Since 2007, DNAPL has been recovered from wells installed on and downgradient of the Site. Thirty-one (31) additional product recovery wells were installed to supplement the existing recovery wells.

Additionally, National Grid has installed two groundwater treatment systems downgradient of the site. These systems, which are components of the full site-wide remedy, deliver oxygen to the groundwater plume to allow naturally occurring bacteria to consume and destroy dissolved phase hydrocarbons originating from the Site.

There are two areas of known contamination not related to the former MGP Site. An Adjacent Oil Storage Terminal that has had some petroleum releases is located immediately east of the Site beyond the inactive railroad right-of-way. Petroleum storage and distribution activities are conducted at this location. The Mollineaux Brothers Fuel Company operated a fuel loading and storage facility immediately southeast of the Site that is now inactive. Documentation indicates that a petroleum release occurred at the Mollineaux facility.

Pre-design investigation activities were performed in 2008 and 2009 that focused on collecting data to support the design for the In-Situ Solidification (ISS) remediation and groundwater remediation systems. A summary of the investigation activities is provided below. The ISS remediation areas and groundwater treatment system locations are shown on Drawing 3.

- A soil boring program was completed to refine the delineation of MGP source material.
- A test pit was excavated to investigate the limits of a former MGP structure at the Site boundary.
- Environmental forensic analyses were performed on NAPL saturated soil samples that were collected in borings and wells located in the vicinity of the Adjacent Oil Storage Terminal.
- Soil borings were completed and geotechnical tests were performed to provide data that will be used to evaluate excavation stability during implementation of the ISS remediation.
- Bulk soil samples were collected for Solidification bench-scale testing and leaching assessments to develop representative ISS mix(es).
- Slug testing was performed on monitoring wells to obtain hydraulic conductivity data that was used in groundwater flow and contaminant mass transport models.
- Soil and groundwater samples were collected and analyzed for geochemical parameters that were used for a leaching assessment model to evaluate the ISS solidified mass.
- The locations of utilities were verified and mapped within the proposed ISS and groundwater treatment system locations.
- Groundwater sampling and analysis was performed to verify and delineate the dissolved phase contamination plume in the vicinity of proposed groundwater treatment system locations and to document geochemical conditions in the aquifer relative to intrinsic bioremediation processes.
- Geotechnical testing was performed on soil samples to support design of groundwater treatment system wells.

1.2.3 Previous Investigations and Reports

Several investigations have been performed at the Site and at adjacent properties to identify the presence of MGP impacts, determine the presence and extent of off-site MGP impacts, establish IRM boundaries, install NAPL recovery wells, and characterize the hydrogeology of the area. The RI Report (PS&S, 2006) documents investigations that were performed prior to and during the RI. Since completing the RI, the following reports have been completed:

- Groundwater Sampling and NAPL Monitoring/Recovery Reports.
  - Report for the Second and Third Quarters of 2007
  - Annual Report for 2007
  - Report for the First Quarter of 2008
  - Report for the Second Quarter of 2008
  - Report for the Third Quarter of 2008
  - Annual Report for 2008
  - Report for the First Quarter of 2009
  - Report for the Second Quarter of 2009
  - Report for the Third Quarter of 2009
  - Annual Report for 2009
  - Report for the First Quarter of 2010
  - Report for the Second Quarter of 2010
  - Report for the Third Quarter of 2010
  - Annual Report for 2010
  - Report for the First Quarter of 2011
  - Report for the Second Quarter of 2011
- IRM Remedial Action Work Plan (URS, 2007b).
- Feasibility Study/Remedial Action Plan (FS/RAP) (URS, 2008b).
- Technical Specifications/Contract Documents for Interim Remedial Measures (URS, 2008c).
- Pre-Design Investigation Work Plan for In-Situ Solidification and Off-Site Groundwater Treatment (URS, 2008e).
- Construction Operations Plan for Interim Remedial Measures (URS, 2008f).
- IRM Excavation Completion Report Interim Remedial Measures (URS, 2009c).
- Technical Specifications/Contract Documents for Off-Site Groundwater Treatment (URS, 2009g).
- Pre-Design Investigation Report for In-Situ Solidification and Off-Site Groundwater Treatment, (URS, 2010a).

- Off-Site Groundwater Treatment Remedial Design Report (URS, 2010b).
- Construction Operations Plan for Groundwater Treatment (URS, 2010c).

1.2.4 MGP Source Material

MGP source material subject to remediation, as defined for the Site, includes MGP impacted soil that is saturated with NAPL to a vertical thickness greater than six inches, and visibly impacted soil that contains total PAH's greater than 1,000 milligrams per kilogram (mg/kg) or total BTEX greater than 50 mg/kg to a vertical thickness greater than six inches.

1.3 Other Remedial Actions

1.3.1 Interim Remedial Measures

A "cut and plug" IRM Program was undertaken at the Site during the winter of 1999. The objective of that IRM was to locate underground piping associated with historic MGP operations so that each pipe could be cut, drained of any fluids and plugged in order to limit the potential for any off-Site migration of MGP-related constituents. The IRM was completed in summer 2000. Known Site utilities are shown on Drawing 5.

A second IRM was implemented in 2008 for the excavation of shallow MGP source materials from the Site and for the recovery of NAPL from the groundwater (refer to Drawing 3 for IRM excavation locations). The IRM was performed to remove MGP source materials from areas of the Site where no additional future remediation will be necessary and to support future Site-wide remediation activities by providing clean areas for support facilities, vehicle parking, and the staging of equipment and materials. A total of 4,432 cubic yards of MGP source material (as contaminated soil) and construction/demolition debris was taken off-site for treatment and disposal. 9,493 gallons of liquid was also taken off-site for treatment and disposal (URS, 2009c).

1.3.2 Groundwater Treatment

Groundwater treatment systems were designed to provide zones of elevated dissolved oxygen (DO) that will stimulate enhanced aerobic bioremediation of contaminated groundwater as it flows through the treatment areas. Aerobic bioremediation of the plume at select locations, in conjunction with solidifying the contaminant source via ISS, will accelerate the rate at which the dissolved contaminant mass is oxidized and will eventually lead to decreased contaminant concentrations in the entire plume.

Based on the dimensions and location of the groundwater contaminant plume, two separate groundwater oxygen treatment systems were designed and constructed (Drawing 3):

- System No. 1 – located in the vicinity of Smith Street, the inactive LIRR ROW, and the ROWs on Atlantic Avenue and Hilton Avenue.
- System No. 2 – located in Mirschel Park, on private property at 158 Hilton Avenue, and in the road ROWs on Hilton Avenue and Kensington Court.

Two additional systems are planned to be installed following completion of the ISS treatment:

- Wydler Place – located along Wydler Place.
- Intersection Street – located along Intersection Street, just east of the former MGP Site and partially within the LIRR ROW.

The groundwater treatment systems will incorporate a patented technology developed by Matrix Environmental Technologies, Inc. that involves the delivery of high-purity oxygen into groundwater at a rate low enough to avoid potential volatilization of the contaminants, but high enough to increase DO concentrations within the aquifer. The resulting zones of elevated DO will stimulate aerobic bioremediation of contaminated groundwater as it flows through the oxygenated areas.

Each system will consist of an equipment enclosure that houses the oxygen generation and control systems, a piping system for distribution of the oxygen, and oxygen delivery wells.

The oxygen will be generated using air compressors and pressure swing adsorption units and will be stored in tanks until it is directed out to the oxygen wells. Each system will include additional spare connections for expansion into other areas, should that be required in the future.

The system manifold will be connected to each well via separate ¾-inch diameter high-density polyethylene tubing that will be installed in bundles in a common trench parallel to the line of oxygen delivery wells with one tube connected to each well.

The oxygen wells will be screened in or below the zone of groundwater contamination. The wells will be constructed with schedule 40 polyvinyl chloride (PVC) with 2 feet of 0.01 inch (No. 10) slotted screen. System monitoring points will also be installed in the vicinity of the oxygen wells.

1.4 Report Organization

This report has been prepared using the following sections:

- Section 1 –Introduction
- Section 2 – Objectives and Scope of the Remedial Action
- Section 3 – Site Conditions
- Section 4 – Design Overview
- Section 5 – In-Situ Solidification
- Section 6 – Implementation
- Section 7 – References

The report drawings are first organized to present the Site conditions and are followed by the planned remedial activities (in sequence).

- Drawing 1 - Index of Drawings, Location Map, Legend and Notes
- Drawing 2 - Legend
- Drawing 3 - Site Remediation and Groundwater Treatment Locations
- Drawing 4 - Existing Site Plan Showing Former MGP Structures
- Drawing 5 - Existing Site Utilities
- Drawing 6 - Solidification Methods Layout
- Drawing 7 - West/East Cross Sections
- Drawing 8 - South/North Cross Sections
- Drawing 9 - Top of Solidification
- Drawing 10 - Bottom of Solidification
- Drawing 11 - Well Decommissioning Plan
- Drawing 12 - Infrastructure Decommissioning Plan
- Drawing 13 - Utility Protection and Decommissioning Plan

- Drawing 14 - Construction Sequencing Plan (Sheet 1 of 2)
- Drawing 15 - Construction Sequencing Plan (Sheet 2 of 2)
- Drawing 16 - Excavation Plan
- Drawing 17 - Excavation Cross Sections
- Drawing 18 - Site Restoration Phase 1
- Drawing 19 - Site Restoration Phase 2
- Drawing 20 - Post-Remediation Monitoring Network
- Drawing 21 - Remediation Details (Sheet 1 of 2)
- Drawing 22 - Remediation Details (Sheet 1 of 2)
- Drawing 23 - Erosion and Sediment Control Details
- Drawing 24 - Example Temporary Facilities Layout
- Drawing 25 - Existing LIPA Overhead Wires Plan and Profile – LIRR Right of Way

Remediation-related work plans, assessment reports, and supporting information are provided in the following appendices:

- Appendix A – Boring Logs
- Appendix B – Geotechnical Data
- Appendix C – Solidification Bench Scale Treatability Study Report
- Appendix D–Groundwater Flow and Solute Transport Model Report
- Appendix E–Surface Soil Sampling Results
- Appendix F– Solid and/or Liquid Waste Transportation Plan
- Appendix G–Community Air Monitoring Plan
- Appendix H– Community Impacts Mitigation Plan
- Appendix I– Contingency Plan
- Appendix J– Calculations

2.0 OBJECTIVES AND SCOPE OF THE REMEDIAL ACTION

The remedial action will be conducted at areas of the Site and adjacent properties that contain MGP source material, which are shown on Drawing 6. The remedial action will consist of the excavation of shallow MGP soil source material from the Site for off-Site treatment and disposal. Former MGP structures on the Site will also be removed and taken off-site for treatment and disposal during the shallow soil source material removal action.

The excavation of on-site contaminated soils will be performed within a temporary fabric-covered enclosure that incorporates a vapor management system (VMS). This enclosure is referred to as the temporary containment building (TCB) in this document . Certain areas will be excavated outside of the enclosure to address safety considerations with moving the TCB, due to the proximity of work near the operating natural gas regulator station, or where precharacterization sampling has indicated that odor-generating surface soil should not be expected.

ISS will be performed in accessible areas that contain MGP source material located deeper than the shallow MGP source material addressed by excavation and off-site treatment/disposal. ISS will be performed using the deep soil mixing (DSM) technique.

The goals of ISS at the Site are the following:

- To reduce the mobility of NAPL by treatment, i.e. effective mixing with soils and addition of cementitious reagents, to reduce levels of organic contaminants below the residual saturation point of the site media.
- To control the effect of the remaining MGP source material by reducing permeability to facilitate the flow of groundwater around, rather than through, the impacted media, and enhancing on-going bioremediation of the existing dissolved-phase plume.

Some areas of MGP source material are inaccessible to ISS treatment. Inaccessible areas include soil under the Professional Office Building (POB), soil under high-voltage lines located on the Long Island Railroad (LIRR) Right-of-Way (ROW), and soil located under drainage and sewer lines west of the site. The oxygenation systems will provide treatment in these areas.

3.0 SITE CONDITIONS

3.1 Geology and Hydrogeology

3.1.1 Geology

A thorough understanding of Site geology and hydrogeology has been developed from the previous investigations. In general, fill/topsoil overlies glacial sediments, which consist of glacial outwash and the upper and lower subunits of the Magothy formation. Specifically, the four primary geologic units present at the Site, in descending order (i.e. from ground surface down through the subsurface), include:

- Fill/topsoil
- Glacial Outwash
- Upper Magothy formation
- Lower Magothy formation.

3.1.1.1 Fill/Topsoil

The fill/topsoil unit is present on and immediately adjacent to the Site. Topsoil is present in the northern and northwestern portions of the Site. Fill is present over much of the remainder of the Site and is highly variable in composition. It often consists of brown to black sands, silts and gravels with varying amounts of concrete, brick, coal, bluestone, clinker, vesicular slag and wood. The unit is not continuous throughout the Site and it ranges in thickness from approximately 0.5 to 16 feet where present. The fill/topsoil unit appears to be thickest in the central-western portion of the Site where building demolition debris was used to backfill building foundations (e.g., in the area of former drip oil tanks and receiving reservoir). A thin surface layer of gravel is spread throughout much of the Site. In some areas, concrete foundations from the former MGP structures are present beneath the gravel.

The fill does not appear to extend a significant distance south of the Site. A thin layer of fill was observed at several soil borings located west of the Site within the Village of Garden City property.

3.1.1.2 Glacial Sediments

The geology of Long Island is formed by soil deposits that were left by the advance and retreat of glacial ice sheets. In general, these deposits thicken from north to south. Glacial sediments beneath the Site consist of three primary units: glacial outwash, the upper Magothy Formation, and the lower Magothy Formation.

3.1.1.3 Glacial Outwash

The uppermost glacial deposit beneath the Site is a relatively porous glacial outwash deposit consisting of yellow to light brown, fine to coarse sand with varying amounts of gravel. These sediments underlie the fill/topsoil and range in thickness from 60 to 70 feet within the Site to more than 95 feet south of the Site. Intermittent zones and lenses of silty sand and silt are present in the glacial unit and appear to limit the vertical movement of groundwater and NAPL.

3.1.1.4 Upper Magothy Formation

Underlying the glacial outwash sediments is the upper subunit of the Magothy Formation, which is characterized by a sequence of sand, silt, and clay layers. Its thickness ranges between 50 and 110 feet at the Site. Because of its diverse stratigraphy and the heterogeneous distribution of sediment types, the upper subunit is highly anisotropic with the vertical hydraulic conductivity several orders of magnitude less than the horizontal hydraulic conductivity.

3.1.1.5 Lower Magothy Formation

The lower subunit of the Magothy Formation, which is found at approximately 120 feet below ground surface (feet bgs) and below, is characterized by a low permeability silty fine sand and stiff clay. Due to the high clay content of the lower subunit, it acts as an effective confining layer limiting the vertical migration of groundwater and NAPL.

3.1.2 Hydrogeology

The water table occurs within the glacial outwash sediments (Upper Glacial aquifer) at depths ranging from approximately 25 to 30 feet bgs. Groundwater flow within the glacial outwash is in a south-southwesterly direction, with a hydraulic gradient of approximately 0.001 foot/foot.

Hydraulic conductivities of the Upper Glacial aquifer and the upper subunit of the Magothy Formation were estimated to be approximately 1×10^{-1} centimeter per second (cm/sec) and 1×10^{-2} to 5×10^{-2} cm/sec, respectively (McClymonds and Franke, 1972). Site-specific hydraulic conductivity testing performed during the PDI confirms these values.

The corresponding horizontal-to-vertical anisotropies of the Upper Glacial and Upper Magothy Formation are approximately 1:10 and 1:100, respectively (McClymonds and Franke, 1972). The lower subunit of the Magothy Formation is characterized by very low hydraulic conductivity of approximately 1×10^{-7} cm/sec (PS&S, 2006).

3.2 Conceptual Model

The conceptual Site model presented in the RI Report described the relationship between former MGP operations and the observations of physical impacts (i.e., NAPL, staining, sheen and odors), detected chemical constituents, migration pathways, and potential exposure pathways (PS&S, 2006).The conceptual Site model is summarized below:

- NAPL associated with the former MGP Site is primarily a DNAPL that ranges from a thick tar-like substance to a more mobile, lower viscosity fluid. Following a release from a former structure, the NAPL accumulated in the shallow soils around source areas until the sorptive capacity of the soil was exceeded. The heavier tar-like NAPL remained in the shallow soils while the lower viscosity NAPL tended to migrate downward into the deeper soils.
- The vertical, downward migration of NAPL from the near-surface source areas appears to have occurred via isolated and relatively thin vertical pathways. This conclusion is based on encountering significantly few instances of NAPL saturation in the soils from about 8 to 25 feet bgs.
- The tendency for the DNAPL is to continue to migrate downward. However, at the Site, the downward migration of the NAPL was impeded when it encountered the soils in the zone at and just above the water table (i.e., between approximately 25 to 30 feet bgs). In this zone, and where sufficient NAPL volume was available, the NAPL accumulated to saturated and near-saturated levels. Some NAPL penetration deeper into the saturated zone occurred beneath the former source areas where the volume of NAPL was greatest. However, a significant portion of the NAPL has preferentially migrated horizontally along the slope of the water table approximately 450 feet beyond the southern boundary of the Site beneath the Professional Office

Building parking lot. This NAPL saturation extending south of the Site occurs as thin (0 to 6-inch thick) layers. Interim product recovery wells were installed in this zone in 2008 and are used together with other wells to recover NAPL on a twice-a-month basis.

- While the NAPL is primarily a DNAPL, its vertical, downward migration within the water table is likely limited by lateral groundwater flow, the sorptive capacity of the soils, and limited volume of available NAPL. Consequently, it appears that NAPL has migrated horizontally along the water table as evidenced by only isolated observations of NAPL deeper in the water table, primarily beneath the source areas.
- Because of the limited volume of available NAPL, the thickness of the NAPL-saturated soils decreases significantly away from the source areas. In particular, the thickness of NAPL-saturated soils off-site in the central portion of the Professional Office Building parking lot is typically less than a foot compared to multiple-feet near the southern Site property line.
- There is no migration of MGP-related soil vapors from the off-site contaminants as evidenced by ambient air, soil gas, sub-slab, and indoor air sampling efforts at the Professional Office Building.
- A dissolved phase plume is present in the groundwater and extends approximately 3,800 feet south of the Site. Monitoring data during the period 2000 to 2011 has indicated that the plume is stable and has not increased in size or concentration during this period. With the two oxygenation systems operating downgradient of the site, the size of the plume is expected to decrease.

3.3 Nature and Extent of MGP Source Material

MGP source material includes MGP impacted soil that is saturated with NAPL or visibly impacted soil that contains total PAH's greater than 1,000 mg/kg or BTEX greater than 50 mg/kg. Prior assessment of Site characterization data performed during RI indicated that soils exhibiting visual characteristics of NAPL saturation or heavily NAPL-coated typically exhibited PAH and/or BTEX concentrations greater than these criteria. NAPL properties are summarized on Table 1. The extent and thickness of the MGP source material is shown on Drawings 7 and 8,

3.4 Soil Properties

Geotechnical conditions at the Site are based on information collected from boring logs and laboratory test data from the RI, the IRM investigation, and the PDI. This section provides a discussion of the geotechnical conditions and their implications relative to the proposed excavation and ISS remedial actions. The RI contained numerous boring logs that provided comprehensive qualitative descriptions of the Site soils including geotechnical laboratory test data. Subsequent investigations conducted during the IRM and PDI stages provide more detailed geotechnical information such as Standard Penetration Test (SPT) blow counts and laboratory test data. The IRM investigation and PDI included five (5) geotechnical borings (GTB-xx designations) and 4 solidification treatability study borings (ISS-xx designations) that provide soil descriptions and blow counts. Geotechnical characterization of the soils was also performed during a Solidification Bench Scale Treatability Study. The boring logs are provided in Appendix A. Geotechnical laboratory test results are summarized in Table 2 and are also provided in Appendix B (Geotechnical Data) and Appendix C (Solidification Bench Scale Treatability Study Report). Boring locations are identified in Appendix B.

3.4.1 Laboratory Testing

Laboratory testing was performed on soil samples that were located on or near the proposed remediation area (refer to Table 2).RI samples were obtained from 4 borings (HIMW-01, -02, -06, and -11) at 6 discrete depth intervals between 24 and 38 feet bgs. PDI boring samples were obtained from one boring (GTB-101) at 3 discrete depth intervals between 4 and 40 feet bgs. Drill cutting composite samples were also collected from 4 ISS borings (ISS-01 [25–70 feet bgs], ISS-02 [10-35 feet bgs], ISS-03 [10-50 feet bgs], and ISS-04 [20-40 feet bgs]). The laboratory test data generally agreed with the boring log descriptions and indicated that the soils are predominantly fine sand and larger in size.

3.4.2 Soil Descriptions

SPT N-values were recorded for borings GTB-1B, -2B, -3, and -4; ISS-01, -02, -03, and -04; and GTB-101. The boring depths ranged from 14 to 70 feet bgs.

The soils at these locations generally consist of cohesionless sand and gravel, with some silty soil present, except for soils within the upper 5 to 10 feet that can have considerable silt content. The predominant Unified Soil Classification system (USCS) soil classification is SP, which signifies non-plastic, poorly graded sands or gravelly sands with little or no fines. The measured hydraulic conductivity of these soils varied from 2.3 x10^{-2}cm/secto 7.2 x10^{-2} cm/sec (URS, 2010a). Although boring GTB-2B encountered loose soils throughout its entire 14-foot depth, the other GTB borings typically indicated medium dense soils (i.e., N-values primarily between 10 and 30). The ISS logs indicate a wider range of in-situ densities that vary from loose to dense, occasionally being very dense. On average, the ISS boring logs identify soils that are medium dense to dense (N-values 15 to 45 primarily) with an average N-value of about 26.

3.5 Infrastructure and Development

The Site and surrounding area are generally flat with the ground surface gently sloping to the west, northwest, and southwest. The Site is predominantly covered with crushed stone and is secured with a perimeter fence. Limited grass, shrubs and trees serve as a buffer across the northern fence line. Other than gas piping in the regulator station and Site security fences, there are no permanent aboveground structures on the Site.

Known utilities at and around the Site are shown on Drawing 5 and described below.

- **Gas Lines -** Active lines are located at the northern section of the former MGP Site that are associated with a natural gas regulator station. The active gas lines include a 16-inch (99 pounds per square inch [psi]) line that enters the Site from Second Street and enters the regulator station from the east. Other gas lines located on the Site and south of the regulator station appear to be associated with the former MGP operations (although not verified). An active gas line is situated west of the Site on Village of Garden City property. This line will be isolated by National Grid prior to the start of remedial construction activities in the area. The affected section of the gas line will be moved by the remedial construction contractor and replaced after construction is completed in the area. Movement of the line (and associated remediation) will be performed during the non-heating season.
- **Sanitary Sewers** – Sanitary sewers are present within the remediation area at Intersection Street, Wendell Street, and Cedar Valley Lane (a paper street located on the Village of Garden City property contiguous with the former MGP Site. Former MGP drawings provided by National Grid identify a sanitary sewer on the Site.
- **Storm Sewers** – A 54 to 60 inch diameter reinforced concrete sewer, identified as the “Horse Brook Drain” on Nassau County drawings (Nassau County, 1953), is located west of the Site beneath Wendell Street and Cedar Valley Lane. Storm sewer manholes and drop inlets are also present in the Professional Office Building parking lot.
- **Electric Power Lines** – Overhead power lines are located on the Site as shown on Drawings 5 and 25. Electric power transmission lines on the LIRR ROW include 13-kilovolt (kV) and 69-kV services. Each service consists of, in ascending height, neutral, low voltage, and high voltage wires. The measured heights of the lines are shown on Drawing 25.

- **Water Lines** – Water lines enter the Site from Second Street and three hydrants are present on the Site. Active water lines are also present beneath Intersection Street and Cedar Valley Lane.
- **Communication Lines** – Communication lines are attached to the electric power transmission poles on the LIRR ROW.

3.6 Property Ownership

Property ownership and approximate parcel boundaries are shown in the Community Impacts Mitigation Plan, which is provided in Appendix H. Parcel boundaries shown in the Community Impacts Mitigation Plan were obtained from the Nassau County Department of Assessment Internet Map Server and owner information was obtained from the New York State Office of Real Property Services (2007 Real Property data) that was downloaded from the New York State GIS Clearinghouse. The following parcels and owners were identified within and immediately adjacent to the remediation areas:

Parcel ID	Parcel Address
34.-147-102	101 Second Street
34.-147-116	34 Hamilton Place
34.-147-158	131 Second Street
34.-147-247	133 Second Street
34.-147-248	135 Second Street
34.-173-1	Cedar Valley Lane
34.-173-3	Hilton Ave.
34.-173-12	230 Hilton Ave.
34.-174-11	45 Intersection Street
34.-174-14	301 Franklin Ave.
34.-174-15	130 Franklin Ave.
34.-175-8	230 Hilton Ave. (parking lot south of the MGP Site)
34.-175-204	63 Smith Street
34.-175-209	73-75 Sealey Ave.
34.-175-210	77 Sealey Ave.
Not Identified	Long Island Railroad

4.0 DESIGN OVERVIEW

4.1 Remedial Design Approach

In designing the remedial approach, the area to be remediated has been separated into two areas: the former MGP Site and off-Site areas that include the Professional Office Building parking lot, Intersection Street, limited areas of the LIRR ROW, Wendell Street, the Village of Garden City park (including Cedar Valley Lane – a paper street), and the Active Oil Storage Terminal.

ISS treatment will address the targeted MGP source material as defined in the Pre-Design Investigation Report (URS 2010a):

- Soil saturated with NAPL if the total vertical thickness of a NAPL-saturated soil zone exceeded 6 inches.
- Visibly impacted soil zones exceeding 6 inches vertical thickness if the concentrations of PAH's were greater than 1,000 mg/kg or the concentrations of BTEX were greater than 50 mg/kg.

The limits of ISS do not extend to MGP source material edge areas where access is limited, such as under the Professional Office Building and certain utilities such as high-voltage power lines along the LIRR ROW, and sewer lines located west of the site. The MGP source areas accessible to ISS treatment are referred to below as the targeted MGP source material and are shown on Drawing 6. The total area proposed for ISS encompasses approximately four acres. In addition to ISS, areas of surficial coal tar observations (i.e., within the top 1 foot) and/or shallow impacted soils will be removed by excavation.

The basic remedial design approach is as follows:

- Former MGP Site - Excavate shallow contaminated soil "hotspots" and treat/dispose off-Site.
- Former MGP Site - Excavate MGP structures and targeted shallow MGP source material and treat/dispose off-Site. Solidify targeted deeper MGP source material.

- Former MGP Site – Excavate cleaner surface soil areas and stockpile on-site for later re-use as backfill. Solidify targeted deeper MGP source material.
- Professional Office Building parking lot, Wendell Street and Intersection Street – Create perimeter soil-cement ("soil-crete") retaining wall, excavate soil within wall to 15 feet bgs, solidify targeted deeper MGP source material, and backfill the excavation with the originally excavated soil.
- Village of Garden City Park – Excavate clean soil to about 8 to 11 feet, solidify targeted MGP source material, and backfill excavated area with originally excavated soil.
- Miscellaneous Adjacent Areas (the LIRR ROW and Active Oil Storage Terminal Area) – Create shallow cuts and/or berms for spoils containment and then solidify targeted MGP source material.

4.2 ISS Design Goals and Objectives

ISS is an established technology that has been used for over 20 years to treat a variety of residual wastes at industrial sites. ISS was selected as the appropriate remediation method because it creates a monolithic mass with a hydraulic conductivity much lower than the surrounding unsolidified soil. Since groundwater will flow around the monolith, rather than through it, contaminated soil contact with groundwater is drastically reduced.

ISS, as applied to MGP Sites with NAPL, accomplishes the following goals:

- Reduces or eliminates mobile NAPL by homogenizing it with the surrounding soils, reducing its concentration to below its residual saturation point, and mixing the impacted soils with cementitious reagents.
- Achieves source control through the creation of a low-conductivity mass to redirect the flow of groundwater around rather than through the impacted media.
- Maintains integrity by the creation of a high-strength solidified monolith.

To achieve these goals, a suitable ISS mix must achieve the following objectives:

- Reduce the rate at which liquids enter or pass through the monolith of treated media.
- Create a solidified material with appropriate integrity and strength for future site uses.

4.3 Performance Criteria

To achieve the goals and objectives of the ISS remediation program, performance criteria have been established for hydraulic conductivity reduction and compressive strength of the solidified soil mass. These performance criteria are listed below:

- Hydraulic Conductivity — $\leq 1 \times 10^{-6}$ cm/sec at 28 days
- Unconfined Compressive Strength (UCS) — $\geq$ 50 psi and $\leq$1,000 psi at 28 days

The rationale for these performance criteria is presented in the following sections. Note that durability testing is not proposed for the program. Given that solidified soils at the Site will not be subject to freeze-thaw cycling, and moisture contents around the solidified materials will not be expected to fluctuate widely, wet-dry and freeze-thaw testing is not warranted. Additionally, with a minimum strength criterion of 50 psi, weaker and less durable mixes will be excluded through UCS testing. Early MGP solidification projects utilized durability/weathering evaluations as a quality control parameter with a maximum mass loss criterion of 15 percent. Cement-based solidification mixes applied at MGP Sites have typically shown less than 3 percent mass loss and it is no longer considered a critical performance parameter, especially for sites where the majority of the solidified soil is above the water table and where a clean soil cover is placed over the solidified soils. A post-solidification study performed 10 years after solidification at the Columbus, Georgia MGP Site demonstrated that the solidified soils continue to exceed their original performance criteria and show no sign of structural deterioration (EPRI, 2003).

Based on the satisfactory performance of ISS at several other MGP Sites, and that solidified soils at this Site will be beneath a minimum 4-foot thick soil cover and below the frost line, durability/weathering is not included as a performance criterion for this Site.

4.3.1 Hydraulic Conductivity Reduction

To achieve the remedial objectives, the primary criterion for an effective ISS mix is to reduce the hydraulic conductivity of the treated soil so it is much lower than the hydraulic conductivity of the surrounding soil. In accordance with USEPA guidance (USEPA, 1989), the maximum criteria for hydraulic conductivity is 1×10^{-5} cm/sec. However, hydraulic conductivities lower than 1×10^{-6}cm/sec generally exhibit lower leaching rates as the flow transitions from advective transport to molecular-diffusion-controlled transport. Additionally, it has been shown that when the difference in hydraulic conductivity between two materials is greater than at least two orders of magnitude, water flow will follow the path of least resistance and will mainly flow around the lower permeability material (Environment Canada, 1991).

Based on this guidance, the target hydraulic conductivity for the solidified soil mass is less than or equal to 1×10^{-6} cm/sec. Since the hydraulic conductivity of the surrounding unsolidified soil is in the range of $2.3 \times 10^{-2}$to 7.2×10^{-2}cm/sec, the hydraulic conductivity of the treated soil is considered to be reduced sufficiently to immobilize target constituents and reduce flow rates through the solidified mass. Hydraulic conductivity testing will be performed on solidified soil samples that have been allowed to cure for 28 days.

The contractor will be required to perform a field demonstration test prior to the start of production work to demonstrate that hydraulic conductivities of 1×10^{-6} cm/sec or lower can reliably be achieved. The contractor will be required to conduct production solidification using the same techniques and reagents as were demonstrated to be effective in the field test. If quality control samples from production columns show hydraulic conductivity readings greater than 1×10^{-6} cm/sec, the contractor will be required to modify the techniques and/or reagents in order to meet the performance goals. For practical reasons, production columns not meeting the performance goals will not be retreated; however such off-specification columns would typically have columns located around them that meet the specification, which would continue to limit the flow of groundwater through the solidified monolith.

4.3.2 Unconfined Compressive Strength

Since the soil will be solidified to create a large monolithic mass, this mass must have sufficient strength (as defined by the unconfined compressive strength or UCS) to allow for future site uses. However, the strength of the solidified mass cannot be too great, or it will cause difficulties when performing ISS. In particular, DSM may not be able to achieve the column overlaps required to develop a monolithic soil mass when the strength of the previously made columns is too high, unless special mitigating field procedures are implemented.

The minimum UCS criterion is at least 50 psi when tested 28 days after soil treatment (i.e., UCS $\geq$ 50 psi at 28 days), based on USEPA guidance (USEPA, 1989) to provide a stable foundation for materials placed on it. The minimum UCS criterion of 50 psi is representative of very stiff cohesive soil.

Based on information provided by ISS contractors, the maximum UCS should be in the range of 150 to 500 psi at 28 days.

4.4 Deep Soil Mixing

DSM is a process that creates approximately 4 to 12-ft diameter vertical solidified soil zones by physically mixing of the soil with injected cementitious material using a rotating bit. DSM involves the use of a crane-mounted turntable or track-mounted drill rig to rotate the augers. A liquefied cementitious grout is injected through the crane or drill rig's hollow Kelly bar and the auger's injection ports. As the auger rotates with upward or downward movement, the grout is injected. When mixing cycles are complete, an in-situ column of solidified soil and groundwater is created. The process is repeated by installing a series of overlapping columns until the entire area is solidified. Subsurface foundations and debris must be removed prior to using this type of equipment.

There are two primary types of deep soil mixing systems. One is a Kelly-bar drive system attached to a track-type crane. The other is a self-contained hydraulic drill system. The specific type of deep soil mixing system will be specified by the contractor to meet the required design parameters. The crane-mounted system requires that the crane be on crane mats for stability. The hydraulic drill system can be operated on or off crane mats depending on soil conditions.

A DSM Field Demonstration Test Program will be performed to evaluate the processes, equipment, and techniques that will be used for full-scale execution of the work. Appendix F contains a summary of the minimum requirements for the ISS Field Demonstration Test Program.

4.5 Remediation Approach

4.5.1 Former MGP Site

A number of remnant structures have been identified at the Site, based on historic MGP plans and other means (e.g., test pits, borings, and geophysical survey). These structures, as well as active and inactive utilities, exist in areas that require remediation and need to be removed. In general, the upper 8 feet of soil will be excavated in proposed ISS areas to remove subsurface infrastructure prior to ISS. Structures present greater than 8 feet bgs will also be removed in areas where solidification is planned. Drawing 11 shows wells that are located on the MGP Site that are scheduled for decommissioning prior to the onset of remedial construction activities. Former MGP structures that have been identified are shown on Drawings 4 and 12. Several utilities are also present within the MGP Site that must be protected, moved and replaced, or removed and disposed, which are shown on Drawing 13.

The upper 4 feet of soil will be removed with the remnant structures and debris to allow the ISS to be performed. In some locations, other excavation depths are specified as shown on Drawings 16 and 17. This material will be removed to accommodate the anticipated volume increase due to solidification, as well as the placement of several feet of clean soil over the top of solidified soils.

In addition to the mass excavation areas, excavation and off-site disposal alone will be performed at three locations, as shown on Drawings 14 and 16. These three areas are for near-surface MGP impacts in two discrete zones of contamination in the eastern portion of the site along the LIRR ROW, and surface soils near the sampling location HISS-08 (shown on Drawing DWG-14) where near-surface soil samples demonstrated the presence of mercury above applicable part 375 criteria.

Excavated structures, foundations, and debris will be properly disposed or recycled off-site. Contaminated soil (i.e., MGP Source material) excavated in preparation for ISS will be treated and disposed at an off-site facility. The excavation limits for removal of the MGP Source are shown on Drawing 16. Clean soil excavated in preparation for ISS will be stockpiled for reuse as backfill over solidified areas. Further evaluation of the disposition of excavated soils is expected to be performed in conjunction with the remediation contractor.

After the Site has been excavated to the depths specified on Drawing 16, the ISS of the underlying contaminated soil will begin. Solidification will commence utilizing DSM technology, whereby 4- to 12-foot diameter soil augers will be used to deliver and mix the solidification reagent grout into the soil to the depth required.

The ISS treatment area for the targeted MGP source materials will extend across the accessible MGP source material as shown on Drawing 6 and approximately 2 feet below the accessible delineated targeted MGP source material. The depth below ground surface to the bottom of solidified zone ranges from approximately 34 feet bgs to approximately 66 feet bgs, as shown on Drawing 10. The solidified zone will extend from the bottom elevation of the targeted solidification zone to the prepared surface at the base of the excavation. Cross-sections showing the ISS application at the Site are provided in Drawings 7 and 8. A typical DSM column pattern is illustrated in Drawing 21.

Targeted MGP source material located greater than 60 feet bgs at the northwest section of the Site (refer to sections WE-1 and SN-1 on Drawings 7and 8) is expected to be within the vertical limits that can be achieved by DSM equipment due to the pre-excavation depths that are planned in these areas..

As noted above, ISS is expected to cause a volume increase in the treated soils. This is due to the addition of the solidification reagent grout into the soil, and the overlapping treated columns that are needed to solidify the entire soil mass. Most of the volume increase will be contained in the Site excavation and excess material will be properly disposed off-site. The top of the solidified soil monolith will be at least 4 feet below finished grade, except for some limited areas around LIPA power poles (e.g., within 25-foot radius of the poles), which will allow precipitation to infiltrate and flow off-site without ponding at the ground surface.

4.5.2 Off-Site Areas

Off-Site areas include the Professional Office Building parking lot, Intersection Street, Wendell Street, the LIRR ROW, the Village of Garden City property (Cedar Valley Lane), and the Active Oil Storage Terminal. Compared to the MGP Site, source material in these areas occurs in a much narrower interval at or near the water table surface. In these areas, greater amounts of clean surface soil will be excavated prior to DSM treatment. The clean excavated soils will be stockpiled and used for backfill.

The top of the solidified zone ranges from approximately 8 to 11 feet bgs in the Village of Garden City property, 15 feet bgs in the Professional Office Building parking lot, and 4 feet bgs in other areas, including the top of the soil-crete wall surrounding the Professional Office Building parking lot treatment area. The bottom of the solidified zone will range from approximately 21 to 66.5 feet bgs(refer to Drawing 10). Depths below ground surface to the top and bottom of solidification vary throughout the Site. Cross-sections showing the ISS application at the Site are provided on Drawings 7and 8.

4.5.3 Inaccessible Areas

MGP source material in edge Areas located under the POB, the high-voltage power lines along the LIRR ROW, and under the Horsebrook drain have access limitations for ISS treatment. To address these areas, two additional oxygenation systems will be installed following ISS treatment. The first planned system will be located along Wydler Place. This system will provide treatment of groundwater immediately downgradient of the Horsebrook Drain in the VGC park area, and will oxygenate groundwater immediately upgradient of the POB. The second planned system will be located along Intersection Street east of the site to help address MGP impacts present under the LIRR ROW electric power lines north of Intersection St. These systems are shown on Drawing 6.

4.6 Geotechnical Conditions

4.6.1 Excavation Stability

As discussed in Section 4.5, MGP structures and shallow MGP source material will be excavated prior to ISS remediation. Engineering soil properties have been evaluated relative to excavation stability. Several borings provide SPT values which is a common indicator of soil strength. The uniform nature of the soils (determined from visual descriptions and SPT data) throughout the Site provides confidence that the engineering properties are also consistent. Broad assumptions on engineering soil properties can therefore be made relative to excavation stability since the following conditions exist:

- Most of the on-site excavations will be less than 6 feet deep, except for two on-Site areas up to about 14 feet deep, and areas where former MGP structure removal is required. Groundwater occurs at approximately 25 to 30 feet bgs. Therefore, hydrostatic forces from groundwater will not be acting on the foundation soil (e.g. open cut side slopes or soil-crete wall) for the temporary enclosure that will cover excavations or excavation sidewalls.
- The POB parking lot will be excavated to 15 feet bgs which also will be above the groundwater table. Furthermore, the POB excavation area will be shored by a soil-crete retaining wall.
- The Site soils are mainly cohesionless and some conservative assumptions on the density of the soils can be made where detailed data does not exist (soils can be assumed to be loose and within the fine-grained sand range) without significant over-design of the temporary enclosure foundation or sidewall support/slope cutback systems.

Excavations can be stabilized using open cut and shoring methods. The open cut methods can be used provided there is sufficient adjacent space to accommodate the cutback. A 14-foot deep excavation (the maximum expected open cut depth for this project) would result in a cutback width of about 21 feet (e.g., 1V:1.5H). The preferred shoring method is a soil-crete (SC) gravity retaining wall. Other shoring methods such as a steel sheet pile cantilever and slide rails can create more noise and vibration which is not preferred. A soil-crete wall would require a shallow key-in to the excavation bottom (about 2 feet) and an approximate 7 to 10-foot width for a 10-foot cut and, conservatively, a 12 to 15-foot width for a 15-foot cut. A stabilized soil-crete gravity retaining wall would require that no buried obstructions are present that would interfere with the soil mixing process that would be installed from the ground surface.

4.6.2 In-Situ Solidification

For ISS, obstructions such as old infrastructure, boulders or cobble layers must be removed or pre-drilled beforehand. The proposed ISS areas contain no known obstructions beneath the old MGP infrastructure, which will be excavated prior to DSM. Outside of the former MGP Site, excavation will be performed to a level where all existing utilities can be exposed prior to performing DSM.

For soils that do not contain obstructions, the soil type, plasticity, texture, and moisture content affect equipment type and grout mix. Very dense gravel and very stiff clay zones are difficult soil conditions for typical ISS methods. The geotechnical data within the proposed ISS areas do not indicate that these conditions are present. High moisture content soils would dictate dry grouting methods (dry materials injected using a pressurized air stream). This Site does not contain high moisture content soils such as soft clays or organic layers so wet grout methods will therefore be used. Wet grouting methods can typically be used for soils with moisture content approaching 60%. The moisture content of the in-situ soils measured from the 4 treatability study samples ranged from approximately 5 to 15 percent.

The location of the water table distinguishes saturated soils from unsaturated soils and is an important factor for ISS. DSM will generally blend the entire soil column being treated during the up and down stroke mixing action of the method. Granular soils above the water table typically require a higher water to cement ratio. The water table occurs at approximately 25 to 30 feet bgs and the maximum ISS depths will range from approximately 21 to 66.5 feet bgs.

Granular soils, such as sands and gravels are predominant at the Site and will produce less swell and higher strength than fine-grained soils. Higher moisture content can also produce more swell relative to lower moisture content soil. The typical volumetric swell range for DSM is about 10% to 40% for all soil types so the Site soils, being granular and above the water table primarily, should exhibit the lower end of swell.

A detailed delineation of soil stratigraphy is not critical to ISS mixing for the Site because the soil properties are relatively consistent and any soil variations will be minimized during DSM. Soil conditions that may make DSM difficult would include N-values approaching 100 (e.g., a hard gravel zone) or obstructions. The boring logs do not indicate the presence of hard soil zones or obstructions within the planned DSM limits. In terms of DSM production, an obstruction can also be defined as penetration limited to 1 foot per minute for at least 5 minutes. There are numerous DSM means and methods that can accommodate many types of soil conditions. The remediation contractor can vary factors such as the auger diameter (typically from about 4 to 12 feet), the available torque, shaft rotation speed, and time duration on upstroke/downstroke.

The remedial contractor's experience will be very important for selecting the most appropriate means and methods for the DSM and a field demonstration program, conducted as part of the field start-up, will be required to prove it meets performance requirements. The field demonstration test program will evaluate the ability of the contractor's proposed solidification methods and grout mix to produce soil-cement columns meeting the depth, diameter, column spacing, and material property requirements. The field demonstration test program will consist of a minimum of three grout columns installed at each of two separate locations that are considered to be representative of the soil conditions at the Site. The columns will be installed to extend between depths equivalent to the highest Top Elevation and the lowest Bottom Elevation for ISS treatment that will be encountered during the Work. The field demonstration test program will be used to confirm that resultant in-situ soil-cement properties meet required performance criteria; and optimize the DSM processing to meet the criteria. These parameters include but are not limited to, grout mix composition, fluid(s) flows and pressures, rotational speed, and retraction rate. For the field demonstration test program, the Contractor will use the largest diameter auger that is proposed for production solidification. A minimum of three mixing passes will be conducted for each column.

The field demonstration test program and its results will be observed, reviewed and approved by the Construction Manager. DSM will be performed up to the ground surface to facilitate shallow test trenching or excavation as verification inspection.

A minimum of four acceptable/representative specimens from each column set will be collected for visual observation to evaluate the adequacy of the soil-cement homogeneity and lateral overlap of adjacent columns. Of these samples, at least two will be obtained from the center of different columns: one sample from the centroid of the group of three columns and one sample from an outer edge of one of the columns.

These samples will be formed into specimens, allowed to cure, and then be submitted for strength and permeability testing analyses. Subject to the results of these observations and analyses, the operational parameters, including reagent mix, will be determined for the production work. The contractor will be required to repeat some or all of the demonstration program with altered operating conditions (e.g. auger diameter) or reagent mix if specified parameters do not meet the test requirements.

4.7 Site Restoration

The Site will be restored in a manner that will be suitable to the end use of the property, which may include future development. Restoration plansare shown on Drawings 18 and 19.

- Solidified Soil – provide flat surface for DSM solidified soil to prevent ponding/infiltration.
- Former MGP Site (National Grid property) – the ground surface elevation will be restored to elevations and grades that are similar to existing conditions using a firm, non-paved surface. Driveways on the Site and the perimeter fence will be restored to existing conditions or better.
- Professional Office Building Parking lot – a new parking lot will be constructed.
- Intersection Street and Wendell Street– Disturbed areas of the streets will be rebuilt in accordance with Nassau County Specifications (NassauCounty, 2003, 2009).
- LIRR ROW – the ground surface will be backfilled with clean soil and graded (where necessary) to match existing contours.
- Village of Garden City Park and Active Oil Storage Terminal – Restore to original condition.

5.0 IN-SITU SOLIDIFICATION

5.1 Remediation Areas and Volumes

Approximate remediation areas and volumes, shown on Drawings 6, 7, 8, 9, and 10, are listed below.

Method	Area (ft2)	Volume (yd3)
Former MGP Site		
Excavation	110,370	22,480
ISS	98,765	117,344
Off-Site Areas		
(1) POB Parking Lot, Intersection Street and Wendell Street		
Excavation	64,995	21,476
ISS	49,806	40,211
(2) LIRR ROW		
Excavation	9,047	1,023
ISS	4,125	3,572
(3) Village of Garden City Park Area		
Excavation	16,931	4,897
ISS	8,110	9,316
(4) Active Oil Storage Terminal		
Excavation	1,284	190
ISS	785	1,341
Total Off-Site Areas		
Excavation	**92,257**	**27,586**
ISS	**62,826**	**54,440**

5.2 ISS Bench-Scale Treatability Study

A bench scale treatability study was performed by Remedius, LLC of Amarillo, Texas (Remedius) to test various combinations of reagents needed to treat NAPL-impacted source soils and lower the permeability/increase the integrity of the solidified mass. The purpose of the treatability study is to develop UCS and hydraulic conductivity data (the parameters that comprise the remediation performance goals) for various mixtures with solidification reagents to provide to prospective remediation contractors to enable them to better develop their bids and proposals. In addition to this data, National Grid has provided prospective remediation contractors with site soil samples during the bidding phase for the remediation contractors to perform additional tests of their own.

The Solidification Bench Scale Treatability Study Report is provided in Appendix C and results are discussed below. The treatability study employed a tiered approach. The scope of the tiers has been modified during the testing period to reflect observations obtained in each earlier tier. Tier 1 comprised screening level testing to determine general ranges of mix proportions to meet the physical performance criteria. Tier 2 testing was performed on smaller numbers of samples to refine the amounts of binders needed to meet performance goals, and to evaluate the effects of various additives against a baseline or control mix. Tier 3 of treatability study included evaluating the effect of a water-reducing admixture. Tier 4 of the treatability study was performed to assess the sensitivity of the treatment process to changes in water-to-reagent ratios. Tier 5 of the treatability study, further refined the binder ratio to identify optimum ratios, and also examined higher water content mixes that may be employed.

5.2.1 Soil Samples for Solidification Treatability Study

5.2.1.1 Soil Sample Collection

Four soil samples were collected from the Site for evaluation. These samples were collected from the drill rig auger flights from the depth interval of interest for solidification. This method of sample collection resulted in vertical compositing of the soil samples within each sample location, which is considered to be similar to the effect that the soil mixing augers will have during solidification. This sampling method also results in the creation of a more uniform soil sample for bench scale testing. Samples were placed in screw-top New York State Department of Transportation (NYSDOT) 5-gallon shipping buckets lined with a sealable 3-mil-minimum polyethylene liner bag. A total of four full 5-gallon buckets of auger flight soil sample were collected at each of the four sample locations.

The sample locations selected for treatability evaluations were based on obtaining samples exhibiting a range of soil characteristics and NAPL saturation levels in order to determine the variability in these parameters within the area to be remediated by ISS. The sample collection locations included the following locations:

- **Sample ISS-01 (IPR-2, HISB-59 area)** – Area represented shallow and deep NAPL impacts in area where deeper ISS (i.e., more than 40 feet bgs) is proposed.
- **Sample ISS-02 (HIMW-06 area downgradient of Storage Holder)** – Area represented shallow NAPL impacts over an approximate 20-foot thickness downgradient of a former gas holder.
- **Sample ISS-03 (IPR-6 area)** – Area represented intermittent NAPL impacts between 30 feet bgs and 45 feet bgs towards east limit of ISS.
- **Sample ISS-04 (IPR-21, IPR-21 area)** – Area represented typical DNAPL impacts to the Professional Office Building parking lot.

Soil samples for ISS were collected with hollow-stem auger drilling methods. During advancement of the augers, continuous split-spoon samples were collected and blow counts were recorded. Soil samples were visually characterized relative to soil type and MGP-impacts, and two samples from each sampling area, one above the water table, and one below the water table, were collected for moisture content analysis (ASTM D2216). In-place density at each ISS sample location was determined by using by SPT (ASTM D1586).

5.2.1.2 Soil Sample Compositing and Characterization

At Remedius, the contents of each bucket from a specific sample location were combined and homogenized to form a single composite sample for each specific sampling area (i.e., ISS-01 through ISS-04). A portion of each composite sample was used to characterize the physical and chemical properties of each sample. The soil characterization allowed an assessment of the variability of soil properties and NAPL impacts, which aided in evaluating whether more than one solidification mix design (i.e., reagent combinations) or mix strength (i.e., percent of reagents per dry weight of soil) was needed for the Site. The soil characterization parameters are as follows:

- Moisture Content - ASTM D2216
- Unit Weight - ASTM D2937

- Atterberg Limits - ASTM D4318
- Sieve w/hydrometer - ASTM D422
- USCS Classification - ASTM D2487
- BTEX - EPA 8260B
- PAH's - EPA 8270C
- Total Hydrocarbons /Oil and Grease - EPA 9071B
- pH - EPA 9045

Prior to creating soil solidification reagent mixes (i.e., Tier 1 through Tier 6 testing), the soil samples were screened through a No. 4 sieve to remove oversize particles, and only soil passing through the screen was used to create solidified soil specimens. The ASTM testing methods require that particles larger than one tenth of the specimen diameter be removed so the large particles in the soil do not affect the geotechnical tests for UCS and permeability performed on small diameter solidified specimens. The moisture content of screened soil samples was determined for use as the base soil moisture content for each soil/reagent mix.

5.2.2 Tier 1 – Strength and Permeability Bracketing

Tier 1 testing was conducted to determine if more than one mix design was appropriate for the Site, or if varying the strength of a single mix design was necessary to treat different areas. Therefore, the Tier 1 testing focused on developing a solidification mix designs to bracket the range of cementitious material needed to solidify the soil samples containing NAPL. This step was performed with a solidification mix (i.e., reagent) that has been successfully applied at several other MGP sites: Type I/II Portland cement and ground-granulated blast furnace slag (GGBFS) in a 1:3 mix ratio. This reagent mix typically produces a lower permeability and higher strength soil/reagent mix than a soil mix with cement alone. These reagents are readily available through commercial cement suppliers as they are commonly used materials in commercial slag cement.

This reagent mix was mixed into each of the four soil specimens in four doses: 10, 20, 30, and 40 percent by dry weight of soil, as summarized in Table 3. The mixes were placed in cylindrical molds and moist-cured for 28 days in general accordance with ASTM C192. After curing, all specimens were tested for UCS in general accordance with ASTM D2166.Hydraulic conductivity testing (in general accordance with ASTM D5084) was performed for mixes that exhibited UCS greater than or equal to 50 psi.

5.2.3 Tier 2 – Refinement of Binder Ratios and Additives Evaluation

From the four soil samples used in Tier 1 testing, two samples were retained for Tier 2 testing, the soil from samples ISS-02 and ISS-04. The retained samples represented average and high contaminant levels. Strength and hydraulic conductivity results from Tier 1were also used in the selection of the two soil samples that were carried forward into Tier 2.

Sample ISS-01 was the least contaminated of the samples and not retained for that reason. Sample ISS-02 represented the average or expected soil conditions and generally had lower strength and higher permeability than samples from ISS-03 and ISS-04. Sample ISS-03 was moderately more contaminated than ISS-02, but the difference was not significant enough to retain it in the study. Sample ISS-04 was the most contaminated soil sample and had aslightly higher fines content than the other samples, so it was retained to represent the worst-case contaminant concentration conditions. The sampling locations for both ISS-02 and ISS-04 were within the center of the DNAPL plume area.

The Tier 2 testing was performed to narrow the range of suitable mix designs required for the soil specimens representing average and high contaminant levels, as well as to evaluate the benefit of reagent additives. Specifically, there were three objectives for the Tier 2 testing:

- Evaluate the effects of using lower reagent doses in the soil solidification mixes;
- Evaluate the effects of additives on strength and permeability; and
- Evaluate the relative viscosities of the mixes.

The additives included small amounts of bentonite, organoclay, and a superplasticizer that were added to the mixes to evaluate the effects on strength, permeability, and viscosity, which is related to the mixing torque that would be required for ISS. Bentonite was evaluated to determine its benefit to permeability reduction, and possible grout mix torque reduction and target compound (i.e., BTEX and PAH's) attenuation. Organoclay was evaluated for similar properties as bentonite. The superplasticizer (Rheobuild 1000) was selected to attempt to reduce the viscosity of the wet soil:reagent mix and reduce the mixing torque required, in an effort to determine if the solidification mix can be tailored to allow deeper penetration of the mix augers during full-scale implementation. Note that due to delays in obtaining the superplasticizer, the mixes with this additive were evaluated as Tier 3 testing.

For the Tier 2 testing, five mixes were prepared and evaluated for each soil sample. All mixes used cement:GGBFS as the primary solidification reagent. For each soil sample, the mixes included the following: a control reagent mix with a 10 percent (by dry weight) dose of reagent; two mixes with lower reagent doses (i.e., 5 and 7.5 percent doses of cement/GGBFS); one mix with the control reagent mix and bentonite additive; and one mix with the control reagent mix and the organoclay additive. The doses of bentonite and organoclay added to the control reagent mixes were 1 percent additive (by dry weight) for ISS-02 and 2 percent additive (by dry weight) for ISS-04. The materials and quantities used in the Tier 2 mixes are summarized in Table 3.

Prior to curing, each wet soil/reagent grout mix was tested with a Torvane vane shear tool to determine the relative resistance to mixing. This test provided a comparison between reagent mixes of relative torque requirements for auger mixing. The soil/reagent grout mixes were placed in cylindrical molds and moist-cured for 28 days in accordance with ASTM C192. After curing, all specimens were tested for UCS in accordance with ASTM D2166, and mixes that exhibited UCS greater than or equal to 50 psi also were tested for hydraulic conductivity in general accordance with ASTM D5084.

5.2.4 Tier 3 – Mix Optimization

As stated above, the purpose of the Tier 3 testing was to evaluate the benefits of the superplasticizer (Rheobuild 1000). Since ISS-04 represents the worst-case contaminant concentration conditions for the collected samples, the study focused primarily on mixes using this soil. The reagent doses in the mixes for the Tier 3 testing were based on the results from the Tier 2 tests. Specifically, two mixes were prepared using the ISS-02 soil: one mix with a 9 percent reagent dose and another mix with a 9 percent reagent dose and superplasticizer. The superplasticizer was added at a dose of 5 milliliters of Rheobuild 1000 to 100 grams of cement/GGBFS.

Prior to curing, each wet soil/reagent grout mix was tested with a Torvane vane shear tool to determine the relative resistance to mixing. The soil/reagent grout mixes were placed in cylindrical molds and moist-cured for 28 days in accordance with ASTM C192. After curing, all specimens were tested for UCS in general accordance with ASTM D2166, and mixes that exhibited UCS greater than or equal to 50 psi also were tested for hydraulic conductivity in general accordance with ASTM D5084.

5.2.5 Tier 4 – Preliminary Water Ratio Variation

Following the refinement in binder ratios in the Tier 2 and Tier 3 testing, Tier 4 tested variations in water content. Discussions with a select group of deep soil mixing contractors indicated that adjusting the water/solids ratio was a key operating parameter, with harder drilling conditions requiring a higher water/solids ratio for the grout. Whereas the earlier tiers tested a nominal (approximate) 1:1 water/solid ratio for the grout, Tier 4 examined mixes with ratios ranging from 0.5:1 to 2:1. These tests were also run with and without an organoclay additive.

5.2.6 Tier 5 – Lower Binder Ratio and Further Water Ratio Variation

As discussed below, an outcome of the Tier 4 test results is that three of four of the water ratios tested produced compressive strengths greater than 200 psi, which may complicate overlapping the treatment columns and/or provide other workability issues. Thus, in this tier, the binder ratio was lowered in two tests from 9% to 6% to see if strength could be lowered while still remaining above 50 psi and maintaining sufficiently low permeability. Secondly, some jet grouting technologies require much larger water/solid ratios and thus higher water ratios, up to 8:1, were tested.

5.2.7 Tier 6 – Lower Binder Ratio and Further Water Ratio Variation

Tier 6 mixes were added to the treatability test to define strength and permeability characteristics for mixes prepared using lower doses of binder (with added bentonite) than tested previously. These tests were performed to identify effective mixes that use less binder since sufficient strength appeared to be readily achievable, with bentonite added to reduce permeability.

5.3 Performance Evaluation of Solidification Mix Designs

As noted above, the soil/reagent grout mixes prepared in Tiers 1 through 5 were placed in cylindrical molds and moist-cured in general accordance with ASTM C192 prior to physical and chemical testing. The physical and chemical testing programs are discussed in the following sections.

5.3.1 Physical Properties

To achieve the goals and objectives of the ISS treatment program for the Site, design criteria were established for allowable compressive strength and hydraulic conductivity of the solidified soil, as discussed in Section 4.3. Additionally, the viscosity of each specimen was also determined as part of the Tier 2, 3 and 4 testing programs. The tests and test results are briefly discussed in the following section and test results for the physical properties of the specimens are summarized in Table 4. A draft Solidification Bench Scale Treatability Study Report is provided in Appendix C and includes reporting on Tiers 1, 2, and 3, and raw data tables for Tier 4.

5.3.1.1 Unconfined Compressive Strength

After moist-curing for 28 days, all specimens were tested for UCS in general accordance with ASTM D2166 –Standard Test Method for Unconfined Compressive Strength of Cohesive Soil. This test method is commonly used to evaluate potential solidification mixes and was considered to be appropriate for this treatability study. Specifically, this test determines the compressive strength of cohesive soil and soil-like materials under unsaturated and undrained (i.e., a quick test with no allowance for dissipation of pore pressure build-up) conditions with no lateral confinement of the specimen being tested.

In the UCS test, the specimen is placed between two plates and vertical stress is applied to achieve a strain rate in the range of 0.5 to 2.0 percent per minute. Failure occurs when the vertical stress starts to decrease with increasing strain or when the total strain exceeds 15 percent. The UCS value is defined as the peak stress (i.e., stress at failure) and reported in units of force per area (e.g., psi).

In the Tier 1 tests, the UCS values for the mixes were in the range of approximately 260 to 2,790 psi, which exceeded the minimum required UCS value of 50 psi. In general, the strength of the mixes increased with the increasing reagent doses, as shown on Table 4.

For the Tier 2 tests, the ISS-02 mix with a 5 percent GGBFS/cement dose had a UCS value of 21.4 psi and did not meet the minimum required UCS value. The other mixes using the ISS-02 and ISS-04 soils exceeded the minimum strength criterion, and were in the range of approximately 230 to 720 psi. Adding 1 percent by dry weight bentonite or organoclay to the ISS-02 10 percent doses mixes resulted in higher UCS values (727.4 and 602.0 psi, respectively) than the ISS-02 10 percent doses mix without any additive (UCS value = 461.8 psi). For the ISS-04 soil, the addition of 2 percent bentonite or organoclay to the 10 percent dose mix resulted in strengths (434.7 and 431.3 psi, respectively) that were below the UCS value of the 10 percent dose mix (UCS = 683.3 psi). Otherwise, the strength of the mixes increased with the increasing reagent doses, as shown on Table 4.

Results from the Tier 3 tests show that the strength of the ISS-02 sample with a 9 percent dose and 22.5 mL of superplasticizer (Rheobuild 1000) had a value of 61.3 psi, which just met the strength criterion. The strengths of the other mixes were much higher, in the range of 408.9 to 661.6 psi.

The Tier 4 test results show that the strength of the specimens with a 9 percent dose of reagent (with and without additives) was in the range of 122.5 to 720.3 psi, which exceeded the minimum strength requirement for all mixes. However, the strength of the mixes decreased as the water-to-solids ratio increased, as shown on Table 4. In addition, the strength criterion was met by the specimens with water-to-solids ratios of 0.5 and 1.0 after a 7-day cure duration and by all samples after a 14-day cure duration.

The Tier 5 test results show that the strength of the specimens with a 6 percent dose of reagent (with and without bentonite) was in the range of 287.4 to 419.8 psi, which exceeded the minimum strength requirement for all mixes. The tests with higher water content also met the minimum strength requirements for both the 4% and the 10% binder mixes.

The Tier 6 tests confirmed that lower levels of binder were sufficient for meeting minimum strength requirements with strengths ranging from 269.8 to 365.4 psi for the 4.5% and 5.0% binder mixes.

5.3.1.2 Hydraulic Conductivity

Mixes that exhibited UCS greater than or equal to 50 psi after a 28-day cure time were also tested for hydraulic conductivity (also referred to as permeability) in general accordance with ASTM D5084 –Standard Test Methods for Measurement of Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter. Hydraulic conductivity is a measure of the resistance to water flowing through a saturated porous material. As previously noted, when the difference in hydraulic conductivity between two materials is greater than at least two orders of magnitude, water flow will follow the path of least resistance and flow around the material with the lower hydraulic conductivity.

In the Tier 1 tests, the hydraulic conductivities of the mixes were in the range of 3.3×10^{-6} to 5.2×10^{-9} cm/sec, which were below the maximum allowable hydraulic conductivity value of 1×10^{-6} cm/sec. In general, the hydraulic conductivity of the mixes decreased with the increasing reagent doses, as shown on Table 4.

For the Tier 2 tests, the hydraulic conductivities of the ISS-02 and ISS-04 mixes dosed with 5 percent GGBFS:cement were 3.3×10^{-6} and 5.2×10^{-9} cm/sec, respectively, which exceeded the maximum allowable hydraulic conductivity criterion. The 7.5 percent dose mix for the ISS-02 sample had a hydraulic conductivity of 7.5×10^{-7} cm/sec, which just met the criterion; the 7.5 percent dose mix for the ISS-04 sample had a hydraulic conductivity of 1.1×10^{-6} cm/sec, which slightly exceeded the criterion. The 10 percent dose mixes (with and without additives) were in the range of 1.6×10^{-7} to 7.9×10^{-9} cm/sec, which met the hydraulic conductivity criterion.

The results of the hydraulic conductivity tests for the Tier 3 ISS-02 and ISS-04 mixes dosed with 9 percent GGBFS:cement and superplasticizer were 7.8×10^{-5} and 4.1×10^{-5} cm/sec, respectively, which exceeded the maximum allowable hydraulic conductivity criterion. The other

9 percent dose mixes (with and without additives) were in the range of 3.1×10^{-7} to 3.4×10^{-8} cm/sec, which met the hydraulic conductivity criterion.

The Tier 4 test results show that mixes with a 9 percent dose of reagent and water-to-solids ratios greater than 0.5 had hydraulic conductivity in the range of 2.3×10^{-6} to 1.6×10^{-5} cm/sec, which did not meet the hydraulic conductivity criterion. When the water-to-solids ratio was equal to 0.5, the hydraulic conductivities were 8.6×10^{-7} and 7.7×10^{-7} cm/sec for mixes with a 9 percent dose of reagent, with and without 2 percent organoclay, respectively.

The Tier 5 tests with the 6 percent binder had hydraulic conductivity in the range of 9.0×10^{-7} cm/sec with no bentonite to 8.8×10^{-9} cm/sec with 2% bentonite. The tests with higher water content had an acceptable hydraulic conductivity with 10% binder but were above the 10^{-6} cm/sec target with 4% binder. Each of these higher water tests had 1% bentonite added.

All the Tier 6 tests had hydraulic conductivities less than 10^{-7} cm/sec.

5.3.1.3 Viscosity

In Tier 2, 3 and 4, the viscosity of the specimens was determined by a Torvane vane shear test while each mix was wet. The viscosity data was obtained because it is related to the mixing torque that will be required for ISS and is an important parameter for ISS contractors. This parameter is measured solely for use by the remediation contractors' use in developing a more realistic bid and proposal.

The viscosities of the Tier 2 mixes were in the range of 146,000 cP to 1,680,000 cP. In general, the viscosities for the ISS-02 mixes were higher than the viscosity of the comparable ISS-04 mixes. Also, the viscosities for the mixes with organoclay were lower than the corresponding mixes without the organoclay.

The viscosities of the Tier 3 mixes were in the range of 1,093,000 cP to 1,260,000 cP. Note that the superplasticizer did not produce a lower viscosity than mixes with bentonite or organoclay (Tier 2), and the superplasticizer resulted in mixes with lower strength and higher hydraulic conductivity than the other mixes.

The viscosities of the Tier 4 mixes were in the range of 117,000 cP to 1,268,000 cP. The viscosity of the mixes with water:solids ratio of 1:1 had the lowest viscosities and mixes with water:solids ratio of 0.5 had the highest viscosities. Mixes with water-to-solids ratios equal to 1.5 and 2.0 had viscosities similar to, but slightly higher than, the 1:1 ratio tests.

5.4 Groundwater Flow and Solute Transport Modeling

A groundwater flow and solute transport model was used to simulate study area conditions and to evaluate remedial alternatives and their long-term effects on Site constituents in groundwater. The model was developed using the Modular Finite-Difference Groundwater Flow Model (MODFLOW) developed by McDonald and Harbaugh (1988 and updated in 1996 for the United States Geological Survey) and the Modular Three-Dimensional Multi Species Transport Model (MT3DMS) developed by Zheng and Wang (1999). The Groundwater Flow and Solute Transport Model Report is included in Appendix D.

The model covers approximately 6 square miles with 13 layers to simulate the major aquifers and aquitards beneath the site and downgradient. The steady state flow model was calibrated to reasonably match the observed hydraulic heads and horizontal and vertical hydraulic gradients and to allow a reasonable match of plume migration pathways as observed in the field. The fate and transport model was developed through the 100-year history matching processes of dissolved-phase benzene and naphthalene plume migrations. The calibrated model was used as a tool to evaluate various alternatives for NAPL phase source control and for dissolved phase plume remediation.

5.4.1 Groundwater Flow

Groundwater flow modeling was performed to evaluate if the solidified soil would alter groundwater flow that results in significant upgradient mounding (or downgradient head changes) of the water table surface or if the dissolved phase plume width or depth could be increased relative to existing conditions.

Soil properties and stratigraphy were defined using subsurface investigation data from the RI and PDI. The ISS soil mass was modeled at a permeability of 1×10^{-6} cm/sec, which is greater than four orders of magnitude lower than the native soils. The model was run to evaluate steady-state groundwater flow prior to and after implementation of the ISS remediation.

The pre-ISS groundwater flow conditions are illustrated in the modeling report (Appendix D), which show that groundwater flows south from the Site with a slight downward component within the glacial sediments and the upper Magothy sediments. Changes to horizontal flow patterns caused by the ISS soil mass were illustrated in the PDI report (URS, 2010a), which show how groundwater will flow around the edges of the ISS mass and beneath the ISS mass. A comparison pre- and post-ISS groundwater flow conditions from the model demonstrates that changes in the groundwater flow vectors caused by the ISS mass are minimal and occur only in the immediate vicinity of the solidified soil. Furthermore, the ISS mass will not increase the width or depth of the dissolved phase plume. These results are a consequence of the large contrast in hydraulic conductivity between the native soils and solidified soils.

Changes in hydrostatic head around the ISS mass were also evaluated with the model and showed increases in hydraulic head of much less than a foot immediately north of the solidified monolith and essentially no changes in head side-gradient and down-gradient. With the water table surface at approximately 25 feet bgs, there is no risk of adverse effects caused by groundwater mounding or hydrostatic head decreases related to the solidified mass.

5.4.2 Solute Transport

A solute transport model (MT3DMS) was performed to evaluate the effect that ISS will have on improving groundwater quality over time. This model was used to predict future concentrations of benzene and naphthalene in the downgradient plume assuming that the zone indicated on Figure 4-3 of Appendix D, at depths corresponding to model layers 2, 3, and 4 (to approximate depths of 60 to 70 feet bgs) represents a constant benzene and naphthalene (indicator compounds) concentrations of 5,000 to 50,000 μg/L (see figure 4-3 of Appendix D). This is a conservative assumption as contamination is not this deep in the vast majority of the site.

To model the effectiveness of solidification treatment, the solute transport model assigned a hydraulic conductivity of 1×10^{-6} cm/sec (corresponding to the ISS performance goal) to the areas to be solidified. Three solidification scenarios were evaluated:

- **Scenario 1:** The proposed remedial approach. This scenario does not solidify the inaccessible MGP source material under the POB and under the LIRR ROW transmission wires. This scenario includes an oxygenation system installed along Intersection St. east of the site to treat source material associated with the LIRR ROW. The proposed oxygenation system along Wydler St. north of the POB was not included in the model because the model conservatively assumes that the effect of oxygenation persists only for about 40 to 60 feet and thus its effects would not show during modeling. In practice, oxygenated water will migrate further than this until it intercepts contamination.
- **Scenario 2:** For comparison purposes, a scenario was run that included solidification of material under the POB as if this area was not inaccessible. The LIRR ROW remained unsolidified but treated with an oxygenation line.
- **Scenario 3:** Scenario 3 is the same as Scenario 1, except it adds in the two existing downgradient oxygenation systems to show how these reduce concentrations in the downgradient plume.

The results of the solute transport model, reported in Appendix D, showed that solute concentrations would drop dramatically within 5 to 10 years due to the reduction in hydraulic conductivity achieved through solidification in all three scenarios, as shown through comparing Appendix D Figures 5-4 through 5-7 (post-treatment benzene and naphthalene plumes) to Appendix D Figures 5-1 and 5-2 (pre-treatment benzene and naphthalene plumes). By comparing the results from Scenario 2 (Figures 5-6 and 5-7) to Scenario 1 (Figures 5-4 and 5-5), it is clear that leaving untreated MGP source material under the POB does not significantly impact the shape of the post ISS-treatment plume compared to treating it.

For both treatment Scenarios 1 and 2, the deeper and further downgradient portions of the plume shrink significantly in both size and concentration.

Additionally, the results of Scenario 3 show that in addition to the plume reduction resulting from solidification and (for Scenario 2) upgradient oxygenation shown with Scenarios 1 and 2, the downgradient oxygenation systems (systems No. 1 and No. 2) provide the added benefit of further reducing the size and concentration of the dissolved phase groundwater plume.

6.0 IMPLEMENTATION

All remedial construction activities will be performed in accordance with the Construction Quality Control Plan (CQCP) to be developed by the contractor in accordance with requirements outlined in the Contract Documents. The CQCP will at a minimum include the following:

- Procedures for controlling activities related to inspection, testing and documentation, including those of contractor's, suppliers and laboratories, as necessary.
- Control, verification and acceptance testing procedures for each specific test, to include the test name, test equipment to be utilized, specification section and paragraph requiring test, feature of work to be tested, test frequency, and person responsible for each test.
- Procedures for tracking inspections, verification, and acceptance tests including documentation.
- Procedures for tracking construction deficiencies for identification through acceptable corrective action. These procedures shall establish verification that identified deficiencies have been corrected.

The contractor is required to maintain, as the work is performed, sufficient records to furnish documentary evidence that QA/QC testing has been performed in accordance with the approved CQCP. The records will include the results of reviews, inspections, tests, and audits as well as the procedures, equipment used, date, the name of the inspector, results, inspections, and corrective measures. These records will be maintained in an identifiable, meaningful, and organized manner and be submitted (via the Construction Manager) to National Grid and/or the Engineer for review as they become available. Records will also be stored on site and be readily retrievable.

6.1 Construction Sequencing

The following construction sequence is proposed for the remedial action but is subject to change based on the Remediation Contractor's Work Plan and Means and Methods:

Phase I – Remediate off-Site area west of the former MGP Site, shown on Drawing 14, which consists of the Village of Garden City Park (VGC Park), as well as isolated contaminated zones in the northeast portion of the site. The proposed Phase I construction sequence will include the following elements (certain elements may be sequenced differently by the RC):

- Contractor mobilization.
- Establishment of support areas (field office trailers, batch plant, material staging and equipment laydown areas).
- Installation of temporary construction fences and erosion/sediment control measures on the former MGP Site.
- Installation of community air monitoring system and collecting background data.
- Decommissioning of monitoring wells, piezometers, and product recovery wells.
- Clearing and grubbing as necessary.
- Relocation of gas lines in vicinity of the natural gas regulator station (by National Grid).
- Remediate Mercury-Impacted Area.
- Install grout batch plant and mobilize deep soil mixing equipment.
- Erect temporary containment building (TCB).
- Removal, relocation, or protection of utilities within the Phase I remediation area.
- Construction of a temporary car dealer parking lot on the former MGP Site.
- Position the TCB and perform excavation of soils and former MGP structures of the west side of the former MGP Site; and dispose off site.
- Clear/grub area of VGC Park and remove trees within proposed footprint of temporary parking lot.
- Excavation of soils within VGC Park area and stockpile soils on site for future use as backfill.
- Remove/relocate utilities within Intersection Street.
- Conduct DSM field demonstration test program.
- Perform DSM solidification within proposed footprint of temporary parking lot and the northeast areas.
- Perform DSM solidification at Active Oil Storage Terminal.
- Restore Active Oil Storage Terminal.
- Excavation and backfill of near surface contamination in the northeast areas.
- Construction of temporary parking lot.
- Re-direct POB parking lot traffic entirely to temporary parking lot.

Phase II –Remediate the existing POB parking lot, the remainder of the former MGP Site, and Active Oil Storage Terminalshown onDrawing 15. The proposed Phase II construction sequence will include the following:

- Relocating the community air monitoring units as necessary.
- Installing soil-crete retaining wall on all 3 sides of POB parking lot.
- Excavating within soil-crete retaining wall to required pre-DSM depth and stockpile excavated soils on former MGP Site for later re-use as backfill.
- Mobilize DSM equipment to POB parking lot and perform DSM within footprint of POB parking lot.
- Backfill POB parking lot excavation and restore parking lot surface.
- Re-direct temporary POB parking back to restored POB parking lot.
- Removing the temporary parking lot and restore VGC Park to existing condition.
- Position TCB and perform excavation of soils and former MGP structures within remainder (i.e., east and south of temporary parking lot) of former MGP Site to required pre-DSM depth; and dispose off site.
- Perform DSM within remainder of former MGP site.
- Backfill former MGP site to surface topping subgrade.
- Restore former MGP to required surface topping and perform site-wide landscaping.
- Remove erosion/sediment controls and community air monitoring system.

6.2 Condition Evaluation of Existing Buildings

Prior to the onset of remedial construction activities, a properties condition assessment will be performed for all nearby structures, buildings and roadways. The structures will be inspected, photographed, and marked in the field to document their condition.

6.3 Well Decommissioning

Monitoring wells and product recovery wells within the ISS remediation, shown on Drawing 11, will be decommissioned in accordance with NYSDEC procedures (NYSDEC, 2003) prior to excavation and ISS activities.

6.4 Removal of Shallow MGP Source Material, MGP Structures, and Utilities

Remnant MGP structures and utilities (both active and inactive) exist in areas that require remediation and are shown on Drawing 12 (Infrastructure Decommissioning Plan) and Drawing 13 (Utility Protection and Decommissioning Plan). In general, the top 5 to 6 feet of soil will be excavated in the proposed DSM area to remove subsurface infrastructure prior to ISS. Structures present greater than this depth will also be completely removed. Excavated structures, foundations, and debris will be hauled off Site for treatment and disposal.

Cleaner soils (i.e., non-source material) that are excavated will be stockpiled on Site for reuse as backfill over solidified areas. Contaminated soils(i.e., source material) that are excavated will be treated off-Site at a thermal desorption facility.

6.4.1 Work Platform

The ground surface within the required DSM area will be lowered to remove MGP infrastructure and utilities and to provide a zone to which permeable backfill can be placed that will allow precipitation to infiltrate the ground rather than pond or run off site after site restoration. In general, the ground surface will be lowered approximately 5 feet (deeper if necessary to remove structures).Depending on observed odors, clean soil may be placed on top of this excavation during remediation to limit MGP odors.

6.4.2 Temporary Containment Building

The majority of excavation and load out activities for excavation areas with MGP source materials will be conducted under a TCB. The TCB will meet the design requirements for the local geographic area (such as wind and snow loads and foundation requirements) and will be delivered and assembled during the project preparation phase. The TCB will be a crane-liftable coated membrane structure with cargo doors on each gable end. A skid, rail or roller system will be mounted to the structure to aid in movement and repositioning of the enclosure, possibly supplemented by limited crane lifting.

The TCB will be equipped with a VMS that is designed to provide a sufficient rate of air exchange to maintain a negative pressure inside the structure and to process recovered air from within the structure. The VMS will be equipped with a blower, particulate filter with breakthrough indicator, and vapor phase carbon adsorber. Placement of the VMS will be coordinated with excavation sequencing and TCB movement to ensure there is sufficient room for ancillary equipment outside of the TCB. Emissions from the VMS will be routinely monitored using a PID and/or detector tubes, if needed, to monitor emissions.

Once assembled, the TCB will be moved by either pulling with a dozer and/or excavator or picking the TCB up with a crane. The configuration and repositioning of the TCB over the excavation will be identified in a Construction Operations Plan that will be prepared prior to the onset of construction. The mode of movement will depend on where the TCB is positioned and where it will be positioned next. Once in position, the TCB will be ballasted in place with concrete anchor blocks, chain and cable binders at each enclosure rib.

6.4.3 Handling and Disposal of Contaminated Materials

The handling and disposal of contaminated material will be conducted in compliance with Title 6 New York Code of Rules and Regulations Part 364, *Waste Transporters Permit*, and Part 372, *Hazardous Waste Manifest System Related to Standards for Generators, Transporters and Facilities*. A Solid and/or Liquid Waste Transportation Plan is included in Appendix F.

As part of a comprehensive Health and Safety Plan (HASP) for the ISS work, specific precautions for Site personnel will be identified for handling and disposing of contaminated material. Whenever there is a possibility for exposure to contaminated materials, personnel will be required to wear proper protective equipment.

Before any material is moved off-site, the analytical data (from the waste precharaterization sampling and from samples of spoils and soil collected on an on-going basis) will be provided to the disposal facilities to verify the acceptability of the material under the facility’s permit. Initial acceptance will be based on data collected in-situ during the waste disposal pre-characterization sampling event performed during May 2011 to facilitate the direct loading of material. Continued acceptance will be based upon samples collected during the remediation. A record of all material disposed off-site will be obtained from the disposal facility(s).

All transport equipment used to haul contaminated materials will be equipped with liners to prevent loss or leakage of material during transport.

Transport of materials will be limited to the routes designated in Section 6.4.4, Traffic Patterns. Trucks will be cleaned and inspected prior to departure from the Site to ensure that contaminated material cannot be spilled or tracked off-site.

6.4.4 Traffic Patterns

A traffic assessment was performed for the IRM to identify the most suitable routes for trucks to travel between the Site and the identified treatment/disposal facilities or clean fill source suppliers. The assessment is included in Appendix F and it identifies two preferred transportation routes. One route goes through the Village of Hempstead and the other goes through the Village of Garden City. The traffic assessment recommends a procedure of alternating the two routes to balance the truck traffic through the communities.

- **Truck Route #1** (through the Village of Hempstead to the Hempstead Turnpike) – trucks originating at the Site will travel south to North Franklin Street to westbound Fulton Street. The route continues west on Fulton Street until it becomes Hempstead Turnpike (NYS Route 24) and continues along Jamaica Avenue. At the intersection of Francis Lewis Boulevard and Jamaica Avenue, the route turns north to reach Hillside Avenue (NYS Route 25) where it continues east a short distance to the Clearview Expressway entrance. The northbound Clearview Expressway leads to the westbound Long Island Expressway (I-495) and then the Brooklyn-Queens Expressway to the Verrazano Narrows Bridge (refer to maps presented in Appendix F). The return route from the Verrazano Narrows Bridge to the site would be the reverse of the outgoing route described above, except that returning trucks traveling northbound on North Franklin Street would turn left onto Atlantic Street and thereafter right onto Seeley Avenue to reach the Intersection Street Site entrance. This would avoid left turn movements at an unsignalized intersection at North Franklin and Intersection Streets.

- **Truck Route #2** (through the Village of Garden City to the Jericho Turnpike) – trucks originating at the site travel north on Franklin Avenue to westbound Old Country Road and then to northbound Herricks Road to westbound Jericho Turnpike (NYS Route 25), which becomes Braddock Avenue in Queens. The route continues west to Hillside Avenue (also NYS Route 25) to the northbound Clearview Expressway (I-295), which leads to the westbound Long Island Expressway (I-495) and the Brooklyn-Queens Expressway that terminates at the Verrazano Narrrows Bridge (refer to maps presented in Appendix F). The return route from the Verrazano

Narrows Bridge to the site would be the reverse of the outgoing route described above.

6.4.5 Maintenance and Protection of Existing Structures and Utilities

All existing structures will be protected during construction. Utilities, wells, and former MGP structures will be protected, removed and replaced, decommissioned, or demolished and removed in accordance with Drawings 11, 12, and 13.

6.5 Village of Garden City Park

The Village of Garden City (VGC) Park, located to the west and adjacent to the former MGP Site, will be remediated by first excavating down to approximately 8 feet below existing grade, to a working platform level, and then performing DSM from this platform level. Such excavation is expected to be to the level of the existing sanitary sewer line which handles approximately half of the Village of Garden City's sewage flow according to the Village DPW. The excavation level will also be approximately to that of an adjoining recharge basin where there are side slopes from the basin within the proposed ISS footprint. Therefore, the actual required excavation depth varies from no-cut at the recharge basin to about 8 feet elsewhere. A geo-membrane covered vertical gabion barrier will be constructed between the recharge basin and the ISS area to separate any recharge basin surface water and work zone spoils generation. No structures are expected to be encountered for removal except for an active water line that may be temporarily removed from within the VGC Park work area and then replaced during Site restoration after the remediation is performed in this area.

There is a utility corridor located within the Cedar Valley Ave. paper street in the VGC Park work area that contains the Horse Brook Drain (storm drain) and the VGC sanitary sewer that will be protected from construction traffic and ISS treatment will not be performed within 5 feet of this utility corridor. DSM will be performed on both sides of the corridor. A plan view of the work is shown on Drawing 6 and details of the work are shown on Drawing 22. The VGC Park work area will generally be contained within excavation side slopes.

6.6 Professional Office Building Parking Lot

The POB parking lot area as described here includes the POB parking lot, Intersection Street, and a portion of Wendell Street. This area does not contain shallow source material or former MGP structures so no TCB is required and the excavated soils will be re-used as backfill within the POB parking lot excavation.

Prior to mass excavation and DSM work within the POB parking lot, utilities within Intersection Street will be removed and re-established elsewhere around the Site. LIPA power poles within the LIRR ROW will be protected with a 25-foot no excavation zone. The soil-crete wall around the POB parking lot will be constructed after excavating a 4-foot deep trench above the soil-crete footprint. This trench will be used for containing spoils from the soil-crete wall and to minimize the top elevation of the DSM treated material. Around power poles, shallow surficial soil berms will be constructed to contain spoils. Plan view information on this plan is provided on Drawing 16.

After the preparatory work described just above, DSM will be used to solidify soil contamination and simultaneously create a gravity (soil-crete) retaining wall. Careful sequencing of wall construction will proceed near power poles as the grouted soil will temporarily be very soft and weak. Once the soil-crete wall reaches minimum 50 psi unconfined compressive strength, a 15-foot deep excavation within the wall will proceed. A temporary unexcavated soil ramp will be left in place for access into and out of the excavation. DSM will proceed for the excavated areas where there is no ramp. The ramp will eventually be removed to facilitate the ISS for the remaining POB parking lot footprint and a new ramp will be constructed over the previously stabilized areas for subsequent ingress/egress to the excavation. DSM will proceed in a specific sequencing schedule adjacent to the soil-crete wall to ensure its stability, similar to the caution and proper safety planning required around electric power poles. Details of the work within the POB parking lot can be found on Drawing 22.

Backfilling of the POB parking lot excavation can proceed after DSM is complete and the parking lot is permanently restored including pavement, drainage, electrical, and lighting. Restoration of other utilities within Intersection Street such as natural gas, water, and sanitary sewer will also be completed.

6.7 Active Oil Storage Terminal

ISS will also be performed in a portion of the Active Oil Storage Terminal located to the east of the former MGP Site and adjacent to the LIRR ROW, as shown on Drawing 6.This remediation area consists of the southwest corner of the Terminal just south of a 25,000 gallon tank. Spoils will be contained and any infrastructure utilities will need to be addressed within the planned 4-foot deep excavation except at the west end of this area where spoils will be contained within a shallow surficial soil berm (due to presence of a LIPA power pole nearby). Careful DSM sequencing will be performed to maintain structural integrity of the existing tank and any other One Storage Terminal infrastructure. The remediation contractor may use a DSM auger diameter smaller than that used for other DSM production areas in order to safely work around such facilities. The Terminal is in active use so ingress/egress will need to be closely coordinated with the Terminal owner, and restoration will need to be performed promptly to avoid inconvenience.

Similar to the northeast area DSM, no TCB is planned for this area but off-Site soils and spoils disposal is planned.

6.8 Dust/Vapor/Odor Management and Air Monitoring

The TCB and VMS will serve as the primary odor and dust control measure employed at the Site during excavation activities. The majority of earthwork known to present the biggest point source of odor will be performed within the temporary enclosure. Foam and foaming devices will be used during ISS work, if necessary, to control odors and VOC emissions.

Dust control measures will be implemented to minimize the potential for dust generation during soil excavation and handling, and placement of fill. The main dust control device will include water trucks and/or lay-flat hose connected to on-Site hydrants. Heavily traveled truck routes will be wet down with the water truck to minimize dust emissions. Truck routes on Site will be continuously monitored for excessive dirt or dust. Stabilized construction entrances/exits consisting of smoothly graded areas large enough to accommodate equipment and truck traffic will be constructed at exit points to clean tires of transport trucks exiting the Site. The base will be covered with non-woven geotextile (for non-slippage) and coarse aggregate and will be maintained and redressed while in use.

Truck routes on and off-site will be inspected during high truck traffic periods for excessive dirt or dust. Proper cleaning of trucks exiting the Site will help control off-site dust on adjacent roadways. Transport trucks exiting the Site will pass through an inspection area and/or be inspected to ensure tires and undercarriages are clean and that tarps are secured. Excessive mud and loose dirt observed on the trucks will be manually removed with brooms and brushes as necessary.

Odor will be monitored during excavation and handling of impacted soils from the Site. In the event that odor emissions exceed the specified intensity, controls will be implemented. Controls will also be implemented as directed by National Grid and/or NYSDEC. Odor controls will include foam and foaming devices or tarps to cover open excavations or stockpiles.

Odor will be controlled by sequencing excavation in a manner that will result in manageable areas of open excavation. Offensive odors will be mitigated, if necessary, by placing a layer of non-odorous soils or polyethylene sheeting over the excavation area or stockpile (overnight and off-hours). In addition, foam application equipment and an adequate supply of odor reducing foaming agent will be available for application to the excavation areas or stockpiles as needed.

Contingency monitoring and actions will be implemented in accordance with the CAMP if odor complaints are received from the neighboring community.

Perimeter and work zone air monitoring will be performed in accordance with the CAMP (Appendix G) and the remediation contractor's HASP to evaluate the effectiveness of dust control measures. In general, real time air monitoring equipment will be utilized to monitor dust and VOC levels. If visible dust is generated or work zone and/or perimeter air monitoring results are above action levels, corrective action measures will be implemented. Corrective action measures may include increasing water coverage, controlling or temporarily ceasing select activities during high wind, reducing speed of equipment that may reduce dust generation, and utilizing different sizes or types of equipment that may cause less dust generation.

6.9 Noise and Vibration

The Contactor will be required to implement mitigation measures to reduce noise and vibrations generated during the remedial action in accordance with local codes and ordinances and as directed by National Grid and/or the NYSDEC. Potential mitigation measures that could be implemented will be identified in the Construction Operations Plan. These preventive and mitigation measures may include a combination of the following:

- Properly functioning equipment;
- Minimize idling of trucks;
- Modified general construction practices;
- Modifications to construction equipment;
- Acoustical or sound attenuating panels placed adjacent to noise-generating equipment and/or near sensitive receptors; and
- Use of high frequency vibratory hammers for any pile driving, etc.

Additional details regarding vibration monitoring are presented in the Community Impacts Mitigation Plan (Appendix H).

6.10 Contingency Plan

A Contingency Plan was developed to address potential emergencies that may arise during construction activities and is included in Appendix I.

6.11 Site Restoration

The Site will be restored to support future use or development, as determined by National Grid. Drawings18 and 19provide a general grading plan and identifies structures (parking lot, roads, drainage structures, and fences) that will be installed. On-site restoration will include a minimum of four feet of backfill that will accommodate draining of precipitation from weather events up to a 100-year storm (see Appendix J)

6.11.1 Backfill

Imported material will include clean fill (described as "general fill") or approved equivalent(s), and possibly NYSDOT Type 1 coarse aggregate (select stone fill and stone cover) if necessary. Any use of coarse aggregate materials will be from a NYSDOT-approved certified clean source and will meet NYSDOT gradation requirements or as otherwise required by the project specifications. Proposed source(s) for other general fill materials will be approved by National Grid prior to delivery to the Site. Once the source(s) are approved, samples will be obtained for each fill type per source at a frequency of one sample for every 5,000 yd^3 brought on Site and analyzed at a NYSDOH certified Environmental Laboratory Accreditation Program (ELAP) approved laboratory for total PAH's, total VOCs and metals in accordance with the listing in 6 NYCRR Part 375 Table 375-6.8 (b) for residential use. Ten percent of the samples will also be analyzed for polychlorinated biphenyl (PCB) parameters listed in Table 375-6.8(b).

Clean excavated materials free of visual source material will be evaluated for potential reuse on-site as backfill within the general fill zone. Clean overburden materials obtained from the former MGP Site will be placed back on to the former MGP Site, a minimum 2 feet deeper than the proposed final grade. Clean overburden materials obtained from areas outside of the former MGP Site will be placed back into the "outside" areas, and if there is excess material from these off-site areas, it will be available for reuse as backfill in on-site areas. General fill imported from off Site will be placed to within 6 inches of proposed final grade. The fill will be placed with a dozer in approximately 12-inch lifts and compacted with a roller or hand operated compaction equipment when near sensitive structures to a minimum 95% of the maximum dry density per ASTM D698. In-place quality control compaction testing will be performed by an independent geotechnical testing firm to ensure specified compaction has been achieved. Each lift will be tested at a frequency of one test per 2,500 square feet, with a minimum of 2 tests per backfill lift per each backfill area.

If directed by National Grid, select stone fill may be used as backfill instead of general fill below depths of 8 feet bgs. Stone fill will be placed in loose lifts and tamped in place with the excavator bucket. In the event vibration becomes unacceptable to National Grid or the Engineer, the stone fill may be compacted with a plate compactor that would have a much smaller zone of influence than the bucket of the excavator.

Following geotechnical testing, a surface cover will be placed in a non-compacted single 6-inch lift over the general fill layer and spread with the dozer to re-establish existing grades. Within the former MGP Site, the surface cover will include a stone layer, unless directed by National Grid to substitute a topsoil layer. Outside the former MGP Site, topsoil and seed will comprise the surface cover where asphalt, concrete, or stone cover is not required, such as within the Village of Garden City Park. Topsoil, seed, mulch and fertilizer will meet the requirements of New York State Standards and Specifications for Soil Erosion and Sediment Control for Permanent Critical Area Plantings.

6.11.2 Roads and Parking Lots

The Professional Office Building parking lot will be reconstructed as shown on Drawing 18. Intersection Street, Wendell Street and road access within the Village of Garden City Park will be reconstructed as shown on Drawings 18 and 19.

6.12 Storm Water Pollution Prevention

Because it will result in the disturbance of greater than 1 acre of land, this project will need to meet permit requirements of the New York State Pollution Discharge Elimination System (SPDES) program, but SPDES and other environmental permits will not be required under the NYSDEC remediation program.

Erosion and sediment controls will be established in accordance with New York State guidelines with details as shown on Drawing 23. Erosion and sediment control will only be required for the construction phase of the project. Separate measures (i.e., detention ponds, etc.) for the control of the quality and quantity of post-development storm water runoff will not be required. The project will decrease the area of impervious surface at the site, and the majority of the restored site not currently paved will be covered with permeable gravel or be landscaped, so that it is not anticipated that there will be storm water runoff from the Site. A separate analysis summarized in the Pre-Design Investigation Report demonstrates that the ISS of the former MGP Site, when terminated at least 4 feet below finished grade, will allow the entire depth (8.0 inches) of the 100-year rainfall to infiltrate the restored ground.

6.13 Management of Public Impacts

Appendix H (Community Impacts Mitigation Plan) provides information on how public outreach and communications will be conducted during remedial construction activities, identifies that construction phases and durations of each, and describes how construction activities will be managed to minimize or mitigate community impacts.

6.14 Oxygenation Systems

MGP source material is present under the POB, the Horse Brook Drain, and the high-voltage transmission lines along the LIRR ROW. Source material in these areas will be treated with oxygenation systems. Two new, and one existing, oxygenation systems will be used.

One of the additional planned oxygenation systems will be located along Wydler Place. This system will treat groundwater immediately downgradient of the Horse Brook Drain in the VGC park area, and will oxygenate groundwater prior to flow beneath the POB. This system is shown on Drawing 6.

The second planned additional oxygenation system will be located along Intersection Street east of the site and will address MGP impacts present under the LIRR ROW power lines, north of Intersection Street. This system is shown on Drawing 6.

The existing oxygen system No. 1, shown on Drawing 2, will continue to operate and treat contaminated groundwater that may be present from MGP source material with limited accessibility under the POB and the LIRR ROW power lines south of Intersection Street.

The two new oxygenation systems will be designed and constructed following the completion of the ISS treatment, and will be documented in a separate Basis of Design report.

6.15 Construction Schedule and Sequencing

Construction phases, approximate durations, and approximate start/finish dates for the remedial action are identified below. The Contractor’s schedule will be provided separately for NYSDEC review.

Activity	Approximate Duration (Weeks)	Approximate Start	Approximate Finish
Construction Bidding	6	April 2011	June 2011
Review Bids and Award Construction Contract	8	June 2011	July 2011
Preparation & Approval of Construction Operations Plan and Submittals	10	August 2011	September 2011
Contractor Mobilization	4	October 2011	November 2011
Phase I Remedial Construction (VGC Park, west side MGP Site, temp. POBparking lot, and LIRR ROW)	22	November 2011	March 2012
Phase II Remedial Construction (remainder MGP Site, soil-crete wall and POB parking lot, and Active Oil Storage Terminal)	91	April 2012	November 2013
Contractor Demobilization	4	November 2013	December 2013
Construction Completion and Final Engineering Report	8	March 2014	June 2014
Oxygenation System Construction	40	May 2014	March 2015

6.16 Monitoring and Maintenance

A Site Management Plan (SMP) will be developed at the conclusion of remedial activities that will include a groundwater sampling/monitoring program and engineering controls.

The sampling/monitoring program will be structured to achieve the following objectives:

- Determine whether the design parameters are being achieved; and
- Document the effectiveness of the remediation.

Groundwater monitoring will be an integral component of the sampling program. The monitoring program will include the wells that are identified below as shown on Drawing 20:

- HIMW-03S/I/D
- HIMW-05S/I/D
- HIMW-08S/I/D
- HIMW-12S/I/D
- HIMW-13S/I/D

- HIMW-14I/D
- HIMW-15I/D
- HIMW-20S/I
- HIMW-22
- HIMW-23
- HIMW-24
- HIMW-25

6.17 Institutional Controls

Due to the nature/composition of the spoils that will be left in place, Institutional Controls (ICs) will likely be required to restrict activities on the Site after the remediation has been completed. The ICs may include either of the following:

- Site Management Plan
- An environmental easement pursuant to Title 36, Article 71 of the New York State Environmental Conservation Law, or a deed restriction in accordance with the ACO; or
- Another NYSDEC-approved land use restriction mechanism per the ACO;.

The environmental easement, if necessary, will impose land use limitations or requirements that may be needed to protect current or future users from environmental contamination. Activities or uses that may be limited or required will include restrictions on property uses, controls for certain Site uses such as construction of basements or trenches, and/or operation or maintenance of engineering controls and reporting.

6.18 Construction Completion and Final Engineering Report

A Construction Completion and Final Engineering Report will be prepared at the conclusion to the ISS remediation to document all remedial actions that have been undertaken at the Site. The report will be prepared in accordance with the DER-10, *Technical Guidance for Site Investigation and Remediation* (NYSDEC, 2010).

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