Prepared for:
Condolidated Edison Co. of New York, Inc.
31-01 20th Avenue, Astoria, NY 11105

Remedial Investigation Report
Operable Unit 1 (OU1)

Former East 21st Street Works – Site # V00536
New York, New York

VCA Index D2—0003-02-08

ENSR Corporation
December 2008
Document No.: 01869-170

ENSR | AECOM

Prepared for:
Consolidated Edison Co. of New York, Inc.
31-01 20th Avenue, New York, NY 11105

Remedial Investigation Report Operable Unit 1 (OU1)

Former East 21st Street Works – Site # V00536 New York, New York

VCA Index D2—0003-02-08

Susan Beattie for Anna Sullivan

Prepared By
Anna Sullivan, Senior Geologist

Julia Shackford

Prepared By
Julia Shackford, Project Geologist

Mark McCabe

Reviewed By
Mark McCabe, Project Manager

ENSR Corporation
December 2008
Document No.: 01869-170

ENSR | AECOM

Contents

List of Appendices

List of Tables

List of Figures

Executive Summary

As required under the terms of Voluntary Cleanup Agreement Index No. D2-0003-02-08 (VCA) by and between the New York State Department of Environmental Conservation (NYSDEC) and Consolidated Edison Co. of New York, Inc. (Con Edison), this report presents the results and findings of the remedial investigation (RI) that was performed on Con Edison's behalf by ENSR/AECOM, for Operable Unit 1 (OU1) of the East 21st Street Works site (NYSDEC Site #V00536) located in the borough of Manhattan in New York City, New York. Except as otherwise indicated in this report, the RI was conducted in conformance with RETEC's NYSDEC-approved RI Work Plan dated November 3, 2005 and ENSR's NYSDEC-approved supplemental RI Work Plan dated November 15, 2007.

As approved by the NYSDEC, the RI was designed to be an extension of the Site Characterization Study (SCS) that was conducted for the East 21st Street Works site during 2004, and it focused primarily on the horizontal and vertical delineation of previously identified manufactured gas plant (MGP)-related impacts. RI activities were performed at the site from January to June 2006 in accordance with the NYSDEC-approved RI Work Plan (RETEC 2005). The 2006 RI results were presented in the Draft Remedial Investigation Report for the site (RETEC 2006). Based on NYSDEC August 10, 2007 comments on the December 2006 Draft RI Report, the site was divided into operable units and the Draft RI report was finalized as the Interim Remedial Investigation Report (IRIR) on September 11, 2007 (ENSR 2007). Based on the NYSDEC August 10, 2007 comments, ENSR/AECOM, on behalf of Con Edison, developed a supplemental RI Work Plan (ENSR 2007) to further investigate the impacts associated with the site.

This document presents the results of the remedial investigation performed for OU1 of the East 21st Street Works former MGP site. The East 21st Street Works was located within the footprint of the current Peter Cooper Village residential apartment complex in the Borough of Manhattan in New York City, New York. OU1 of the East 21st Street Works site is comprised of MGP-related soil and groundwater impacts within the property boundary of Peter Cooper Village, including immediately adjacent sidewalks up to the curb along surrounding streets. Operable Unit 2 (OU2) consists of adjacent land areas outside of Peter Cooper Village that contain MGP-related soil and groundwater impacts and the East River. Bedrock beneath the site is defined as Operable Unit 3 (OU3) of the East 21st Street Works site. The results of the remedial investigations pertaining to OU2 and OU3 will be presented in separate RI reports.

The East 21st Street Works comprised the former grounds of a MGP that was owned and operated by Con Edison and its corporate predecessors from approximately 1848 until 1945. The East 21st Street Works former MGP site extended from First Avenue to Avenue C between East 20th and East 22nd Streets and encompassed: the southern and central sections of Peter Cooper Village, a residential apartment complex that includes 21 fifteen-story brick apartment buildings, tennis and basketball courts, playgrounds, parks, and landscaped areas.

The East 21st Street Works former MGP was retired in 1945, when the portion of grounds of the MGP were sold to Stuyvesant Town Corporation and the Metropolitan Life Insurance Company (MetLife) for the construction of the Peter Cooper Village housing complex.

The site geology generally consists of five units. These units, from ground surface downward, include fill; a layer of organic clay, silt, and/or peat; a silty sand unit with varying amounts of silt and clay; a unit of dense silt, sand, and gravel; and bedrock. Bedrock is present at shallow depths (within 10 feet of ground surface) in the western portion of the site along First Avenue and at deeper depths (130 feet below ground surface [ft bgs]) in the eastern portion of the site near Avenue C. The top of the bedrock dips steeply to the east in the western portion of the site and relatively gently in the central and eastern portion of the site.

One unconfined, unconsolidated overburden aquifer is present beneath the site. Shallow (5 to 15 ft bgs), intermediate (25 to 35 ft bgs), and deep (50 to 70 ft bgs) zones within the overburden aquifer were evaluated during the investigations. The groundwater flow direction in all of the depth zones is to the east-northeast towards the East River. The vertical gradient between the units is generally downward in the western portion of the site and upward near the East River. The East River is tidally influenced and has measurable effects on adjacent groundwater elevations.

An evaluation was conducted to look for evidence of an oil water underdrain system that may have been installed on the Peter Cooper Village property and to evaluate whether MPG-related impacts are seeping into the site sewers. The evaluation included visual and video inspection of manholes and drains within the areas where the drains would most likely have been installed overlapping areas of shallowest MGP impacts. In general a storm drainage system typical of an urban environment was encountered during this work. A variety of pipe types, sizes, ages and configurations were encountered. In several areas of the system tar seals were used in the original construction of the system. This was typical construction for gravity flows systems built in the early to mid 20th century. No evidence of the oil water underdrain system was found during the investigation. In addition, Con Edison and its contractors have advanced 156 soil borings, 28 monitoring wells and 47 test pits (environmental and water valve) in OU1. The oil water underdrain system or anything resembling it has not been encountered. Discussions with property owner's maintenance personnel have also failed to turn up any evidence of the oil water underdrain system.

Based on site observations and analytical data, it appears that surface soils were imported to the site after the MGP operations ceased, possibly for final grading purposes during the construction of the Peter Cooper Village housing complex. The concentrations of compounds detected in the SCS and RI surface soil samples are considered to be attributable to fill material quality, anthropogenic sources, or naturally occurring sources unrelated to former MGP operations.

Upper fill soil at the site (between 0.2 and 5 ft bgs) is generally distinct from lower fill/natural soils at the site. The upper fill also appears to represent imported fill material brought to the site after closure of the MGP operations. In general, the SCS and RI upper fill soil samples did not exhibit MGP-related materials. MGP-related impacts were only observed within 5 ft bgs in 13 of 231 subsurface investigation locations in OU1. Similar to surface soils, the compounds detected in upper fill materials are considered to be attributable to fill quality, anthropogenic sources, or naturally occurring sources unrelated to the former MGP.

The lower fill/natural soil unit includes fill below 5 ft bgs and natural soils underlying the fill unit. Visible impacts and analytical results indicate that the lower fill/natural soil unit has been impacted by former MGP operations. MGP-related impacts are associated with former gas holder structures in the western portion of the site and are concentrated around former retort, drip tank, and oil tank structures in the eastern portion of the former MGP. The impacts in the lower fill/natural soil include lenses of staining, sheen, oil-like material, and tar-like material that appear to migrate horizontally and vertically along pathways of greater permeability relative to surrounding material. Impacts in the western portion of the overburden materials generally did not extend to depths greater than approximately 20 to 40 ft bgs. Impacts in the eastern portion of the former MGP site were observed as deep as 47ft bgs in overburden soils. The vertical extent of soil the impacts has been defined at the site. The horizontal extent of impacts in the lower fill/natural soil extends to the eastern boundary of OU1 along Avenue C, to the northeastern OU1 boundary along the eastern portion of East 23rd Street, and to the southeastern OU1 boundary along the eastern portion of East 20th Street. The nature and extent of lower fill/natural soil impacts in adjacent off-site areas will be presented in the RI report for OU2.

A bedrock investigation was performed at the site during the RI due to the presence of dense non-aqueous phase liquid (DNAPL), suspected to be MGP in nature, in the Con Edison steam tunnel recently constructed beneath First Avenue. The results of the bedrock investigations will be provided in the RI report for OU3.

Non-aqueous phase liquid (NAPL) was noted in some of the monitoring wells at the site. Due to the presence of NAPL in monitoring wells at the site, Con Edison submitted an Interim Remedial Measure Work Plan for

NAPL Monitoring and Recovery (ENSR 2008a). This work plan was submitted to NYSDEC on August 18, 2008.

Groundwater in the shallow, intermediate, and deep unconfined aquifer zones beneath the site has been impacted by former MGP operations. Groundwater in the intermediate and deep zones has also been impacted by an unidentified source of chlorinated compounds. The greatest MGP-related groundwater impact concentrations were detected in the vicinity of the former gas holders and the former retort, drip/oil tank area, similar to soil impacts. The horizontal extent of the shallow groundwater impacts has been defined by the existing monitoring well network. The general area of intermediate and deep groundwater impacts at the site has also been determined. The lateral extent of groundwater impacts in the intermediate and deep aquifer zones to the northeast, east, and southeast of OU1 has not been specifically defined based on comparison with groundwater standards. The vertical extent of groundwater impacts has also not been fully defined in OU1. However, unless the evaluation of remedial alternatives or the implementation of remedial actions requires that the groundwater in OU1 be more fully delineated, additional field work for delineation is not proposed at this time. If additional groundwater delineation data are necessary for remedial alternative evaluation or remedial action implementation, they would be collected during a pre-design investigation.

Groundwater monitoring data suggest that naturally occurring biodegradation processes, specifically sulfate reduction and/or methanogenesis, are contributing to some reduction in the concentration of organic constituents within the dissolved phase plume in all depth zones within the aquifer at the site. Additional monitoring (both time series and at alternate well locations) will further develop a baseline dataset for long-term evaluation of natural attenuation as a potential supplemental groundwater remedy following active remedial measures at the site.

Soil gas sampling performed during the RI indicates that the soil gas concentrations at the perimeter of the site are lower than the highest soil gas concentrations found at the site during previous investigations. The results from the previous sampling events indicated that the indoor air quality within the residential buildings on the Peter Cooper Village portion of the site, as measured on each sampling day, was not likely to have been adversely impacted by subsurface intrusion of MGP-related vapors. Based on the results of these sampling events, intrusion of vapors emanating from MGP-related material that may be present at the site was not evident. There does not appear to be any need for additional indoor air sampling or soil gas sampling for MGP constituents at this time; however, Con Edison submitted an Interim Remedial Measure Work Plan for Indoor Air Sampling (ENSR 2008b) to continue to evaluate whether air quality within buildings is adversely affected by residuals from historic operations. This work plan was submitted to NYSDEC on August 18, 2008.

A qualitative human health exposure assessment was performed to identify the potential exposure pathways associated with impacted media for workers, residents, and visitors on the Peter Cooper Village property (OU1). For OU1, subsurface maintenance or utility workers who perform subsurface excavation work and/or repairs could possibly be exposed to impacted media and controls are recommended to limit potential exposures in these areas. Additionally, building residents, occupants, visitors, and workers could potentially be exposed to indoor air impacts if sub-slab construction activities are performed and controls are recommended to limit exposure during these activities. Remedial options for these areas will be evaluated in an alternatives analysis report. Exposure of residents of the Peter Cooper Village complex to MGP residuals is considered to be unlikely.

A Draft Interim Site Management Plan (ENSR 2008c) (SMP) was developed and submitted to NYSDEC on August 15, 2008. The SMP specifically details institutional controls enacted on the Peter Cooper Village property to protect maintenance, utility and landscape workers from soil impacts present below 5 feet. The plan outlines procedures for detecting and managing impacted soil and groundwater if they are encountered. While still draft, property owner personnel are currently operating under these procedures.

Based on the combined findings of the SCS and RI, additional investigative work is not recommended for surface soil, upper fill soil, lower fill/natural soil, groundwater, or soil gas for OU1. Additional delineation of subsurface soil and groundwater impacts that are MGP-related is not necessary to begin remedial alternative development and evaluation for impacts identified in OU1. Impacts have been identified in the lower fill/natural soils and groundwater northeast, east, and southeast of OU1 and within bedrock beneath the site and will be addressed in the RI reports for OU2 and OU3, respectively.

List of Acronyms

µg/kg	microgram per kilogram
µg/L	microgram per liter
µg/mg	microgram per milligram
$\mu g/m^3$	microgram per cubic meter
ADT	Aquifer Drilling and Testing, Inc.
ASP	Analytical Service Protocols
Air Toxics	Air Toxics Limited, Inc., Folsom, California
AWQSGVs	Ambient Water Quality Standards or Guidance Values
bgs	below ground surface
BTEX	Benzene, Toluene, Ethylbenzene, Xylenes
CAMP	Community Air Monitoring Plan
CEC	Community Environmental Corporation
COC	Constituents of Concern
COI	Constituents of Interest
Chemtech	Chemtech Laboratories, Mountainside, New Jersey
cm	centimeter
Con Edison	Consolidated Edison Company of New York, Inc.
CRDL	Contract Required Detection Limit
DEP	New York City Department of Environmental Protection
DNAPL	Dense Non-aqueous Phase Liquid
DO	Dissolved Oxygen
DUSR	Data Usability Summary Report
EDC	New York City Economic Development Corporation
ENSR/AECOM	AECOM, Inc. (formerly known as ENSR Corporation)
GC	Gas Chromatograph
GPR	Ground-Penetrating Radar
H&A	Haley & Aldrich, Inc.
HASP	Health and Safety Plan
HSA	Hollow Stem Augers
ICP	Inductively Coupled Plasma
IDW	Investigation-Derived Waste
LCSs	Laboratory Control Standards
LNAPL	Light Non-aqueous Phase Liquid
m	meter
MBVD	Manhattan Borough Vertical Datum
META	Meta Environmental, Inc.
MetLife	Metropolitan Life Insurance Company
MEG	Miller Environmental Group of
mg/kg	milligram per kilogram
mg/L	milligram per liter
MGP	Manufactured Gas Plant
MNA	Monitored Natural Attenuation

MPE	Multi-Phase Extraction
MS	Matrix Spike
MSD	Matrix Spike Duplicate
NA	Natural Attenuation
NAPL	Non-aqueous Phase Liquid
NCP	National Contingency Plan
NTU	Nephelometric Turbidity Unit
NWMCC	National Water Main Cleaning Company
NYCRR	New York Code of Rules and Regulations
NYSDEC	New York State Department of Environmental Conservation
NYSDOH	New York State Department of Health
OLM	Oil-Like Material
ORP	Oxidation/Reduction Potential
PAH	Polycyclic Aromatic Hydrocarbons
PEC	Paragon Environmental Construction, Inc.
PID	Photo-Ionization Detector
PPE	Personal Protective Equipment
ppm	parts per million
PVC	Polyvinyl Chloride
QAPP	Quality Assurance Project Plan
RASR	Remedial Action Selection Report
RETEC	The RETEC Group, Inc.
RI	Remedial Investigation
ROW	Right-of-way
RPDs	Relative Percent Differences
RQD	Rock Quality Designation
RSCOs	Recommended Soil Cleanup Objectives
SCS	Site Characterization Study
SSBVs	Site-Specific Background Values
SVI	Soil Vapor Intrusion
SVOCs	Semi-Volatile Organic Compounds
STL	Severn Trent Laboratories, Inc. of Pittsburgh, Pennsylvania
TAGM	Technical and Administrative Guidance Memorandum
TEA	Terminal Electron Acceptor
TLM	Tar-Like Material
USEPA	United States Environmental Protection Agency
USGS	United States Geologic Survey
UST	Underground Storage Tank
VCA	Voluntary Cleanup Agreement
VOCs	Volatile Organic Compounds

1.0 Introduction

As required under the terms of Voluntary Cleanup Agreement Index No. D2-0003-02-08 (VCA) by and between the New York State Department of Environmental Conservation (NYSDEC) and Consolidated Edison Co. of New York, Inc. (Con Edison), this report presents the results and findings of the remedial investigation (RI) that was performed on Con Edison's behalf by ENSR/AECOM, for the East 21st Street Works site (NYSDEC Site #V00536) located in the Borough of Manhattan in New York City, New York. Except as otherwise indicated in this report, the RI was conducted in conformance with The RETEC Group, Inc.'s (RETEC) NYSDEC-approved RI Work Plan dated November 3, 2005 and ENSR's NYSDEC-approved supplemental RI Work Plan dated November 15, 2007. The RI was also carried out in general accordance with the most recent and applicable guidelines of the NYSDEC, the United States Environmental Protection Agency (USEPA), as well as the National Contingency Plan (NCP).

The RI was designed to be an extension of the Site Characterization Study (SCS) performed on behalf of Con Edison in 2004 by Haley & Aldrich, Inc. (H&A). Data collected during the SCS revealed that additional investigation was necessary due to the presence of manufactured gas plant (MGP) impacts that required further vertical and lateral delineation. RI activities were performed at the site from January to June 2006 in accordance with the NYSDEC-approved RI Work Plan (RETEC 2005). The 2006 RI results were presented in the Draft Remedial Investigation Report for the site (RETEC 2006). Based on NYSDEC August 10, 2007 comments on the December 2006 Draft RI Report, the site was divided into operable units and the Draft RI report was finalized as the Interim Remedial Investigation Report (IRIR) on September 11, 2007 (ENSR 2007). Based on the NYSDEC August 10, 2007 comments, ENSR/AECOM, on behalf of Con Edison, developed a supplemental RI Work Plan (ENSR 2007) to further investigate the impacts associated with the site.

This document presents the results of the remedial investigation activities performed on Operable Unit 1 (OU1) of the East 21st Street Works former MGP site. The East 21st Street Works was located within the footprint of the current Peter Cooper Village residential apartment complex in the Borough of Manhattan in New York City, New York. OU1 of the East 21st Street Works site is comprised of MGP-related soil and groundwater impacts within the property boundary of Peter Cooper Village, including immediately adjacent sidewalks up to the curb along surrounding streets. Operable Unit 2 (OU2) consists of adjacent land areas outside of Peter Cooper Village that contain MGP-related soil and groundwater impacts and the East River. Bedrock beneath the site is defined as Operable Unit 3 (OU3) of the East 21st Street Works site. The results of the remedial investigations pertaining to OU2 and OU3 will be presented in separate RI reports for the East 21st Street Works site.

This RI Report incorporates the findings of other phases of environmental investigation work performed at the site. A Geotechnical Study and Preliminary Environmental Evaluation was completed by Langan Engineering & Environmental Services, P.C. (Langan), in 2001. An evaluation of indoor air and soil gas sampling was performed in the residential apartment buildings at the Peter Cooper Village section of the Site in 2003 and 2004 by RETEC. The SCS was performed by H&A in 2004. Unrelated to the RI activities, valves on water mains servicing the Peter Cooper Village Apartment Complex were replaced between November 2006 and June 2007 as part of a maintenance program for the complex. RETEC provided third-party oversight of the water valve replacement activities on behalf of Con Edison and summarized the quality of soil and groundwater encountered during the activities in a report.

1.1 Purpose of the Remedial Investigation

The goals of the RI were to:

- Further delineate the extent of soil and groundwater impacts associated with former MGP operations.

- Evaluate soil gas conditions at select RI locations.
- Investigate the proposed oil water underdrain system
- Investigate bedrock in the western portion of the site in an attempt to identify the migration pathway of dense non-aqueous phase liquid (DNAPL) from presumed former MGP structures to the Con Edison steam tunnel that was recently constructed beneath First Avenue, including mapping the surface of the top of bedrock. Bedrock has been designated OU3 of the site. A general discussion of bedrock beneath the site is included in this OU1 RI report. Bedrock investigation methodologies and result details will be presented in a separate RI report for OU3.
- Evaluate the potential for MGP impacts to the East River. The area outside of the Peter Cooper Village complex, including the East River to the east of the site has been designated OU2. The investigation methodologies and results for activities performed outside of the OU1 boundary and above bedrock will be presented in a separate RI report for OU2.
- Further develop the dataset necessary to allow preparation of a Alternatives Analysis report for OU1 to evaluate and select possible remedial alternatives for site cleanup.

1.2 Scope of Work

The scope of work for the OU1 RI was defined by the NYSDEC-approved RI Work Plan (RETEC, 2005) and the NYSDEC-approved Supplemental RI Work Plan (ENSR, 2007). The RI included the following tasks:

- Underground utility clearance
- Community air monitoring
- Surface soil sampling and analysis at adjacent off-site locations
- Soil boring advancement and subsurface soil sample collection and analysis
- Advancement and inspection of bedrock cores
- Monitoring well installation and development
- Groundwater level and NAPL thickness measurements
- Groundwater sampling and analysis
- Aquifer conductivity testing
- Tidal influence monitoring
- Soil gas sampling and analysis at perimeter locations
- Additional subsurface utility evaluation
- Oil water underdrain system investigation
- Surveying of new sampling locations
- Management of investigative-derived waste (IDW)

All activities were performed in accordance with the methods specified in the RI work plan and SRI work plan, including the site-specific Quality Assurance Project Plan (QAPP) included in Appendix A of the work plans and the site-specific Health and Safety plan (HASP) included in Appendix B of the work plans.

1.3 Report Organization

The remainder of this RI report is organized into the sections and appendices listed below.

- Section 2 provides a description of the East 21st Street Works former MGP site and surrounding properties, a summary of information regarding site ownership and operational history, and a summary of previous investigations.
- Section 3 provides a description of field investigation activities and sample analyses performed during the RI.
- Section 4 provides a discussion of the site geology and hydrogeology.
- Section 5 provides a discussion of the observations regarding the extent of observed MGP residuals, and a summary of the analytical results for environmental media sampled during the investigation within OU1.
- Section 6 presents a qualitative evaluation of the risk associated with the MGP constituents for OU1 of the site.
- Section 7 presents a summary of and conclusions for OU1 of the RI.
- Section 8 presents recommendations for future activities regarding OU1 of the site.
- Section 9 presents references cited.

Tables and figures are included in the sections immediately following the text of this report.

Appendices to this report include the following:

- Appendix A – Historic site maps
- Appendix B – Boring logs for the RI and previous investigations
- Appendix C – Draft Water Valve Replacement report (June 2007)
- Appendix D – Well development forms
- Appendix E – Groundwater sampling sheets
- Appendix F – Tidal survey data
- Appendix G – Aquifer conductivity data
- Appendix H – Investigation-derived waste manifests
- Appendix I – Oil water underdrain system investigation
- Appendix J – RI and SCS analytical results summary tables and data usability reports

2.0 Site Description and History

2.1 Site Location, Description, and Setting

The grounds of the East 21st Street Works former MGP extended from First Avenue to Avenue C between East 20th and 22nd Streets in the Borough of Manhattan, New York City, New York. Figure 2-1 illustrates the site location on a portion of the Brooklyn, New York quadrangle topographic map. The former MGP was situated within the section of the Peter Cooper Village residential housing complex bounded by East 20th Street to the south, First Avenue to the west, the former East 22nd Street to the north, and Avenue C to the east. This area is designated as Block 978, Lot 1 on the tax map of the City of New York, New York (Langan, 2004).

OU1 of the East 21st Street Works site encompasses the 21 fifteen-story brick apartment buildings, tennis and basketball courts, as well as playground, park, and landscaped areas within the Peter Cooper Village complex including adjacent sidewalks up to the curb along surrounding streets. The current site structures are illustrated on Figure 2-2. All of the Peter Cooper Village apartment buildings reportedly have full basements except for one (390 First Avenue – building number 1) which is constructed with crawl spaces and a central basement corridor. The Peter Cooper Village complex is fenced along its perimeter with several gateways for access to the complex and surrounding streets. The main entrances to the complex are through the security gates/booths along Peter Cooper Road at First Avenue and Avenue C. Except for a portion of one building in the southwestern corner of the Site (350 First Avenue), all of the buildings encompassed by the former MGP are residential. The Peter Cooper Village property was sold to an affiliate of Tishman Speyer Properties, L.P. and Blackrock Realty Advisors, Inc. by Metropolitan Tower Insurance Company, an affiliate of the Metropolitan Tower Insurance Company, an affiliate of the Metropolitan Life Insurance Company (MetLife).

Current surrounding land uses consist of residential, commercial, and institutional. South of the site, on the south side of East 20th Street, is the Stuyvesant Town apartment complex and small commercial operations including a small market, deli, and fitness center. A restaurant is situated on the northeast corner of the First Avenue and East 20th Street intersection (southwestern corner of the site). First Avenue consists of several northbound traffic lanes with an access road with parking and sidewalks along the east side. Commercial establishments such as Dunkin Donuts, Burger King, a pharmacy, etc., are located along the west side of First Avenue across from the site. North of the site along 23rd Street, are institutional facilities including the Special Education Services School, the Veterans Memorial Hospital, Chase Bank, and a public bath house that contains indoor and outdoor pools, gymnasium, and restroom facilities.

The section of Avenue C and the elevated FDR Drive between East 20th and East 21st Streets are situated east of the grounds of the former MGP. Parking areas are located beneath the FDR and a waterfront park, Stuyvesant Cove Park, is situated further east between the parking areas and the East River. The park property is owned by the City of New York and managed by the New York City Economic Development Corporation (EDC). The Community Environmental Corporation (CEC) leases the property from EDC and manages and operates Stuyvesant Cove Park. The park consists of landscaped areas, bike and walking paths, benches and tables. An Environmental Education Building (Solar One) is situated in the northern portion of Stuyvesant Cove Park.

A gasoline station is situated north of Stuyvesant Cove Park, northeast of the site. Previous releases of petroleum products have been documented from a former service station facility with several underground storage tanks (USTs) at this location. Two multi-phase extraction (MPE) systems were installed within Stuyvesant Cove Park between East 18th Street and East 23rd Street to address this contamination and have been decommissioned.

2.2 Site History

2.2.1 Pre-Manufactured Gas Plant

The following information regarding the pre-MGP site history was excerpted from the *Report of Geotechnical Study and Preliminary Environmental Evaluation, Peter Cooper Village, Manhattan*, *New York* prepared by Langan in April 2001 (Langan, 2001).

The site was originally part of the East River with the historic shoreline located approximately 1,500 feet to the northwest of the existing waterfront (approximately First Avenue). The area has undergone extensive filling activities to reclaim the land to the existing elevations. Historic filling along waterfront areas was generally carried out as uncontrolled bulk fills consisting of a wide variety of materials including construction debris, organic soil matter, excavated material from adjacent construction sites, and miscellaneous debris. Therefore, the constituents and in-situ conditions of these materials are highly variable.

2.2.2 Manufactured Gas Plant

Detailed historic information was previously compiled and presented in a report entitled *MGP Research Report, East 21st Street Works* (Langan, 2002). The historical information provided herein was derived from the SCS Report (H&A, 2004) which referenced the MGP Research Report.

The former East 21st Street Works operated circa 1848 to 1945 and was used for gas manufacturing, gas purification, and storage. The location of significant former MGP structures, based on Sanborn maps from 1903 and 1944, are shown on Figure 2-2. Historic site maps are provided in Appendix A. Major gas manufacturing structures included generators, retorts, condensers, scrubbers, purifiers, gas holders, and meter houses.

The north and south boundaries of the former MGP at its most developed state in 1945 reportedly were between the former alignment of East 22nd Street and East 20th Street, respectively, and comprised approximately 14 acres. At that time, Avenue A and Avenue B extended north through the Site above East 20th Street to East 23rd Street, and Avenue C was referred to as Marginal Street or Wharf Street. Consolidated Gas Company reportedly owned the four blocks bounded by East 20th Street and East 22nd Streets and First Avenue and Avenue B, as well as the area between East 20th Street and East 21st Street and Avenue B and Avenue C.

Coal gas manufacturing operations reportedly started with 19 retorts circa 1848 on the northern half of the Site, which may have occupied the area located east of former Avenue A and bounded by former East 21st Street and former East 22nd Street. By 1849, the first telescopic gas holder in New York City reportedly was put into service on the Site. Between 1853 and 1868, the MGP continued to expand. Between 1923 and 1927, the plant capacity was increased with two additional water gas sets.

Between 1890 and 1929, other land uses adjacent to the former MGP to the northeast between East 22nd Street and East 23rd Street at Avenue C included a coal and stone yard, furniture factory, brass foundry, veterinary hospital, chandelier factory, garage, parking lot, and railroad storage yard (Langan 2001). A garage with two 275 gallon gasoline USTs was situated between East 22nd and East 23rd at Avenue A (Langan, 2001).

2.2.3 Post-Manufactured Gas Plant

The grounds of the former East 21st Street Works MGP were sold by Con Edison to Stuyvesant Town Corporation and MetLife in 1944 and 1945, respectively, for development of the Peter Cooper Village Housing Project (Langan, 2002). The Peter Cooper Village residential units were constructed in the late 1940s and are primarily pile supported, although the buildings along First Avenue may be partially supported directly on shallow bedrock (Langan, 2001). An affiliate of Tishman Speyer Properties, L.P. and Blackrock Realty Advisors, Inc. purchased the Peter Cooper Village property in 2006.

During the construction of Peter Cooper Village, an underdrain system consisting of gravel encased porous 8-inch concrete piping was designed for installation in oil contaminated areas throughout the eastern portion of the site. Based on information provided by Langan (Report of Geotechnical Study and Preliminary Environmental Evaluation, April 21 2001) from a review of available construction drawings, the underdrain was reportedly installed at about the water table for the collection of oil floating on the water table. The underdrain was designed to collect water and oil primarily during high water table periods and discharge to the combined sewer system running through the site (Langan 2001).

2.3 Previous Investigations

Previous investigations performed at the site prior to the RI are summarized in the following sections.

2.3.1 Geotechnical Study and Preliminary Environmental Evaluation

A geotechnical engineering study and preliminary environmental evaluation were completed for proposed construction activities for the Peter Cooper Village property. The geotechnical and environmental field investigation included drilling 23 test borings (LB1 through LB23) and five road cores (LC-1 through LC-5). These locations are illustrated in green on Figure 2-3. Copies of the boring logs for these borings are included in Appendix B of this RI Report. Six soil samples were collected from the borings and analyzed for Volatile Organic Compounds (VOCs), Semi-Volatile Organic Compounds (SVOCs), and Priority Pollutant Metals. Several compounds were detected at concentrations exceeding NYSDEC soil criteria. The laboratory analytical results are provided in Appendix B2 of the *Report of Geotechnical Study and Preliminary Environmental Evaluation* (Langan, 2001).

2.3.2 East 21st Street Site Works Comprehensive Report of Evaluation of Indoor Air and Soil Gas Sampling

An evaluation of the potential for subsurface vapor intrusion at the Peter Cooper Village Apartment property was conducted by RETEC on behalf of Con Edison in June 2003. Additional sampling was conducted in August 2003, March 2004, and April 2004. The overall goal of the work was to ascertain whether air quality within the apartment buildings that lie within and adjacent to the boundary of the former MGP was being adversely affected by residual subsurface impacts that might remain from the former MGP operations. Several samples were collected from ambient air, indoor air, and soil gas. Results from this sampling indicate that the indoor air quality, as measured on the sampling day, was not likely to have been adversely impacted by subsurface intrusion of vapors related to the previous MGP operations at the site. Based on the results of these sampling events, intrusion of vapors emanating from any MGP-related material present at the site does not appear to be evident. The sampling activities and results are presented in the report entitled *East 21st Street Works Site Comprehensive Report of Evaluation of Indoor Air and Soil Gas Sampling for Sampling Dates June 2003, August 2003, and March-May 2004* (RETEC, 2004).

2.3.3 Site Characterization Study

A SCS was completed by H&A in November 2004. The SCS field investigation included 15 test pits, 108 soil borings, and 20 monitoring wells (10 couplets). Figure 2-3 illustrates the SCS sampling locations in purple. A total of 743 soil samples and 20 groundwater samples were collected and analyzed to assess the presence or absence of MGP-related constituents at the site. An evaluation of background soil quality was also performed on the Stuyvesant Town residential apartment complex located south of the site. The investigation found that MGP residuals were present at the site in concentrations exceeding regulatory criteria, and that a remedial investigation was warranted to further delineate impacts and characterize environmental conditions. The findings of the investigation are provided in the report entitled *Site Characterization Report, Former East 21st Street Works Manufactured Gas Plant Site, Peter Cooper Village Housing Development New York, New York*

(H&A 2004). Copies of the test pit and boring logs from the SCS are included in Appendix B of this RI report. Surface soil, subsurface soil, and groundwater analytical results from the SCS are presented in conjunction with the RI analytical results in Section 5 of this RI report.

2.4 Adjacent Site Investigation and Remedial Action at Stuyvesant Cove Park

The Stuyvesant Cove Park property became the subject of investigation in 1995 due to complaints of fumes in an office near the north end of the site and observation of a sheen in the East River. A site investigation was performed and interim remedial measures were implemented by MEG under contract to NYSDEC – Region 2. The investigations focused on the former service station area and tank farm in the northern portion of the site. Two separate MPE systems were installed to address the contamination at the site. This RI report on OU1 includes limited results of groundwater level measurement and quality sampling from four of the monitoring wells installed as part of the Stuyvesant Cove Park investigation. These data are presented in Sections 4 and 5 of this RI report.

2.5 Water Valve Replacement Activities

Unrelated to the RI activities, valves on water mains servicing the Peter Cooper Village Apartment Complex were replaced between November 2006 and June 2007 as part of a maintenance program for the complex. Due to the presence of the former MGP located within the Peter Cooper Village complex, RETEC provided third-party oversight of the water valve replacement activities on behalf of Con Edison. A report was developed and provides a summary of the quality of soil and groundwater encountered in the trenches excavated to access and replace the valves and also provides a summary of the material disposed during the activities. A copy of the Water Valve Replacement report (RETEC 2007) is included as Appendix C of this OU1 RI report. In addition, as requested by NYSDEC in the August 10, 2007 comments on the Draft RI report (RETEC 2006), a figure was developed of the water valve excavation locations overlayed on the environmental investigation locations at the site. This figure is also provided in Appendix C, before the water valve report.

3.0 Remedial Investigation Field Activities

This section provides a description of the methodologies used during the field investigation of the East 21st Street Works former MGP site. The first round of RI field tasks was initiated in January 2006 and completed in June 2006. All of these field activities were conducted in accordance with the methods and procedures specified in the NYSDEC-approved RI Work Plan (RETEC, 2005) for the site. Based on field observations, additional investigative activities were proposed along the north side of East 23rd Street and to the north and south in Stuyvesant Cove Park (in OU2). These activities were approved by NYSDEC on April 10, 2006 and will be detailed in the OU2 RI report. The second round of RI field activities was initiated in February 2008 and completed in September 2008. These activities were performed in accordance with the methods and procedures specified in the NYSDEC-approved Supplemental RI Work Plan (ENSR 2007). One additional boring, 21GH030, was drilled within former gas holder #2 in OU1. Representatives of the NYSDEC, Division of Environmental Remediation of Albany, New York, were on site to observe many of the boring and well installation and sampling activities.

The location and number of samples collected along with the corresponding analytical parameters are presented in the following subsections. Descriptions of all field activities are included by field task and/or environmental media. The locations of the OU1 2006 RI samples are illustrated in blue on Figure 3-1, locations of the OU1 2008 RI samples are illustrated in green on Figure 3-1, and previous investigation locations are illustrated in black on Figure 3-1. Specific tasks performed during the RI included the following:

- Underground utility clearance
- Community air monitoring
- Surface soil sampling and analysis
- Upper fill sampling and analysis
- Lower fill/native soil sampling and analysis
- Bedrock investigation (to be presented in the OU3 RI report)
- Monitoring well installation and development
- Groundwater elevation and NAPL thickness measurements
- Groundwater sampling and analysis
- Evaluation of tidal influence on groundwater elevations
- Aquifer conductivity testing
- Soil gas sampling and analysis
- Oil water underdrain investigation
- Survey of sampling locations
- Management of IDW

3.1 Underground Utility Clearance

Prior to the initiation of intrusive fieldwork, the drilling sub-contractors, Aquifer Drilling and Testing, Inc. (ADT) for the 2006 drilling efforts and Paragon Environmental Construction, Inc. (PEC) for the 2008 drilling efforts contacted Dig Safely New York to arrange for the location and marking of all underground utilities in the vicinity of the proposed test pits, soil gas probes, soil borings, and monitoring well locations, as required by New York Code of Rules and Regulations (NYCRR) Part 753. Where possible, ENSR/AECOM worked directly with the representatives of each utility company to ensure that all underground lines were properly identified and marked-out.

Utility clearance was performed by NAEVA Geophysics, Inc. (NAEVA) and Advanced Geophysical Services (AGS) under contract to RETEC or ENSR/AECOM. NAEVA and AGS used ground-penetrating radar (GPR) and electro-magnetic (EM) survey methods to scan each proposed investigation location. Plates of gas and steam mains, high tension lines, low tension lines, and composite feeders were provided by Con Edison. Sewer as-builts were prepared and provided by the City of New York Department of Public Works, Division of Sewage Disposal, and Bureau of Sewage Disposal Design. Maps providing the location of water mains were provided by the New York City Department of Environmental Protection (DEP). On-site utility maps were provided by Rose Associates as incorporated in the SCS report (H&A 2004).

Prior to excavating soil borings using a drill rig or geoprobe, each boring location was hand excavated to a minimum depth of 5 ft bgs with 2 ft by 2 ft dimensions. Excavations were performed to locate any utilities that may have been marked incorrectly, are privately owned, have been abandoned, were not known to exist, or were not detectable by surface investigation methods. Hand-clearing was performed by ADT and PEC under contract to RETEC or ENSR/AECOM. ADT and PEC employed a combination of high vacuum extraction, hand-digging with shovels and posthole diggers, and other non-mechanical means.

3.2 Community Air Monitoring

Community air monitoring was performed and documented to provide real-time measurements of total VOCs and particulate (airborne dust) concentrations upwind and downwind of each designated work area during intrusive investigation activities. Site personnel monitored any odors produced during these activities. The monitoring was designed to provide protection to the public downwind of the work area from any potential releases of airborne contaminants due to investigation activities and to document air quality during intrusive activities.

Instrumentation used during the Community Air Monitoring Program (CAMP) was located upwind and downwind of the work area on stands located in the breathing zone. The instruments were calibrated daily and recorded on separate field forms. The instrumentation used during the investigation activities included the following: a photo-ionization detector (PID) 10.6 eV to measure volatiles in parts per million (ppm) and a Dustrak meter to detect the particulate concentrations in milligrams per cubic meter (mg/m3). A Dräeger pump and benzene colorimetric tubes were used to detect the presence of benzene.

The instruments were programmed to log air quality data once per minute during intrusive work activities. Personnel recorded readings and any observations from these instruments every 15 minutes on a separate CAMP field form. If elevated readings were observed, they were noted and the PID used to screen soil samples was placed next to the CAMP PID for direct comparison of readings. If both PIDs indicated sustained elevated readings for 15 minutes, a Dräeger pump with a colorimetric tube was used to test for the presence of benzene. Data from the PID and Dustrak monitors were downloaded to a field laptop computer on a daily basis. The recorded logs were reviewed for any exceedances and downloaded to a daily file with the work area location as the file name.

During the RI, there were several instances where CAMP action levels (PID readings greater than 1 ppm) were reached or exceeded at downwind locations during subsurface investigation activities. Exceedances were generally due to humidity and ambient background conditions. None of the colorimetric benzene tubes indicated the presence of benzene. Based on the air quality monitoring data, the intrusive activities performed during the RI did not negatively impact the air quality at the site.

3.3 Surface Soil Sampling and Analysis

Four surface soil samples were collected during the 2006 RI to evaluate the extent of surface soil impacts noted near the site boundaries during the SCS. No surface soil samples were proposed as part of the

Supplemental RI Work Plan (ENSR 2007). Only one of the RI surface soil samples was collected within OU1. The location of the OU1 surface soil sample is illustrated on Figure 3-1. Table 3-1 summarizes the OU1 surface soil sample designation, depth, date, collection method, rationale, and laboratory analyses. The remaining RI surface soil samples will be presented in the OU2 RI report.

At each surface soil sample location, a 2 ft by 2 ft area was scraped with a stainless steel trowel and samples were collected from 0.0 to 0.2 ft or at 0.5 ft depending on the surface cover. Soil samples to be analyzed for VOCs were placed directly in a jar supplied by Chemtech Laboratories of Mountainside, New Jersey (Chemtech) and sealed. Soil samples for other analyses were homogenized and then placed in jars supplied by Chemtech and sealed. Sample jars were labeled, placed in a cooler with ice, and sent under chain-of-custody protocol by courier to Chemtech.

3.4 Upper Fill Sampling and Analysis

Seven upper fill soil samples were collected during the RI to evaluate the extent of upper fill impacts noted near the site perimeter during the SCS. The RI work plan specified the collection of six upper fill soil samples. One additional sample was collected at 3 ft bgs to characterize odors noted during pre-clearing activities for the installation of monitoring well 23MWD12. No upper fill soil samples were proposed as part of the Supplemental RI work plan. Three of the upper fill sample locations were collected from OU1 and are illustrated on Figure 3-1. Table 3-2 summarizes the sample designation, depth, date, collection method, rationale, and laboratory analyses for the OU1 upper fill samples collected during the RI. The remaining RI upper fill soil samples will be presented in the OU2 RI report.

Upper fill samples were collected from 0.2 to 5 ft bgs during utility clearance activities. Aliquots of soil were collected at 1-foot intervals with a steel trowel to a depth of 2 ft. Sample aliquots were placed in plastic bags and screened with a PID. The steel trowel was decontaminated between each use. A hand auger, posthole digger, or shovel was used to collect soil aliquots at 1-foot intervals from a depth of 2 to 5 ft bgs. The sampling instrument was decontaminated between each sample aliquot collection. Samples were screened with a PID for VOCs. If there was no olfactory or instrument indications of contamination, the sample for VOC analysis was collected by scraping soil from along the side of the utility clearance hole. If there was olfactory or instrument indications of contamination, the soil aliquot exhibiting the highest PID reading was jarred and submitted for VOC analysis. The soils for the remaining analyses were composited and placed in the appropriate sample jars. Sample jars were labeled, placed in a cooler of ice, and sent under chain-of-custody protocol by courier to Chemtech.

Excavated soils that showed evidence of contamination were placed in 55 gallon drums and managed in accordance with Subsection 3.15 of this report. Excavated soils that did not show signs of contamination were placed back in the utility clearance test pit.

3.5 Lower Fill/Natural Soil Sampling and Analysis

During the 2006 RI activities, 18 borings were drilled within OU1 and five were completed as monitoring wells. These borings are summarized in Table 3-3. A total of 23 lower fill/natural soil samples were collected from nine boring locations within OU1 during the 2006 RI activities to further characterize and evaluate the extent of impacts detected during the SCS. Additional sample collection was performed at one monitoring well and four deep (to the top of bedrock) boring locations, relative to the RI work plan (RETEC 2005) based on field conditions. Eleven borings were drilled within OU1 during the 2008 RI activities to advance borings to the top of the bedrock for inspection and coring purposes and to evaluate soil quality in the vicinity of playground and basketball/tennis court areas. A total of 17 lower fill/natural soil samples were collected from seven boring locations within OU1 during the 2008 RI activities. The OU1 lower fill/natural soil sample locations are illustrated on Figure 3-1. Table 3-3 provides a summary of the OU1 soil borings, sample designation, depth, date, collection method, rationale, and laboratory analysis for each lower fill/natural soil sample collected during the 2006 and 2008 RI activities. The lower fill/natural soil samples collected from borings situated outside of the OU1 area will be presented in the OU2 RI report.

The initial RI soil borings were drilled between January 24, 2006 and May 9, 2006. These soil borings were performed by ADT under the supervision of a RETEC geologist or engineer. The supplemental RI soil borings were drilled between March 31, 2008 and May 20, 2008 by Paragon under the supervision of an ENSR/AECOM geologist or engineer. Soil borings were advanced using hollow stem auger (HSA) drilling rigs (truck- and track-mounted variations) or direct-push technology using a geoprobe rig. At certain locations, casing was advanced using drive and wash methods where heaving sands were encountered at depth, as described below. Continuous soil samples were generally collected from a depth of 5 ft to the base of each borehole. The upper 5 ft of each boring was logged continuously during utility clearance. The soils were logged for composition and presence of visual and olfactory impacts and were field screened with a PID for the presence of VOCs. Boring logs and monitoring well construction diagrams are provided in Appendix B of this RI report.

Samples were collected using either a 2-inch or 3-inch outside diameter, 2-foot long split-spoon sampler. Soil samples were collected in advance of the augers or drive casing by driving the split-spoon sampler through the sample interval with a 140 pound hammer on an anvil attached to the drive head on the sampler (via automatic hammer). Blow counts were recorded for every 6-inch interval. Split-spoon sampler refusal was considered 100 blows per 6-inches. Split spoons were decontaminated with Alconox® and water between each sample. The downhole drilling equipment was decontaminated by steam cleaning between each boring.

The site is underlain by saturated sand that frequently complicates continuous split-spoon sampling and boring advancement at depths greater than approximately 30 to 35 ft due to increased pressure at the base of the borehole that causes sand to heave. Heave is a condition that results from sand pushing up into the augers during drilling due to pressure differences. Several steps were taken to collect representative soil samples when heave occurred. The first step was to flush the augers out with water and keep the augers filled with water to add downward pressure in the borehole to balance the upward pressure exerted by the saturated sands at the base of the borehole. If the water pressure was insufficient to prevent further heaving, a mixture of water and either bentonite or Revert® (natural food-grade guar gum polymer) was used to create a drilling ‘mud’ that is denser than water. This mud mixture created greater downward pressure within the augers to prevent heave. If the mud mixture was also insufficient to prevent heave, the augers were removed and a 3-inch or 4-inch removable casing was pounded into the ground with a pneumatic hammer. The removable casing sufficiently seals off the boring from heaving sands and allows for sample collection with a split-spoon sampler. The casing was advanced using drive and wash methods until non-heaving sand/soil was encountered.

Soil borings advanced by direct-push geoprobe used a 5-foot long steel sampling tube (macro-core sampler) with an acetate liner. New liners were used for each 5-foot sample interval.

Upon completion, boreholes were completed as monitoring wells or tremie-grouted from the base of the boring. IDW was managed in accordance with Subsection 3.15 of this RI report.

In general, three samples were collected from each boring location; one at the depth interval corresponding to adjacent boring impacts for lateral delineation, one at the depth interval with the greatest observed impacts based on olfactory and visual observations and PID readings, and one below the deepest impacts or at the base of the boring to provide vertical delineation information. In the event that olfactory and visual observations and PID readings did not indicate impacts at a location, a sample was collected at the water table interface and bottom of boring.

Soil for VOC analysis was collected directly from the interval exhibiting the highest PID readings when detected. Soil collected for the remaining analyses was sampled across the sample interval. Soil samples were placed in jars, labeled, placed in coolers of ice, and sent under chain-of-custody protocol by courier to Chemtech.

3.6 Bedrock Investigation

A bedrock investigation was performed to try to identify the migration pathway of DNAPL seeping into the Con Edison steam tunnel located approximately 90 ft bgs along the east side of First Avenue, and to define the top of the bedrock surface beneath the site to evaluate whether DNAPL was present and migrating along the surface. During the 2006 RI, four borings were cored to approximately 90 ft bgs along First Avenue. These bedrock borings were identified as 21FA102B through 21FA105B. An additional four borings were drilled with HSA methods to the top of bedrock in the western portion of the site. These borings were identified as 21GH101B through 21GH104B. During the 2008 RI activites, four borings were cored to approximately 90 ft bgs in the northwestern portion of the site (21BR01B, 21BR02B, 21BR03B, and 21BR05B) and four borings were drilled to the top of the bedrock surface in the northwestern portion of the site (21BR04B, 21BR06B, 21BR07B, and 21BR08B). All of these bedrock investigation boring locations are illustrated on Figure 3-1 and boring logs are provided in Appendix B. The data for the overburden at each of these boring locations are included in this RI report for OU1. The bedrock investigation methodology and results will be presented in the OU3 RI report

3.7 Monitoring Well Installation and Development

Twenty-one monitoring wells were installed on and along the perimeter of the site during the 2006 RI activities. Four shallow (S-series) monitoring wells (screened from approximately 5 to 15 ft bgs) and eight intermediate (D-series) monitoring wells (screened from approximately 25 to 35 ft bgs) were installed to expand the existing SCS monitoring well network at similar depth intervals. Nine deep (DD-series) monitoring wells were installed with 10-foot screened intervals situated between approximately 50 and 70 ft bgs to evaluate deep groundwater quality in an attempt to provide vertical delineation of groundwater impacts at the site. In addition, eight groundwater grab samples were collected from two separate borings north of the site for additional groundwater delineation data. Six monitoring wells were installed in OU2 during the 2008 RI activities to further delineate the extent of MGP-related groundwater impacts. Two D-series monitoring wells and two nested pairs consisting of D-series and DD-series wells were installed. The OU1 monitoring well locations are illustrated on Figure 3-1. Table 3-4 summarizes the OU1 and OU2 RI monitoring well and groundwater grab sample designation, screened interval, date installed, location rationale, and subsequent groundwater sampling method and laboratory analyses. The groundwater level and analytical results for both OU1 and OU2 wells are presented in Section 5 of this OU1 RI report to enable presentation of groundwater elevation contours, groundwater quality results, and a limited evaluation of groundwater natural attenuation parameters.

Borings for monitoring well installation were advanced with HSA techniques as described in Subsection 3.5 above. At locations where well pairs or triplets were installed, continuous soil sampling using split-spoon samplers was performed only during the advancement of the borehole for the deepest monitoring well at that location. Soil inspection and logging of split-spoon samples was performed in accordance with the method described in Subsection 3.5 above. Borings drilled for the installation of shallower wells at coincident locations were not continuously sampled with split spoons. Boring log and monitoring well construction diagrams are provided in Appendix B.

All monitoring wells installed during the 2006 and 2008 RI activities are constructed of 2-inch diameter schedule 40 polyvinyl chloride (PVC) with 10-foot sections of 0.020-inch slot screens and 2-foot sediment sumps. A sand pack extends from the base of each well screen to at least 1-foot above the top of the screened interval. The sand pack is overlain by a 2-foot bentonite seal and the remaining annular space is filled with grout to within approximately 1-foot of ground surface. Flush-mounted limited access road boxes were used to complete the wells and the surface surrounding the well was restored to pre-drilling conditions.

Monitoring wells were developed a minimum of 24 hours after well installation (following NYSDEC protocol) to remove fine sediments from within the well, well screen, sand pack, and aquifer to promote good hydraulic connection between the well and the formation. Various techniques were used for well development, including surging using a plunger, one and two stage downhole centrifugal pumps, and a peristaltic pump. The plunger was a handmade design that consisted of PVC pipe with a gasket and valve on one end and tubing on the other end that directed development water into a drum.

For wells with large amounts of sediment in the sump, a two stage centrifugal pump was used for surging, then for purging water for well development. For wells with measurable product that needed to be developed, the product was first removed using a dedicated bailer or dedicated tubing connected to a peristaltic pump to the extent practicable. The product and water purged was containerized. The depth to product was measured to assure all product was removed prior to development and then a one or two stage whale pump or a peristaltic pump was used to develop the wells.

Monitoring well 21MWDD04 was installed via mud rotary using Revert® and permanent casing. Prior to development, a solution of bleach and water was pumped into the well to break down the Revert®. After the solution was allowed to react with the Revert® for 24 hours, the well was developed using a two stage whale pump.

Monitoring well EBMWD14 was developed by bailing product and groundwater.

All of the wells installed as part of the RI were developed until approximately 10 well volumes of water were removed or until turbidity was low (less than 50 Nephelometric Turbidity Unit [NTU]) and groundwater pH, temperature, and conductivity parameters stabilized. Water quality data monitored during well development are summarized on the well development forms provided in Appendix D. All of the development water was containerized in 55-gallon closed top drums and managed in accordance with Subsection 3.15.

3.8 Groundwater Sampling and Analysis

Three types of groundwater sampling were performed during the 2006 RI activities. Groundwater samples were collected on April 12, 2006 from three monitoring wells (EBMWDD18, 21MWDD03, and 23MWDD12) and analyzed for VOCs under a quick-turnaround timeframe to help determine additional sampling locations and appropriate well screened intervals. Groundwater grab samples were collected between April 27 and May 9, 2006 from specific depth intervals during the advancement of borings AC101 and 23N101 to provide additional groundwater quality and delineation data. Groundwater samples were collected between May 16 and May25, 2006 from 45 monitoring wells comprised of the 20 wells installed during the SCS, the 21 wells installed during the RI, and four shallow wells (LR02, LR08, LR11, and LR17) installed by others in Stuyvesant Cove Park. A summary of the groundwater sampling performed during the 2006 RI is provided in Table 3-5.

During the 2008 RI activities, groundwater samples were collected from 35 of the previously sampled monitoring wells and from the six newly installed monitoring wells. Unlike the 2006 groundwater sampling event, groundwater samples were not collected from monitoring wells which contained indications of NAPL during the 2008 RI groundwater sampling event. Monitoring well LR11 could not be located and was not sampled during the 2008 sampling effort. A summary of the groundwater sampling performed during the 2008 RI is also provided in Table 3-5.

The groundwater grab samples collected from borings AC101 and 23N101 were collected via stainless steel temporary screen points from the depth intervals summarized in Table 3-5. The screen point was advanced to the desired depth using direct-push technologies, the screen sleeve was retracted 2 to 4 ft, depending on the apparatus, and tubing was placed through the geoprobe rods. A peristaltic pump was attached to the tubing and groundwater was drawn through the tubing into sample jars. In the shallow depth intervals where sufficient recharge was available, the borehole was purged until the water attained visual clarity prior to collecting the sample. In deeper depth intervals, recharge was poor and there was barely sufficient volume to fill the VOC sample vials, so purging could not be performed. Sample jars were labeled, placed in coolers containing ice, and sent under chain-of-custody protocols by courier to Chemtech for VOC analyses.

Groundwater samples were collected from 45 monitoring wells between May 16 and May 25, 2006 as summarized in Table 3-5. Groundwater samples were collected from 41 monitoring wells between August 27, 2008 and September 25, 2008. Monitoring wells were purged and groundwater samples were collected using a peristaltic pump and low-flow sampling methodologies. Prior to purging and sampling the depth to water and presence/thickness of NAPL were measured to the nearest 0.01 of a foot in each monitoring well. Tubing (and for the deep DD-series wells, a foot valve) was placed at the approximate midpoint of the screened interval unless NAPL was observed/detected in the well. If NAPL was observed in the well during the 2006 sampling event, the tubing intake was placed approximately 2 ft above the NAPL. Monitoring wells in which NAPL was noted during the 2006 groundwater sampling efforts include 21MWD03, 21MWDD04, 21MWD07, 23MWD12, 23MWDD12, EBMWD14, EBMWDD15, and LR08. During the purging and sampling of monitoring wells 21MWDD04 and EBMWDD15, the intake was placed above the screened interval to avoid entraining NAPL. Groundwater samples were not collected from wells in which NAPL was noted during the 2008 groundwater sampling event. Monitoring wells in which NAPL was noted in 2008 include 21MWD03, 21MWD04. 21MWDD04, 21MWD07, 21MWD10, 23MWD12, EBMWD14, EBMWDD15, and EBMWD18.

Groundwater purge rates were set below the maximum sustainable flow rate to ensure that the water table remained within 0.3 ft of the initial depth to water reading in the well. During purging activities, groundwater was passed through a Horiba U-22 flow-through cell which contained probes to measure the water temperature, pH, conductivity, and oxidation-reduction potential. Samples of water discharging from the cell were collected at 5-minute intervals and analyzed for turbidity using a LaMotte® 2020 turbidity meter. After passing through the cell, the water was discharged and temporarily contained in 5 gallon buckets. The purged water was later transferred to 55 gallon closed top drums and managed in accordance with Subsection 3.15.

Groundwater samples were collected in appropriate glassware once the water quality parameters had stabilized. Sample jars were labeled, wrapped in plastic, placed in coolers with ice, and sent by courier to Chemtech under chain-of-custody protocol. In addition, groundwater samples were collected from 17 monitoring wells and analyzed for parameters to evaluate the potential for intrinsic bioremediation/natural attenuation of groundwater impacts in the Site area during the 2006 sampling event. The wells from which samples were collected for the intrinsic bioremediation/natural attenuation evaluation in 2006 include 21MWS01, 21MWD01, 21MWS03, 21MWD03, 21MWDD03, 21MWD07, 21MWS11, 21MWD11, 23MWS12, 23MWD12, 23MWDD12, EBMW13D, EBMW13DD, 20MWS16, 20MWD16, 23MWDD20, and LR02. The wells from which samples were collected for the intrinsic bioremediation/natural attenuation evaluation in 2008 included 21MWS01, 21MWD01, 21MWD03, 21MWDD03, 23MWS11, 23MWD11, 23MWS12, 23MWDD12, EBMWD13, EBMWDD13, EBMWD15, 20MWS16, 20MWD16, EBMWD18, 23MWDD20, EBMWD24, EBMWDD24, EBMWD25, and EBMWDD25. Groundwater sampling sheets for the April 2006, May 2006, and August through September 2008 groundwater sampling events are compiled and presented in Appendix E.

The groundwater samples collected from monitoring wells EMBWDD18, 21MWDD08, and 23MWDD12 for quick-turnaround VOC analysis in 2006 were collected using the low-flow methodology described above. These samples were shipped to New England Testing Laboratories of North Providence, Rhode Island for VOC analysis.

Purged groundwater was containerized in 55 gallon closed top drums and managed in accordance with Subsection 3.15

3.9 Groundwater Elevation and Nonaqueous Phase Liquid Thickness Measurements

Depth to water measurements were collected from the majority of the monitoring wells on April 7, 2006, May 4, 2006, and during groundwater sampling activities between May 16 and 25, 2006. The April 7, 2006 event was performed while evaluating the condition of monitoring wells installed during the SCS to determine whether additional development would be necessary prior to groundwater sampling events. The May 4, 2006 survey was conducted to help select wells to be used during the tidal survey and aquifer conductivity testing. A complete round of depth to water measurements and NAPL presence/thickness measurements was also performed in the 45 monitoring well network on June 12, 2006. Depth to water measurements and presence of NAPL were recorded during the groundwater sampling events performed between August 27 and September 29, 2008. A complete round of depth to water measurements and NAPL presence/thickness was also performed in the 50 well monitoring network (original 45 wells except for LR11 which could not be located plus the six monitoring wells installed in 2008) on September 24, 2008. These depths were measured using electronic water level meters and/or oil-water interface probes. The May 4, 2006, June 12, 2006, and September 24, 2008 depth to water measurements and resulting groundwater elevations were compiled along with other well construction details and are presented in Subsection 4.5. These data were used to develop groundwater contour maps and evaluate groundwater flow directions at the site as presented and discussed in Subsection 4.5.

During the RI, the presence/absence and thickness of NAPL was also measured and recorded for the site monitoring wells. NAPL removal efforts were performed in monitoring wells 21MWD03, 21MWD04, 21MWD07, 21MWD10, 23MWD12, EBMWD14, and EBMWDD15 in 2006. These NAPL observations and removal efforts are summarized in Subsection 5.4.1.3.

3.10 Tidal Survey

A tidal survey was conducted in 14 wells and the East River in order to assess the extent of tidal influence on groundwater at the East 21st Street Works former MGP Site. Prior to beginning the long-term tidal survey, a pilot test was run for approximately two hours on June 6, 2006, to determine the optimum measurement frequency and to ensure proper set up of the equipment for the full scale test.

Water levels and temperatures were measured using an In-Situ miniTROLL® placed within the screened section of the wells over an approximate 52-hour period. The full scale tidal survey began between 20:00 and 22:00 on June 6, 2006 and was completed on June 9, 2006 between 06:40 and 07:40. The following wells were monitored, in addition to the East River: 21MWD02, 21MWDD03, 21MWS05, 21MWD05 21MWD06, 21MWD08, 23MWS12, 23MWDD12, EBMWD13, EBMWDD13, EBMWD18, 23MWD20, LR02, and LR08.

The miniTROLLs® were connected to a cable and placed within the 14 monitoring wells to a depth where they would remain immersed in water over the course of the test. The wells were covered to keep rain from entering the casing during the test. Excess cable was wrapped around and secured to the well casing to prevent the miniTROLL® from slipping. The curb box was then cleaned and secured to prevent leakage. The test wells were inspected on June 7, 2006 to ensure that the wells were not being influenced by rain.

The miniTROLL® set in the East River provided direct measurement of the tidal fluctuation adjacent to the Site and was set near the Solar One building in Stuyvesant Cove Park. In order to prevent wave damage to the miniTROLL® unit over the course of the survey, a 2-inch slotted PVC standpipe was secured to the fence at the edge of the bulkhead and the miniTROLL® was placed at a depth of 13.5 ft (from the top of the guardrail) inside the standpipe. The cable connected to the miniTROLL® was secured to the well cap used to cover the standpipe to prevent slippage. Excess cable was folded down and threaded back into the standpipe.

Removal of the miniTROLLs® occurred between 06:40 and 07:40 on June 9, 2006. Prior to stopping the test, the miniTROLLs® were connected to a pocket PC, the test data downloaded, and a final reading of temperature and water level was recorded for each well and the river. Data from the miniTROLL® placed in 21MW06D was downloaded following its return to Pine Environmental due to an elastomer connection problem encountered while trying to download the data.

The results of the tidal survey are presented in Subsection 4.5.1. The tidal survey raw data are provided in Appendix F.

3.11 Aquifer Conductivity Testing

Aquifer conductivity testing was performed at the site by conducting slug tests at five locations: 21MWS03/DD03, 21MWS08/D08/DD08, 21MWS09/D09, 23MWS12/DD12, and EBMW13D. Aquifer conductivity testing was performed in general accordance with the RI Work Plan. The shallow (S-series) wells were stressed using a weighted PVC slug since the water table was within the screened interval and the intermediate (D-series) and deep (DD-series) wells were stressed with a pneumatic pressure device. Each well in the cluster was stressed separately and water levels were allowed to equilibrate between tests. Each test was repeated between two and four times in each well following return to equilibrium levels. Water levels were monitored in the well being stressed and the adjacent wells in the cluster, except 21MWD03 and 23MWD12 which contained NAPL.

The conductivity data were logged and recorded using miniTROLLs® and downloaded to a pocket PC and then transferred to office computers. The data were analyzed by the Bouwer and Rice method (1989) to calculate aquifer hydraulic conductivity values for each depth interval within the overburden aquifer. The aquifer conductivity test data and evaluation are compiled and presented in Appendix G and discussed in Subsection 4.5.2.

3.12 Soil Gas Sampling and Analysis

Soil gas samples were collected from eight locations along the northern, western, and southern boundaries of the site during the 2006 RI field activities in general accordance with the RI Work Plan. Of these eight samples, five were collected in OU1. The OU1 soil gas sample locations are illustrated on Figure 3-1. Soil gas samples were collected following utility clearance processes. Two outside ambient air samples were collected from the breathing zone during the soil gas sampling activities. Following apparatus set-up and purging procedures using a helium shroud, soil gas samples were collected over a one-hour period at each location using Summa canisters. The soil gas and outdoor air samples were shipped via overnight courier service under chain-of-custody protocol to Air Toxics Limited, Inc. (Air Toxics) of Folsom, California. The samples were analyzed for VOCs and other parameters by USEPA Method TO-15. Table 3-6 provides a summary of the OU1 soil gas sample designation, date, depth, collection method, rationale, and analyses for the soil gas samples collected during the RI. The anticipated depth of sample collection in the 2006 RI work plan was modified in the field based on perched water conditions at some locations. Additionally, the sample planned for the 23GH102 location was shifted westward to the 23GH101 location due to perched water conditions which caused water to be entrained in the sample. The OU1 soil gas results are discussed in Subsection 5-7. The soil gas results for the samples collected in OU2 will be presented in the OU2 RI report.

3.13 Analytical Program

3.13.1 Chemical Analyses

The majority of the soil and groundwater samples collected during the 2006 RI were analyzed for:

- VOCs by USEPA SW-846 Method 8260B
- SVOCs by USEPA SW-846 Method 8270C
- Metals by USEPA SW-846 6000/7000 Series
- Total cyanide by USEPA SW-846 Method 9012A
- Available cyanide by USEPA MCAWW 1277

These analyses, except for available cyanide, were performed by Chemtech in accordance with NYSDEC Analytical Services Protocol (ASP). Available cyanide analyses were performed by Severn Trent Laboratories, Inc. (STL) of Pittsburgh, Pennsylvania.

A subset of groundwater samples collected from monitoring wells EBMWDD18, 23MWDD12, and 21MWDD03 were analyzed under a quick-turnaround time frame for VOCs only using USEPA SW-846 Method 8260B by New England Testing Laboratories of North Providence, Rhode Island.

The groundwater samples collected for intrinsic bioremediation or monitored natural attenuation (MNA) parameters including nitrate, sulfate, sulfide, total iron and manganese, dissolved iron and manganese, alkalinity, dissolved gasses (nitrogen, oxygen, methane, carbon dioxide) were analyzed by Microseeps, Inc. of Pittsburgh, Pennsylvania.

The soil gas and ambient air samples collected during the RI were analyzed for VOCs plus naphthalene, 2-methylpentane, isopentane, 2,3-dimethylpentane, isooctane, indene, indan, thiophane, and helium using USEPA Method TO-15. These analyses were performed by Air Toxics.

Based on the results of the 2006 RI and the 2004 SCS, the majority of the soil and groundwater samples collected during the 2008 RI were analyzed for:

- VOCs by USEPA SW-846 Method 8260B
- SVOCs by USEPA SW-846 Method 8270C

These analyses were performed by Chemtech in accordance with NYSDEC Analytical Services Protocol (ASP). The groundwater samples collected for intrinsic bioremediation or monitored natural attenuation (MNA) parameters were analyzed by Microseeps, Inc. of Pittsburgh, Pennsylvania.

3.14 Management of Investigation-Derived Waste

The management of IDW was performed by RETEC and ENSR/AECOM field personnel during the RI activities at the site. Waste generated during the RI included soil cuttings, decontamination fluids, groundwater purge and development water, and construction and debris material (C&D), including personal protection equipment (PPE). All of the waste was containerized in either closed-top (liquid) or open-top (soil and C&D) 55-gallon drums. The drums were collected at the end of each day and transported to the equipment storage area underneath FDR Drive. Drums were labeled and composite samples were collected for waste characterization analysis by Chemtech. Samples submitted to the laboratory for analysis were requested for a 5-day turnaround time to expedite disposal. Clean Earth of North Jersey, Inc. provided transport and disposal of the drums.

A field log was developed and maintained to keep track of the number of drums, waste type, and designation. Table 3-7 provides a summary of the date, manifest number, and the total number and type of drums included on the manifest for the waste that was generated and disposed during the RI field activities. The waste generated during the investigation was separated as per waste profiling with the transport/disposal facility (Clean Earth of North Jersey, Inc.). The manifests for the IDW are located in Appendix H.

3.15 Survey of Remedial Investigation Sampling Locations and Basemap Development

The 2006 RI sample locations were surveyed by a surveyor licensed in the State of New York. The 2006 RI sample locations were tied into the site map prepared by H&A during the SCS. That map is based on the Borough of Manhattan Vertical Datum which is equivalent to +2.75 United States Geologic Survey (USGS) Vertical Datum of 1929. Elevations were surveyed to the nearest 0.01 foot. The SCS site map was developed from surveys conducted by Leonard J. Strandberg & Associates, Inc., Freeport, New York in 2002 on behalf of Mathews-Nielsen Landscape Architects, New York, New York and Rose Associates (Strandberg, 2002). The 2006 RI locations were tied into the site plan using coordinates provided for previously installed monitoring wells, fixed utility locations (lights), and buildings on the Peter Cooper Village property. Surveyed property features were referenced to the Borough of Manhattan Horizontal Coordinate System.

The 2008 RI sample locations were surveyed by Geod, Inc. These locations were surveyed in the 1983 North American Datum (NAD 83) Long Island Lambert Zone of the New York State Plane Coordinate System and were referenced to the 1988 North American Vertical Datum (NAVD88). 2006 RI boring logs were revised to reflect these datums. A table was generated for previous investigation boring logs (2004 SCS borings and Langan borings) which presents the Manhattan Borough Datum coordinates and corresponding Long Island Lambert (NAD83) and NAVD88 coordinates. This table is presented before the 2004 SCS boring logs in Appendix B.

3.16 Subsurface Utility Evaluation

After the 2006 intrusive fieldwork was completed, RETEC compiled all of the available service utility maps to mark the location of underground utilities on the site and surrounding public streets. The purpose of this work was to evaluate utilities as migration pathways for subsurface impacts. Service utilities included are water mains, electrical ducts, gas mains, sewer drain, storm sewer, telephone lines, fiber optic cables, and steam mains. In addition to the utility location program undertaken in anticipation of invasive activities, several site visits by RETEC personnel were performed to evaluate site utilities.

The utility plates used during the investigation were combined with the utility plan developed during the SCS and is presented in Figure 3-2. However, while the utility locations shown were estimated based on the available information, the majority could not be field verified. Given the age/nature of utility systems and the records in this area, additional utilities not shown on the records may exist and some information shown may be inaccurate. It is recommended that a localized utility investigation be performed prior to design of invasive remedial measures. This would likely be performed as part of a pre-design investigation.

The utility map illustrates one line for multiple diameter mains for a service line, for visual reference only. Due to the size and nature of the utility records for this area, detailed utility drawings are not provided in this document; however, a copy of all utility drawings used in this investigation is available upon request from either Con Edison or ENSR/AECOM.

The depths of impacts were compared to the depths of the service utilities. The investigation looked at various depth intervals to see pathways of the impacts. The chosen depth intervals were 0 to 10 ft, 10 to 20 ft, and 20 to 40 ft. The service utilities were divided out in these intervals according to their depths.

3.17 Oil Water Underdrain System Investigation

ENSR/AECOM conducted an evaluation of a proposed oil water underdrain system as part of the 2008 RI of OU1. The evaluation was conducted on May 2, 2008, May 14, 2008, May 15, 2008 and May 28, 2008 to look for evidence of an oil water underdrain system that may have been installed on the Peter Cooper Village property and to evaluate whether MGP-related impacts are seeping into the site sewers.

The evaluation included visual inspection of manholes and drains within the areas of the site where the drains would most likely have been installed based on the design plan of the proposed underdrain system and areas of shallowest MGP-related impacts. Figure 3-3 illustrates the proposed oil water underdrain system, storm sewers, manholes, yard drains, environmental investigation locations and water valve replacement excavations in the eastern portion of OU1. Video inspection footage was collected along the eastern portion of the 48-inch circular, brick, storm sewer line that extends from 22nd Street eastward and along the 36-inch circular, concrete drain running from the northwest corner of Building No. 9 eastward across the site. Video inspection was performed by National Water Main Cleaning Company (NWMCC) under the direction of ENSR/AECOM personnel using a combination of crawling and floating cameras. Footage was recorded on DVD's, photographs were taken as requested by ENSR/AECOM personnel, and inspection reports were generated by NWMCC per section between manholes (MH). The results of the investigation are discussed in Subsection 4.2 of this report.

4.0 Field Investigation Results

This section presents a summary of the field measurements and observations made during the RI and the SCS of OU1 of the East 21st Street Site Works former MGP site. Included is a discussion of the topography and drainage, geology, and hydrogeology of the Site.

4.1 Regional Geology

The site is located on the southern end of the Manhattan Prong, a northeast-trending, highly eroded sequence of metamorphosed schists and gneisses, within the Taconic Sequence (or Hartland Formation). The Taconic Sequence consists of aluminum-rich schists, including the Manhattan Schist, granofels, and metavolcanic rocks previously deposited on the ocean crust and subsequently accreted onto North America during the Medial Ordovician Taconic orogeny (Merguerian, 1996). The structurally highest, upper schist unit in the Manhattan Schist is predominantly gray-weathering, fine- to coarse-grained, well-layered muscovite-quartz-biotite-plagioclase-kyanite-garnet schist, with some gneiss, thin- to massive granofels, and cm- and m-scale layers of greenish amphibolite and garnet (Merguerian, 1996). This unit, underlying most of the southern half of Manhattan, is lithologically identical to the Cambrian and Ordovician Hartland Formation found in western Connecticut and Massachusetts.

According to the SCS report (H&A 2004), Baskerville's bedrock and engineering geologic map (1994) indicates that the site is situated on the eastern side of an anticline axis between the eastern and western faults that bound Cameron's Line, a major regional northeast-trending fault that exhibits complex structural geology. The bedrock strike of the anticline is expected to be approximately north-northeast and the dip direction is expected to be approximately south-southeast.

4.2 Topography and Drainage

The general topography of the site is relatively flat, but slopes towards the east as indicated on Figure 4-1. During a rain event, infiltration is absorbed into the green space across the site. Surface runoff not absorbed is directed to storm sewer curb inlets. The drainage system is comprised of an intercept sewer, trunk storm sewer lines, smaller local storm sewer lines, curb inlets, and wet weather overflow outfalls.

The storm sewer system is comprised of curb inlets that drain to the smaller local lines which in turn discharge to the larger trunk lines. The trunk lines and smaller storm lines form a complex web of storm drain lines that ultimately discharge to the intercept sewer under dry weather conditions. The intercept sewer discharges to the Newtown Creek waste water treatment plant, which discharges treated wastewater to the East River.

The intercept sewer is 108 inches in diameter and appears to flow south down First Avenue, east on 20th Street, and then south again on Avenue C. As it passes the site, storm and sanitary sewer lines drain into it.

During wet weather events overflow chambers allow local storm water to flow to the East River at three outfall locations adjacent to the site rather than to the intercept sewer. The ratio of storm water discharge to outfalls and the intercept sewer is unknown; however, it is likely that the bulk of the local storm water discharges to the outfalls adjacent to the site during heavy precipitation events. The outfalls are permitted under the New York State Pollution Discharge Elimination System (NYSPDES) permit #00262004. The outfall identification numbers and locations are located on Figure 3-2. From observations during several precipitation events the system appears effective at controlling runoff.

The majority of the known subsurface utilities are located in the 0 to 10 ft depth range, except for the 108-inch intercepting sewer that is included in the 20 to 40 ft depth range, with a noted depth of 25 to 35 ft bgs, and several of the storm sewer overflow lines in the 10 to 20 ft depth range. Given the depth of the water table and the known impacts, it is unlikely that significant preferential migration is currently occurring through any of the shallow utilities or utility bedding. The 10 to 20 ft depth storm sewer overflow lines may present a potential migration pathway; however, given the torturous path from the Site to the river, it is unlikely. The deeper sewer interceptor does not appear to traverse significant MGP-related impacts and therefore is not a likely preferential pathway.

4.2.1 Oil Water Underdrain System Investigation

An evaluation was conducted on May 2, 2008, May 14, 2008, May 15, 2008, and May 28, 2008 to look for evidence of an oil water underdrain system that may have been installed on the Peter Cooper Village property and to evaluate whether tar-like material (TLM) or oil-like material (OLM) are seeping into the sewers.

An underdrain system consisting of gravel encased porous 8-inch concrete piping was designed for installation in oil contaminated areas throughout the eastern portion of the site prior to Peter Cooper Village construction/development. Appendix I contains a copy of the underdrain system plan that was prepared for the Peter Cooper Village Board of Design by Clarke, Rapuano & Holleran in 1947 and illustrates potential locations and construction details of the underdrain system, including that the drains should generally be placed 5 to 7 ft below finished grade. The plan notes that the underdrains will only be installed at locations specified by a representative of the Metropolitan Life Insurance Company (Met Life) and a handwritten note states that red lines on the drawing indicate the first recommendation for installation of the porous tile drainage. However, the plan is black and white and the recommendations are not evident.

The evaluation included visual inspection of manholes and drains within the areas where the drains would most likely have been installed overlapping areas of shallowest OLM/TLM impacts. The inspection consisted of two phases; Phase 1 was a visual inspection of the manholes/yard drains from the surface and Phase 2 was a video camera inspection of each of the pipes entering or leaving manholes.

The evaluation program focused on the areas of the system indentified in Figure 1 of Appendix I. Each manhole and yard drain was given a unique identification in Figure 1 of Appendix I. Table 1 in Appendix I references the specifics of the drainage system. A photo log of the inspection program is included in Appendix I as well.

4.2.1.1 Phase 1: Manhole Visual Inspection

Field observations from each manhole are included in Appendix I. All manholes are associated with either a 48-inch circular, brick, storm sewer line that extends from 22nd Street eastward across the site or a 36-inch circular, concrete, storm drain that extends from the northwest corner of Building No. 9 eastward across the site. All manholes have inlets and outlets related to the main sewer line or drain line. Two manholes, manhole # 8 and manhole # 11, have tie-ins unrelated to these inlets and outlets. Manhole # 8 has an 8-inch active red, clay pipe from the northwest at a depth of approximately7 ft bgs, along with an 8-inch capped red, clay pipe from the north at a depth of approximately 7 ft bgs. Manhole #8 had a pipe that appeared to have oil-like staining on it during the initial evaluation. Video inspection was utilized to trace the northwest tie-in to yard drain # 9 and footage revealed no visible impacts. Video inspection of the north tie-in was not possible, as the pipe was capped; however, the tie-in likely originates from yard drain # 6 and is not part of an underdrain system. Manhole # 11 has an 8-inch active clay red, pipe from the south at a depth of approximately 3.2ft bgs, along with an 8-inch capped red clay, pipe from the east at a depth of approximately 4.6ft bgs. Both tie-ins to manhole # 11 are shallower than the depth range proposed for the underdrain system.

Field observations from each yard drain are included in Appendix I. Two types of tie-ins were visible in yard drains: 8-inch black, corrugated PVC and 8-inch red, clay. Clay pipes were observed at depths ranging from 4.5-5 ft bgs. Corrugated pipes were observed at depths ranging from 2-4 ft bgs. No visible impacts were observed within yard drains.

4.2.1.2 Phase 2: Video Inspection

Video inspection footage was collected by National Water Main Cleaning Company (NWMCC) under the direction of ENSR/AECOM personnel using a combination of crawling and pontoon cameras. Footage was recorded on DVDs, photographs were taken as requested by ENSR/AECOM personnel and inspection reports were generated by NWMCC per section between manholes (MH). Inspection reports are included as Appendix I.

Footage was taken between manhole # 1 and manhole # 5 along the 48-inch circular, brick, storm sewer line that extends from 22nd Street eastward. There are 20 tie-ins between manhole # 1 and manhole # 2 of which five are active and the remaining are capped. The location of tie-ins is summarized in Table 1 of Appendix I. All tie ins between manhole # 1 and manhole # 2 are at the water level (18-24inches) except the tie-in located 23.5 ft into the segment and the tie-in located 40.1 ft into the segment, which enter the pipe two-thirds of the way up the wall. There is also a pipe crossing the ceiling of the sewer pipe at 30.4 ft into the segment. Other notable features in this section include plant material at 56.2 ft into the segment. No visible impacts were observed in this section.

There are four tie-ins between manhole # 2 and manhole # 3, two of which are active. Tie-ins are at the water level (4.2 ft, 9.6 ft), in the ceiling of the pipe (26.8 ft) and two-thirds of the way up the wall (54.9 ft). Other notable features in this section include wall deposits (20 ft into segment), concrete (29.6 ft into segment) and missing mortar (53 ft into segment). Toward the end of the section the sewer line takes a bend to the left. No evidence of OLM or TLM was visible in this section.

There is one tie-in between manhole # 3 and manhole # 4 (4.1 ft into segment). The tie-in is active and enters the sewer two-thirds of the way up the wall. Other notable features in this section include plant material located 11.8 ft into the segment and exposed wood on the pipe wall located 16.3 ft into the segment. Toward the end of the segment the sewer line changes material and shape to a 48-inch concrete square pipe.

There are three tie-ins between manhole # 4 and manhole # 5, two of which enter the pipe two-thirds of the way up the wall (31.9 ft and 55.4 ft into segment) and the other from the top of the pipe (93.2 ft into segment). The tie-in at 31.9 ft is the only active tie-in of the segment. This segment has some cracks (2.8 ft and 81.7 ft into segment), exposed wood (10.3 ft into segment), patches of erosion (40.1 ft into segment), and black sealant material (81.7 ft and 103.4 ft into segment). However, no TLM or OLM was observed with these features or in any portion of the segment.

The segment between manhole # 5 and manhole # 6 was not examined because access was not possible through manhole # 5 or manhole # 6 because the camera clearance was exceeded by the water level. Footage was taken between manhole # 8 and manhole # 12 along the 36-inch circular, concrete drain running from the northwest corner of Building No. 9 eastward across the site. There are three tie-ins between manhole # 8 and manhole # 7 (8.6 ft, 42.3 ft and 47.6 ft into the segment) entering the pipe two-thirds of the way up the wall. All of the tie-ins are capped. Footage of this and other segments in the drain pipe includes an examination of each joint. Joints are spaced 3 ft apart and sealed with a black material. All joints had integrity, except the joint located 75.2 ft into the segment from MH#7 to MH#10. The joint at that location shows visible infiltration with a mound of deposition. There was no evidence that this or any other joints in the drain line are a migration pathway for OLM or TLM.

There are three tie-ins between manhole # 7 and manhole # 10 (25.4 ft, 42.5 ft, and 45.5 ft into the segment) entering the pipe two-thirds of the way up the wall. The tie-in located 25.4 ft into the segment is capped; where as the remaining tie-ins are active. Other notable features in this section include plant material at 100 and 114.4 ft into the segment and an infiltration mound located 75.2 ft into the segment as discussed previously. No visible impacts were observed in this segment.

There are two tie-ins between manhole # 10 and manhole # 11 (140.2 ft and 143.8 ft into the segment) that enter the drain line two-thirds of the way up the wall. Both tie-ins are active. Other notable features in this section include plant material located 18 ft, 129.1ft and 148.9 ft into the segment. No visible impacts were observed in this segment.

Footage of the segment between manhole # 11 and manhole # 12 is incomplete. Footage was first attempted via access through manhole # 11. However, an obstacle was encountered 37 ft into the pipe. There are no notable features in the resulting footage. Footage was then attempted through manhole # 12, but an obstacle was encountered at 24.3 ft. In this segment plant material was observed 9 ft, 11.2 ft and 19 ft into the segment. No OLM or TLM was observed in the inspected portions of the pipe between manhole # 11 and manhole # 12.

Drain line footage was attempted from manhole # 12 toward the river (manhole # 13), however, an obstacle was encountered during the inspection at 11.1ft that prevented further footage. No tie-ins are present in this portion of the line. This segment had several joints with plant material (7.1 ft and 9.4 ft into the segment). No visible impacts were observed in the 11.1 ft that were inspected.

Video footage of the inspection work is available and can be provided to interested parties.

In general a storm drainage system typical of an urban environment was encountered during the above work. A variety of pipe types, sizes, ages and configurations were encountered. In several areas of the system tar seals were used in the original construction of the system. This was typical construction for gravity flows systems built in the early to mid 20th century. The tar seals are noted in several of the photos in Appendix I. The site drainage and sewer system appears intact and to be functioning well.

In addition to the above inspection work Con Edison and its contractors have advanced 156 soil borings, 28 monitoring wells and 47 test pits (environmental and water valve) in OU1. In none of these cases was the oil water underdrain system or anything resembling it encountered. Discussions with property owner's maintenance personnel have also failed to turn up any evidence of the oil water underdrain system.

Given the lack of evidence found during inspection of the storm drain and sewer systems on the site, as well as years of invasive activities, it is unlikely that if installed, the oil water underdrain is currently acting as a migration pathway. ENSR/AECOM was unable to confirm the installation of the oil water underdrain system.

4.3 Site Geology

Information concerning the site stratigraphy and hydrogeology were obtained from observations made during the installation of RI soil borings and monitoring wells and from the SCS Report (H&A 2004). Seven geologic cross sections (A-A' through G-G') were developed based on boring log data. The geologic cross section locations are illustrated on Figure 4-2 and the cross sections are provided on Figures 4-3 through 4-9. Boring logs and well construction diagrams on which these cross sections are based are provided in Appendix B.

As shown on the boring logs and cross sections, the site geology generally consists of five units from ground surface downward including:

- Fill
- A layer of organic clay, silt, and/or peat
- A silty sand unit with varying amounts of silt and clay
- A unit of dense silt, sand, and gravel
- Bedrock

The site geology was described in detail in the SCS Report (H&A 2004) by depositional environment. The RI borings encountered subsurface material consistent with that described in the SCS Report. As such, much of the geologic information below is excerpted from the SCS report with additional detail or modifications provided from observations made during the RI field activities.

4.3.1 Fill Unit

The fill material beneath the site typically consists of intermixed sand, silt, and gravel with varying amounts of wood, brick, concrete, boulders, ash, cinders, glass, and metal fragments and pieces. Clinker-like material and ash-like material were occasionally observed in the samples.

The depth of fill at the site ranged from approximately 6 ft near First Avenue to 43 ft in former gas holder #7 in the southwestern portion of the site. In general, the fill depth is shallow in the western portion of the site near First Avenue and deep to the east towards the East River, with the exception of locations with deep subsurface foundations or deep construction-like gas holders. Fill in the western portion of the site likely reflects man-made disturbances to pre-existing natural soils from historical building construction along First Avenue.

The soils further east of First Avenue seem to reflect bulk filling activities that progressed into and over former intertidal areas of the East River to create land, as indicated by the frequent presence of an organic soil horizon below the fill material. The depth of the fill increases to the east across the site and generally ranges from 6.5 to 17 ft bgs between First Avenue and former Avenue A, and between 18 and 33 ft bgs between former Avenue A and Avenue C. Except for the fill associated with gas holder #7, the deepest fill zones were encountered in the northeast portion of the former MGP site in the vicinity of the former drip/oil tanks and retorts. This progression of increased fill thickness to the east is evident on cross sections A-A', B-B', D-D', E-E', and G-G′.

As noted in the SCS report, an upper layer of fill, approximately 5 feet thick, was observed over the majority of the site and appears to represent fill material imported to the site during the construction of Peter Cooper Village to re-grade the property and prepare it for landscaping. The upper fill unit was generally distinct from the deeper, lower, MGP-impacted fill and native soil. The difference was based on appearance (red brown sands with minor silt and gravel), general absence of significant quantities of construction debris (such as metal, wood, brick, ash, concrete, or cinder), very limited observations of discrete MGP or other commingled impacts (i.e., stained soils discoloration, significant odors, hardened TLM, clinker-like material, or tarry material), and the absence of significantly elevated PID readings.

4.3.2 Organic Clay, Silt, and/or Peat Unit

Organic soils consisting of clay, silt and occasionally peat, were frequently encountered beneath the fill, generally between approximately 11 and 34 ft bgs, and where present varied in thickness from 0.5 to 20 ft. The organic silt and clay were generally described as soft to very soft, brown to black, and occasionally containing organic peat, plant fibers or shell fragments, and exuding a hydrogen sulfide odor.

Due to the filling activities in some areas of the site, the organic deposits are missing or appeared substantially disturbed, such that they were considered part of the overlying fill material. In these areas, the top of the organic clay unit is shown as a dashed line on cross sections B-B′ and D-D′. Sometimes the organic soil was described as gray to brown silty sand, occasionally containing shell fragments and could be associated with estuarine deposits. The organic soil is illustrated on the various cross sections as organic clay, clay, silt and clay, and peat.

A relatively thick, fairly continuous section of organic materials (organic clay, sand and clay, silt and sand, and silt and clay) are illustrated in the western portion of the site, beneath the former gas holder area, and are in contrast to the relatively thin and discontinuous layer(s) of organic material in the eastern portion of the site where thicker fill zones were encountered in the vicinity of the drip/oil tanks and retorts and coal houses, on cross sections A-A', B-B', and C-C′. On the western side of the site, along First Avenue where shallow bedrock was encountered, the organic material is essentially absent except at one boring, 21FA102B, where a thin lens of clay was noted as illustrated on cross section F-F'.

4.3.3 Silty Sand Unit

The silty sand unit encountered beneath the site is typically red brown to gray fine sands, silty fine sands, and sandy silts with occasional clay laminations or thin clay layers. These deposits are interpreted to be glaciolacustrine in origin and were generally encountered between 18 and 43 ft bgs and extended to a depth of approximately 150 ft bgs at boring 21BR08B in the central/western portion of the site and approximately 120 ft bgs at boring 21OT001C in the eastern portion of the former MGP site. These sediments are interbedded and lensed throughout the site. However, there is a slight trend of sandier sediments in the west and finer grained more silty sediments in the east, especially deeper in the sequence, based on a review of cross sections B-B', and D-D'. There also appears to be a trend of finer grained sediments at depth as illustrated on cross sections D-D', and E-E.

4.3.4 Dense Silt, Sand, and Gravel Unit

At the deep boring locations, more dense silt, sand, and gravel materials were encountered beneath the silty sands and overlying bedrock. These deposits are considered to be glacial fluvial or glacial till in origin and were encountered in SCS borings 21GH027A (113.5 ft bgs), 21BR001 (116.6 ft bgs) and 21OT001C (120.0 ft bgs); and RI borings 21GH101B (92 ft bgs), 21GH102B (46 ft bgs), 21GH103B (79 ft bgs), 21GH104B (116 ft bgs), and 21BR08B (146 ft bgs).

4.3.5 Bedrock

Four borings were drilled to the top of bedrock (21GH101B through 21GH104B) and four borings were cored into bedrock (21FA102B through 21FA105B) during the 2006 RI. Four borings were drilled to the top of bedrock (21BR04B, 21BR06B, 21BR07B, and 21BR08B) and four borings were cored into bedrock (21BR01B, 21BR02B, 21BR03B, and 21BR05B) during the 2008 RI. Several borings advanced during the SCS encountered bedrock along the western portion of the site and three borings were advanced to the top of bedrock (21GH027A, 21BR001, and 21OT001C). In addition, several borings were drilled to the top of bedrock by the Giles Drilling Corporation for Starrett Brothers and Eken in the mid-1940s in support of constructing the Peter Cooper Village Complex (New York City Building Department). These historic boring logs were reviewed and the elevation of the top of bedrock data were used in conjunction with the RI and SCS boring data to generate the top of bedrock contour map illustrated on Figure 4-10.

As illustrated on Figure 4-10 and cross sections A-A′ and B-B′, the top of bedrock dips steeply from an elevation of approximately 10 ft above NAVD88 at the western edge of the site along First Avenue eastward, towards the East River to an elevation of approximately -118 ft NAVD88 near Avenue C. The top of the bedrock surface dips more steeply in the western portion of the site and more gently in the eastern portion of the site. There appears to be a depression in the top of the bedrock surface in the western portion of the Peter Cooper Village property at boring HB-12 where the top of bedrock was encountered at an elevation of approximately -148 ft NAVD88. The bedrock surface east of this depression is relatively flat and gently rises to the east-northeast from an elevation of approximately -130 to -100 ft NAVD88. In the southeastern portion of Peter Cooper Village, it appears that the top of the bedrock surface is also relatively flat and gently rises to the northwest from an elevation of approximately -125 to -100 ft NAVD88.

The rock mass classification of the bedrock cores was based on the Rock Quality Designation (RQD), which is defined as the sum of the cumulative length of core pieces longer than 0.33 ft divided by the total length of the core run. The total length of the core run includes all lost core sections, however, any mechanical breaks caused by the drilling process or in extracting the core from the core barrel are ignored in the calculation. A calculated RQD of <25% is classified as very poor, 25-50% is poor, 50-75% is fair, 75-90% is good, and 90-100% is excellent. RQD is used as a standard parameter in drill core logging and has been used to identify low-quality rock zones. The eight bedrock cores taken during the 2006 and 2008 investigations had RQDs ranging from 13 to 100%, very poor to excellent, with the majority of the “very poor” classification coming in the upper part of the bedrock. The general trend was towards a classification of “excellent” with depth, indicating fewer fractures and bedrock fragments with depth. Bedrock is discussed further in the OU3 RI Report.

4.4 Regional Hydrogeology

There are no surface water bodies located on the site. The East River is the closest surface water body to the site and is approximately 300 feet east/northeast of the eastern boundary of the former MGP. The East River is classified by the NYSDEC as a Class I saline surface water which is used for ship traffic, but not contact recreational purposes. Class I saline surface waters are also designated for fishing, however, numerous New York State Department of Health (NYSDOH) health advisories exist for consumption of fish caught in the East River. The west shoreline of the East River in the vicinity of the site is listed in the National Wetlands Inventory (Langan, 2002).

The NYSDEC groundwater classification for the site area is GA (aesthetic – fresh waters). The regional groundwater flow is assumed to mimic the area surface topography which slopes gently from the west to the east-northeast. The East River is tidally influenced and has measurable effects on adjacent groundwater elevations. Depending on the tide, the East River may recharge the unconfined overburden aquifer or the aquifer may discharge to the river.

The site area receives city-supplied drinking water which is supplied by upstate reservoirs.

4.5 Site Hydrogeology

Twenty-one monitoring wells were installed during the 2006 RI, six monitoring wells were installed during the 2008 RI, and 20 monitoring wells were installed during the SCS to evaluate groundwater conditions at the site. Table 4-1 provides a summary of the monitoring well designations, installation dates, screened intervals, top of casing elevations and groundwater elevation measurements. In addition to the 47 monitoring wells installed as part of the environmental investigation of the former MGP site, four monitoring wells, installed as part of separate investigative and remedial actions within Stuyvesant Cove Park, were monitored during the RI and are included on Table 4-1.

One unconfined, unconsolidated overburden aquifer was encountered beneath the site during the investigations. Although a discontinuous and varying thickness organic clay/silt unit was frequently encountered beneath the site, a confining unit within the unconsolidated sediments above the bedrock is not present with the possible exception of the basal till unit encountered in deep borings above the bedrock surface. This inference is based on the density and lack of notable impacts of this material compared to shallower soils.

As illustrated on Table 4-1 the monitoring wells are screened at three general depth zones within the unconfined overburden aquifer beneath the site. The shallow zone wells (S-series) are generally screened between approximately 5 and 15 ft bgs. The intermediate zone wells (D-series) are generally screened between approximately 25 and 35 ft bgs. The deep zone wells (DD-series) have 10-foot screened intervals generally situated between 50 and 70 ft bgs. No deep, DD-series wells were installed during the SCS. The four Stuyvesant Cove Park monitoring wells (LR02, LR08, LR11, and LR17) are shallow series wells and were used to provide shallow groundwater data in the vicinity of intermediate and deep wells installed during the 2006 RI.

Water level data collected on April 19, 2004 during the SCS, May 4 and June 12, 2006 during the 2006 RI, and on September 24, 2008 during the 2008 supplemental RI were converted to groundwater elevations using surveyed well elevations and are presented on Table 4-1. Groundwater elevation contour maps for the April 19, 2004 measurement event are presented in the SCS report (Figures 7 and 8). Groundwater elevation contour maps for the shallow, intermediate, and deep zones for the May 2006, June 2006, and September 2008 groundwater measurement events are illustrated on Figure 4-11.

As illustrated on this figure, groundwater flow direction in all three overburden aquifer zones is to the east-northeast towards the East River. Occasionally, it appears that tidal affects (discussed in Subsection 4.5.1) on groundwater levels may result in groundwater elevations that cause elevation contours to bend sharply and somewhat unrealistically as illustrated on the panels for the June 2006 and September 2008 intermediate zone. The groundwater elevation for monitoring well 21MWS10 in September 2008 was anomalously high and was not used to generate the groundwater elevation contours on the September 2008 shallow zone panel of Figure 4-11.

Horizontal hydraulic gradients for the three aquifer zones were calculated for the May 4, 2006, June 12, 2006, and September 24, 2008 gauging events. For the shallow zone, three flow paths perpendicular to groundwater flow were selected including the path between 21MWS01 and 23MWS12, the path between 21MWS06 and LR08, and the path between 20MWS16 and 21MWS05. Horizontal hydraulic gradients along these paths ranged between 0.0028 ft/ft to 0.0076 ft/ft. The average horizontal gradient for both the May and June 2006 gauging event was 0.006 ft/ft, and for the September 2008 gauging event was 0.004 ft/ft. The data show little variation over time.

For the intermediate aquifer zone, three flow paths were also selected, including one path between wells 21MWD01 and EBMWD13, one between 21MWD02 and EBMWD14, and one path between 20MWD16 and EBMWD15. Horizontal hydraulic gradients along these paths ranged between 0.0008 ft/ft to 0.005 ft/ft. The average horizontal gradient for both the May and June 2006 gauging events was 0.002 ft/ft and for the September 2008 gauging event was 0.003 ft/ft. and are less than the shallow aquifer zone horizontal hydraulic gradients. Similar to the shallow zone, the horizontal hydraulic gradient data in the intermediate zone were relatively consistent over time.

In the deep aquifer zone, one flow path crossing the entire site was selected between well 21MWDD08 and EBMWDD13. The horizontal hydraulic gradient for both the May and June 2006 events were 0.0027 ft/ft and 0.0030 ft/ft, respectively, with an average of 0.0029 ft/ft. The horizontal hydraulic gradient for the September 24, 2008 event was 0.0028 ft/ft.

The vertical hydraulic gradient between the shallow and intermediate zones is generally downward in the western portion of the site and upward near the East River, as is evident from the groundwater elevations provided in Table 4-1 and the vertical gradient summary table presented on Table 4-2. This finding is consistent with a conceptual model showing groundwater discharge to the East River in the absence of tidal influence. The vertical gradient between the intermediate and deep zone wells is small and inconsistent between measurement events. The vertical gradient is greater between the shallow and intermediate zones than it is between the intermediate and the deep zones, and wells in the western portion of the site show a steeper gradient than the wells in the eastern portion of the site.

Specifically, the vertical gradients were downward between all shallow and intermediate well pairs with the exception of the two well pairs (23MWS/D12 and 21MWS/D05) located closest to the East River. Downward vertical gradients were consistent between gauging events and ranged between 0.05 ft/ft to 0.33 ft/ft. Vertical gradients in the shallow to intermediate zone are more than one order of magnitude greater than the average horizontal gradient in the shallow and intermediate zones. Between the intermediate and deep aquifer zones, vertical gradients showed more variability over time and were lower in magnitude, ranging between 0.00 ft/ft to 0.08 ft/ft. Compared to horizontal gradients in both the intermediate and deep zones, the vertical gradients were consistent at the low end and higher by approximately one order of magnitude on the high end of the range. Combined, the overall findings are consistent with a conceptual model showing intermediate groundwater recharge from shallower zones across the central portion of the site, with a transition of intermediate to shallow recharge near the eastern site boundary with ultimate discharge to the East River. Tidal influence and good hydraulic connection between zones are suspected to be the main reasons why vertical gradients shift between upward and downward in some well pairs, particularly 23MW12S/D and the intermediate and deep zone well pairs (Table 4-2).

4.5.1 East River Tidal Influence on Groundwater Elevations

A tidal survey was conducted in 14 wells and the East River to assess the extent of tidal influence on unconfined aquifer groundwater elevations at the site. The water level and temperature were measured using an *In-Situ* miniTROLL® placed within the screened section of the wells over roughly a 52 hour period. Data charts illustrating groundwater elevation fluctuations relative to tidal fluctuations are shown on Figure 4-12. Tidal survey data are compiled in Appendix F.

The well points used during the tidal survey are color-coded by depth interval on Figure 4-12; the shallow well points (S-series) are colored green, the intermediate well points (D-series) are colored blue, and the deep well points (DD-series) are colored red. Tidal influence was measured in nine of the 14 wells surveyed. As illustrated on Figure 4-12, groundwater elevations are influenced by tidal fluctuations in the shallow, intermediate, and deep unconfined aquifer zones. The tidal influence was observed furthest away from the river (approximately 950 ft) in the deep wells. The influence of tidal fluctuations on shallow groundwater elevations was not observed further than approximately 50 ft west of the East River. Tidal influence in the shallow aquifer is likely limited by the sea wall construction along Stuyvesant Cove Park. Tide fluctuations were not observed in the intermediate unconfined aquifer zone further than approximately 300 ft west of the East River.

The average time lag for observing a change in groundwater elevation relative to a change in tide was calculated for each well where tidal influences were measured and is summarized in the table below.

Well ID	Distance due West of East River (feet)	Average Time Lag	Average Magnitude of Change (feet)
23MWDD20	470	179 min.	0.337
EBMWDD13	72	37 min.	1.597
23MWDD12	228	79 min.	0.922
23MWDD03	950	252 min.	0.124
21MWD05	222	84 min.	0.841
EBMWD18	42	54 min.	1.076
EBMWD13	60	49 min.	1.422
LR02	48	119 min.	1.102
LR08	36	141 min.	0.451

As expected in the deep and intermediate wells, the average time lag increases and the magnitude of groundwater elevation change decreases with increased distance from the river. The tidal fluctuations in the East River resulted in changes in groundwater elevations in the shallow zone ranging between 0.4 and 1.1 ft and are difficult to relate to distance from the river based on the relatively small area (within 50 ft) of the shallow zone that was influenced by the tides. The sea wall along the East River likely interferes with tidal fluctuations measured in the shallow aquifer zone.

4.5.2 Aquifer Hydraulic Conductivity and Seepage Velocity Calculations

Single well slug tests were performed at five monitoring well cluster locations: 21MWS03/DD03, 21MWS08/D08/DD08, 21MWS09/D09, 23MWS12/DD12, and EBMWD13/DD13. The data were evaluated using the Bouwer and Rice Method (1989) to estimate the hydraulic conductivity of the aquifer material. Table 4-3 provides a summary of the wells tested; the type of material within the screened intervals, the test and solution methods, and the estimated range of hydraulic conductivity values. The slug test data, recovery curves, and hydraulic conductivity calculations are provided in Appendix G.

The estimated hydraulic conductivity values for the shallow overburden aquifer zone were relatively consistent and ranged from 16.1 to 25.9 ft per day (ft/day), with a geometric mean value of 21.1 ft/day. These values are consistent with the type of material within the shallow well screened intervals which consisted of fill materials of sand, silt, gravel, and brick that are relatively permeable.

The estimated hydraulic conductivity values in the intermediate and deep zones of the unconfined aquifer varied between locations and can be explained by type of material within the screened interval. The intermediate zone estimated hydraulic conductivities ranged between 0.85 and 41.7 ft/day and reflected permeability differences between clay/silt/sand/peat units versus fine sand/sand and gravel units. The hydraulic conductivities estimated from the testing performed in the deep wells range from 0.26 to 20.92 ft/day and also reflected variation in material within the screened intervals. In general, the hydraulic conductivity values estimated for clay/silt/sand zones within the intermediate and deep zones were consistent. The lowest hydraulic conductivities were estimated for finer grained clayey sediments (23MWDD12) and the highest hydraulic conductivities were estimated for the coarse sand and gravel sediments (EBMWD13).

Water levels were monitored in the adjacent wells making up well clusters during each single well slug test. There were no measured effects on water levels in adjacent wells screened both above and below the test well during the testing events.

Groundwater seepage velocities in each aquifer zone were calculated using measured horizontal hydraulic gradients and estimated hydraulic conductivity values using a modification of Darcy's Law:

$$V = Ki/n$$

where:

V=Groundwater Seepage Velocity (ft/day)

i=Horizontal Hydraulic Gradient (ft/ft)

K=Hydraulic Conductivity (ft/day), and

n=Porosity of Aquifer Sediments.

Average horizontal hydraulic gradients (i) for the shallow, intermediate, and deep aquifer zone were 0.005 ft/ft, 0.002 ft/ft, and 0.003 ft/ft, respectively. The mean hydraulic conductivity value (K) for the shallow aquifer was 21.1 ft/day. Given the significant variability in K values noted, the range of K values for the intermediate zone was 0.85 to 41.7 ft/day, and the range of K values for the deep aquifer zone was 0.26 to 20.9 ft/day. An estimated porosity value of 30% was used for each aquifer zone, which is typical for sandy material. Using the above equation, horizontal groundwater seepage velocity within the shallow aquifer zone is calculated to be approximately 0.35 ft/day. Using the range of K values, horizontal groundwater seepage velocities for the intermediate zone range from 5.7×10^{-2} ft/day to 0.28 ft/day. For the deep aquifer zone, groundwater seepage velocities are calculated to range between approximately 2.6×10^{-2} ft/day to 0.21 ft/day.

5.0 Analytical Results and Subsurface Observations

This section presents and describes the analytical results for the soil, groundwater, and soil gas samples collected during the RI and the SCS as well as the visible MGP-related impacts noted during subsurface intrusive activities. Analytical results tables for the surface soil, upper fill soil, lower fill/natural soil, groundwater, and soil gas samples collected during the RI and the SCS are presented in the following subsections. The soil gas analytical results from previous investigations are not included in this RI report. The analytical results were compared to applicable NYSDEC guidance values or standards. The discussion is presented by environmental media following the discussion of analytical data quality and validation results.

5.1 Data Quality Evaluation

To meet the data quality objectives for this RI project, NYSDEC ASP were used and Category B deliverable packages were prepared by the laboratory for the analyses. Summary result pages from the full Category B data deliverable packages (Form 1s), including data validation qualifiers for the samples collected as part of the RI, are compiled on a compact disk included in Appendix J. During the 2006 RI, surface soil, subsurface soil, and soil gas samples were collected from January 19 to May 9, 2006 and groundwater samples were collected between May 16 and May 25, 2006. During the 2008 RI, subsurface soil and groundwater samples were collected between March and September 2008.

Comprehensive data packages were submitted by Chemtech and STL-Pittsburgh Laboratories for the soil and groundwater samples for validation by a qualified chemist. Data Usability Summary Reports (DUSRs) were prepared by RETEC and ENSR/AECOM for the soil samples and the groundwater samples. The DUSRs for this project are included in Appendix I. Data was validated according to method specifications and the *USEPA Contract Laboratory Program National Functional Guidelines for Organic Data Review*, EPA540/R-99/008, October 1999 and *USEPA Contract Laboratory Program National Functional Guidelines for Inorganic Data Review*, EPA540-R-04-004, October 2004, as they apply to the analytical methods employed.

Organic data quality was evaluated by reviewing the following parameters: holding times, GC/MS tuning and performance, internal standards, initial and continuing calibrations, surrogate recoveries, matrix spike/matrix spike duplicate (MS/MSD) samples, MS/MSD relative percent differences (RPDs), laboratory control standards (LCSs), laboratory blanks, field duplicates, compound identification, and compound quantitation.

Inorganic data quality was evaluated by reviewing the following parameters: holding times, initial and continuing calibrations, contract required detection limit (CRDL) standard recoveries, MS/MSD samples, LCSs, laboratory duplicates, Inductively Coupled Plasma (ICP) interference check sample results, ICP serial dilution results, laboratory blanks, and field duplicates.

As part of the data validation process, the laboratory report sheets and the analytical result tables were revised to include the data validation qualifiers to indicate the limits of data usability. A glossary of USEPA-defined organic and inorganic data qualifiers and their definitions are provided as notes on the analytical result tables. Overall, the data are considered to be usable and any noted data qualifications will not affect site decisions.

5.2 Surface Soil

The surface of the site is covered by 15-story apartment buildings, grass and landscaped areas, asphalt roads and walkways, concrete, cobblestones, playgrounds, and tennis and basketball courts. As noted in the SCS and observed in the RI, the surface soil and upper fill soil at the site appear generally distinct from the MGP-impacted lower fill/natural soil. Based on historical site information, the surface soils were imported to the site after the MGP operations ceased, possibly for final grading purposes during the construction of Peter Cooper Village. As concluded in the SCS Report, it is considered likely that the elevated concentrations of SVOCs, polynuclear aromatic hydrocarbons (PAHs), and metals observed in the background study surface soils and in the site surface soils are attributable to the imported fill quality, anthropogenic sources, and/or naturally occurring sources that are not related to the former MGP operations (H&A, 2004). During the 2006 RI, four surface soil samples were collected to the west, south, and east of the site to evaluate soil quality along the perimeter of the site where elevated concentrations of compounds were noted during the SCS. One of the four samples was collected from OU1 and is summarized in Table 3-1.

Analytical results for VOCs, SVOCs, metals, and total and available cyanide in OU1 surface soil are provided in Tables 5-1 and 5-2. One hundred and five surface soil samples were collected and analyzed during the SCS, the results of which are provided in Table 5-1. One surface soil sample was collected from OU1 and analyzed during the 2006 RI and the results are provided in Table 5-2. Tables 5-1 and 5-2 include only analytes that were detected in at least one surface soil sample. A table summarizing the results of every analyte analyzed during the SCS is provided as Table 1 in Appendix J. A table summarizing the results of every analyte analyzed in the surface soil sample collected from OU1 during the 2006 RI is provided as Table 2 in Appendix J. The surface soil analytical results were compared to the NYSDEC Technical and Administrative Guidance Memorandum (TAGM) Recommended Soil Cleanup Objectives (RSCOs) and Site-Specific Background Values (SSBVs) developed during the SCS. For details regarding the development of the SSBVs, refer to Subsection 5.4 of the SCS report (H&A, 2004). Figures 5-1A and 5-1B illustrate the SCS surface soil analytical results and Figure 5-2 illustrates the RI surface soil analytical results.

Only two occurrences of a VOC concentration exceeding its RSCO were detected during the SCS (benzene at 0.072 mg/kg in 21GH007 and acetone at 0.21 mg/kg in 21PF001). All of the SCS and RI surface soil samples were below the RSCO total VOC criteria of 10 mg/kg. VOCs were not detected in the RI surface soil sample collected from OU1.

Many SVOCs, mostly PAHs, were detected in the SCS surface soil samples, some at concentrations exceeding RSCOs as summarized on Table 5-1 and illustrated on Figures 5-1A/1B. The OU1 RI surface soil sample did not contain detectable concentrations of PAHs as shown on Table 5-2 and Figure 5-2. All of the SCS and RI surface soil samples were below the total SVOC RSCO of 500 mg/kg.

The metals detected in site surface soils exceeding RSCOs or SSBVs included aluminum, arsenic, beryllium, cadmium, calcium, chromium, copper, iron, magnesium, manganese, mercury, nickel, silver, sodium, and zinc. The concentrations of the metals detected in the RI surface soil sample are consistent with the concentrations of metals detected in the SCS surface soil samples.

Nine SCS surface soil samples contained concentrations of cyanide exceeding the SSBV of 0.705 mg/kg. Cyanide concentrations ranged from 0.74 to 12.1 mg/kg in the SCS surface soil samples. A low concentration of available cyanide was detected in the OU1 RI surface soil sample.

The concentrations of compounds detected in the OU1 RI surface soil sample are consistent with or lower than the concentrations of compounds detected in the SCS surface soil samples. The detected surface soil concentrations are considered to be attributable to fill material quality, anthropogenic sources, or naturally occurring sources unrelated to former MGP operations.

5.3 Upper Fill Soil

The upper fill soil is considered to be 0.2 to 5 ft bgs and, as noted in the SCS and observed in the RI, is generally distinct from the deeper, lower, MGP-impacted fills and natural soils. The distinction is based on the general absence of construction-type debris, the limited observation of MGP or other impacts, and the absence of elevated PID readings. The upper fill was noted over the majority of the site and the SCS concluded that it appeared to represent imported fill material brought to the site after closure of MGP operations (H&A, 2004). During the RI, three upper fill soil samples were collected from OU1 to further evaluate the quality of this soil horizon as summarized in Table 5-2.

Analytical results for VOCs, SVOCs, metals, and total and available cyanide in upper fill soil are included in Tables 5-3 and 5-4. One hundred and three upper fill soil samples were collected and analyzed during the SCS, the results of which are provided in Table 5-3. Three upper fill soil samples were collected from OU1 and analyzed during the RI and the results are provided in Table 5-4. Tables 5-3 and 5-4 include only analytes that were detected in at least one upper fill or lower fill/natural soil sample. A table summarizing the results of every analyte analyzed in the upper fill soil samples during the SCS is provided as Table 3 in Appendix J. A table summarizing the results of every analyte analyzed in the OU1 upper fill soil samples during the RI is provided as Table 4 in Appendix J. The upper fill soil analytical results were compared to the NYSDEC TAGM RSCOs and SSBVs developed during the SCS. For details regarding the development of the SSBVs, refer to Subsection 5.4 of the SCS Report (H&A, 2004). Figure 5-3 illustrates the SCS upper fill soil analytical results and Figure 5-4 illustrates the OU1 RI upper fill soil analytical results. In addition, the distribution of total VOCs and total SVOCs exceeding RSCOs are illustrated by depth interval on Figures 5-5 and 5-6, respectively. The upper left panel of each of these figures illustrates the distribution of these compounds in soils between 0.2 and 10 ft bgs.

Detected VOC concentrations in SCS and RI upper fill soils did not exceed individual RSCOs or the total VOC RSCO of 10 mg/kg. As illustrated on Figure 5-5, there were only eight locations in the 0.2 to 10 ft bgs depth zone where total VOCs were detected at concentrations exceeding 10 mg/kg. At all of these locations, the samples that contained concentrations greater than the total VOC RSCO were collected from depths greater than 5 ft bgs.

As noted in the SCS report and as illustrated on Figure 5-3, SVOC concentrations exceeding RSCOs were noted in less than half of the SCS upper fill soil samples and were generally limited to a few individual PAHs. The SCS report stated that the range of concentrations and types of PAHs detected in upper fill soils at the site were similar to the results of the soil data collected for the site background evaluation, with the exception of a few samples where the results were within one order of magnitude higher in concentration. The OU1 RI upper fill SVOC results follow the same pattern. Detected SVOC concentrations did not exceed the total SVOC RSCO of 500 mg/kg. As shown on Figure 5-6, there were only six locations in the 0.2 to 10 ft bgs depth range where total SVOCs were detected at concentrations exceeding 500 mg/kg. At all of these locations, the samples that contained concentrations greater than the total SVOC RSCO were collected from depths greater than 5 ft bgs.

Several metals were detected at concentrations exceeding the RSCOs or SSBVs in both the SCS and RI upper fill soil samples as illustrated on Figures 5-3 and 5-4 and Tables 5-3 and 5-4. The SCS report concluded that the range of concentrations and types of metals detected in upper fill soils at the site were similar to the results from the background soil study area, with the exception of a few samples where the results were less than one order of magnitude higher in concentration (H&A, 2004). The RI upper fill soil sample results are generally consistent with the SCS findings.

The concentrations of compounds detected in the RI upper fill soil samples are consistent with or lower than the concentrations of compounds detected in the SCS upper fill soil samples. The RI upper fill soil samples were also consistent with the SCS upper fill soil samples in appearance and generally did not exhibit MGP-related materials. The detected upper fill soil concentrations are considered to be attributable to fill material quality, anthropogenic sources, or naturally occurring sources unrelated to former MGP operations.

5.4 Lower Fill/Natural soil

The lower fill/natural soil unit includes fill below 5 ft bgs and natural soils underlying the fill unit. Visible impacts and analytical results indicate that the lower fill/natural soil unit has been impacted by former MGP operations. The distribution of the visible impacts and the analytical results for the lower fill/natural soil unit is illustrated on several figures and tables within this subsection. Additionally, cross sections A-A' through G-G' (Figures 4-3 through 4-9) illustrate visible impacts and provide a summary of analytical results.

5.4.1 Visible Impacts

Tables 5-5 and 5-6 summarize visible impacts noted during the SCS and RI drilling activities, respectively. These impacts were summarized from a review of the boring logs that are provided in Appendix B. These tables were used to generate Figures 5-7 and 5-8 that illustrate the distribution of stained soils and/or soils with sheen and the distribution of soils that are visibly impacted with OLM and/or TLM, respectively.

5.4.1.1 Stained Soils

As illustrated on Figure 5-7, stained soils and/or soils exhibiting a sheen were observed in lower fill/natural soils across the majority of the site. There appears to be a strip of relatively non-impacted lower fill/natural soil in the center of the site in the vicinity of former Avenue A. This finding is consistent with the general lack of former MGP structures in this area of the site.

The stains and sheen in the western portion of the site are within or near the former gas holders and ranged in depth between approximately 7 and 40 ft bgs. The impacts noted at boring 21GH013 indicate slight black staining or sheen to a depth of 63 ft bgs. No other boring in the vicinity of 21GH013 encountered staining or sheen to this depth. Based on the description of the impacts at depth in this boring and the drilling difficulties (added water to the borehole for increased pressure), it is likely that these impacts were related to shallower impacts.

The soils with observed sheen and stain in the eastern portion of the site are also relatively widespread, especially along the southeastern part of the Site where the former purifiers and coal houses were situated. Lower fill/natural soils with limited staining and/or sheen were noted along the northern edge of the site along the western portion of the south side of East 23rd Street. Cross section E'E' illustrates the visible impacts along the northern edge of the site.

In their August 10, 2007 comment letter, NYSDEC requested that the playground, basketball court, and tennis/bocce ball court areas within OU1 be investigated to evaluate whether sources of MGP impacts are present beneath these surfaces. The property owner, Tishman Speyer, requested that the surfaces of the courts and playground area not be disrupted with drilling activities. Additional borings (21BR06B/21BB01, 21BR07B/21BB02, 21BR08B/21PG01, 21PG02, 21TC01, and 21TC02) were drilled adjacent to these park areas during the 2008 RI. Lenses of staining were observed adjacent to the playground/court areas in all of these borings between 8 and 25 ft bgs. These findings are consistent with the other subsurface MGP impacts noted during previous investigations of the site.

5.4.1.2 Oil-Like Material/Tar-Like Material Impacted Soils

Figure 5-8 provides a generalization of the OLM and TLM visible impacts observed in the subsurface of the site by depth interval. Observations of OLM and TLM include lenses of material with OLM and/or TLM blebs, globules, residual, or saturation. The data used to develop Figure 5-8 does not indicate that the full thickness of each depth zone illustrated was saturated with OLM/TLM. Refer to Tables 5-5 and 5-6 and the boring logs in Appendix B for a detailed description of visible impacts observed at specific locations.

As illustrated on Figure 5-8, relatively shallow, 10 to 20 ft bgs OLM/TLM impacts were noted in soils beneath the former retort, drip tank, and oil tank area in the northeastern portion of the former MGP. This area of shallower impacts is surrounded by an area of deeper, 20 to 40 ft bgs OLM/TLM impacts that appears to have migrated downward and horizontally from the shallower impacts in the retort, drip tank/oil tank area. Deeper OLM/TLM lenses (greater than 40 ft bgs) were observed in borings in the southeastern portion of the former retort, drip tank/oil tank area and east-southeastward to Avenue C. Visible impacts in the eastern portion of the former MGP site were observed as deep as 47 ft bgs. These impacts are also evident on cross sections A-A', B-B', and D-D'.

A smaller relatively shallow area of OLM/TLM impacts was also noted between 10 and 20 ft bgs along the southern boundary of the site in the vicinity of the former purifiers. These impacts generally did not extend deeper than 20 ft bgs in this area.

Further west, the majority of observed OLM/TLM impacts are situated within and adjacent to former gas holder structures. All of the former holders were encountered during the SCS test pit and/or boring activities and contained varying compositions of debris and soils impacted with stain, sheen, and OLM/TLM. One area of intermediate depth (20 to 40 ft bgs) OLM/TLM impacts is situated around former gas holder #2. A boring, 21GH030, was drilled in former gas holder #2 during the 2008 RI activities. OLM/TLM impacts were not observed in boring 21GH030. Impacts in the western portion of the overburden materials generally did not extend to depths greater than approximately 20 to 40 ft bgs. Additional borings (21BR06B/21BB01, 21BR07B/21BB02, 21BR08B/21PG01, 21PG02, 21TC01, and 21TC02) were drilled adjacent to these park areas during the 2008 RI. OLM was only noted in one of these borings, 21TC02, between 16 and 30 ft bgs and was present in the form of blebs and lenses. This finding is consistent with the other subsurface MGP impacts noted during previous investigations of the site.

The extent of the visible OLM/TLM impacts in lower fill/natural soils at the site have been defined to the west (cross section F-F'), and extend to the eastern portion of the northern OU1 boundary (cross sections E-E' and G-G'), and along the southern edge of OU1. Visible OLM/TLM impacts extend to the northeastern, southeastern, and eastern limits of OU1.

5.4.1.3 NAPL in Monitoring Wells

Measured NAPL (both LNAPL and DNAPL) in various monitoring wells is presented in Table 5-7. NAPL was detected at measurable thicknesses in monitoring wells 21MWD03, 21MWD04, 21MWDD04, 21MWD07, 21MWD10, and 23MWD12. Quantities of NAPL have been removed from all of these wells except 21MWDD04 where the greatest thickness was measured. At this location, NAPL could not be removed by pumping due to high viscosity and increased depth to NAPL.

Approximately 3.8 ft of NAPL was measured in the base of 21MWD03 on March 31, 2006. A peristaltic pump was used to remove approximately 4 gallons of water and 1 gallon of NAPL from this well on March 31, 2006. During subsequent gauging events, on April 7 and June 12, 2006, NAPL thickness in this well was measured to be 1.5 and 3.2 ft, respectively. NAPL was also removed from 21MWD04 in March 2006. Approximately 1 gallon of NAPL was bailed from 21MWD04. Subsequent gauging events indicate that approximately 1 to 2 feet of NAPL is present in the base of the well. Field observations indicate that the majority of the NAPL is denser than water and likely related to former MGP operations at the site

Trace amounts of NAPL, both LNAPL and DNAPL, were also indicated in monitoring wells 21MWS10 and 23MWDD12.

Due to the presence of NAPL in monitoring wells at the site, Con Edison directed ENSR/AECOM to develop an Interim Remedial Measure Work Plan for NAPL Monitoring and Recovery at the site. This work plan was submitted to NYSDEC for review on August 18, 2008.

5.4.2 Correlation of Visible Impacts and Analytical Results

As is typical at former MGP sites, the analytical results for the site correlate well with the observed visible impacts. Figures 5-5 and 5-6 illustrate the distribution of total VOCs and total SVOCs exceeding NYSDEC RSCOs by depth interval across the site. The majority of the total VOC and total SVOC exceedances of RSCOs were detected in the 10 to 20 ft and 20 to 40 ft depth zones, and were concentrated in the northeastern portion of the former MGP in the vicinity of the former retorts, drip tanks, and oil tanks and in the western portion of the former MGP within and adjacent to former gas holders. The 20 to 40 ft depth zone also contains total VOCs and total SVOCs at concentrations exceeding their RSCOs in the southeastern portion of the site in the former scrubber/purifier area and the in former oil tank area.

As shown in Figures 5-5 and 5-6, the horizontal delineation of total VOC and total SVOC exceedances of RSCOs has been generally defined in the lower fill/natural soils along the north, west, and southern limits of OU1. Total VOCs and SVOCs exceeding the RSCO are present along the northeastern, eastern, and southeastern limits of OU1. The vertical extent of lower fill/natural soil total VOC and total SVOC exceedances of RSCOs has been defined at the site as is evident by the green rings in the lower right panel of Figures 5-5 and 5-6.

5.4.3 Analytical Results

Analytical results for VOCs, SVOCs, metals, and total and available cyanide in lower fill/natural soil are included in Tables 5-3 and 5-4. Three hundred and eighty-eight lower fill/natural soil samples were collected and analyzed during the SCS, the results of which are provided in Table 5-3. Twenty-three lower fill/natural soil samples were collected from OU1 and analyzed during the 2006 RI and 18 lower fill/natural soil samples were collected and analyzed during the 2008 RI. These RI results are provided in Table 5-4. Tables 5-3 and 5-4 include only analytes that were detected in at least one upper fill or lower fill/natural soil sample. A table summarizing the results of every analyte analyzed in the lower fill/natural soil samples during the SCS is provided as Table 3 in Appendix J. A table summarizing the results of every analyte analyzed in the OU1 lower fill/natural soil samples during the RI is provided as Table 4 in Appendix J. The lower fill/natural soil analytical results were compared to the NYSDEC TAGM RSCOs and SSBVs developed during the SCS. For details regarding the development of the SSBVs, refer to Subsection 5.4 of the SCS Report (H&A, 2004).

5.4.3.1 Volatile Organic Compounds and Semi-Volatile Organic Compounds

Figure 5-9 illustrates the results of VOC analyses and Figures 5-10A through 5-10C illustrate the results of the SVOC analyses for the lower fill/natural soil samples collected during the SCS. As illustrated on these figures and discussed in subsection 5.5.3 of the SCS report, VOCs and SVOCs were detected in lower fill/natural soil samples at concentrations exceeding RSCOs at the majority of the locations investigated at the site. The predominant VOCs that exceeded their respective RSCOs were the BTEX compounds, and the predominant SVOCs that exceeded their respective RSCOs were PAHs, which is common at MGP sites. The distribution of the exceedances of the VOCs and SVOCs as presented on Figures 5-9 and 5-10A/B/C and discussed in the SCS report coincide with the visible impact and analytical correlation discussions provided in Subsections 5.4.1 and 5.4.2 above.

The purpose of the OU1 RI lower fill/natural soil sampling was to further delineate the extent of MGP-related impacts detected during the SCS and to evaluate soil quality in the vicinity of the basketball court, tennis/bocce ball court, and playground areas within Peter Cooper Village as requested in the NYSDEC August 10, 2008 comment letter. The VOC, SVOC, metal, and cyanide analytical results for the OU1 RI lower fill/natural soil samples are presented in Table 5-4. Because the predominant VOCs detected at the site during the SCS were BTEX compounds, and the predominant SVOCs detected at the site during the SCS were PAHs, Figure 5-11 illustrates the BTEX and PAH analytical results for the OU1 lower fill/natural soil samples collected during the RI. Figure 5-11 presents total VOC and total SVOC concentrations which include but are not limited to BTEX and PAHs, respectively. Therefore, the total VOC and total SVOC concentrations illustrated on Figure 5-11 may be greater than the sum of the individual BTEX and PAH concentrations reported on Figure 5-11.

As illustrated on Figure 5-11, the horizontal and vertical extent of VOCs and SVOCs generally have been defined along the southwestern, western, and northwestern perimeters of OU1. In the northeast portion of OU1 at 23RE102 and 23RE101/23MWS/D/DD12, total VOC and/or total SVOC concentrations in soils exceed their respective RSCOs in samples collected between 22 and 30 ft bgs. The vertical extent of these impacts was defined at each of these locations.

Along the eastern limit of OU1 adjacent to Avenue C, lower fill/natural soil analytical results indicate the presence of VOCs and SVOCs at concentrations exceeding RSCOs. Concentrations of VOCs and SVOCs in soils between 5 and 10 ft bgs along the eastern border of the former MGP site along the west side of Avenue C were as high as 754 mg/kg and 2702 mg/kg, respectively in 21DT004 (5-7). The lower fill/natural soil VOC and SVOC analytical exceedances along the eastern limit do not extend deeper than approximately 47 ft bgs with vertical confirmation samples containing concentrations of VOCs and SVOCs below RSCOs collected from depths ranging between 49 and 51 ft bgs. Lower fill/natural soil samples collected from areas adjacent to playground/court areas contained similar concentrations of VOCs and SVOCs as surrounding areas of the site.

5.4.3.2 Metals and Cyanide

Metal concentrations in SCS and RI lower fill/natural soil samples exceed RSCOs and/or SSBVs. Figure 5-12 illustrates and Table 5-3 summarizes the metal analytical results for the SCS lower fill/natural soil samples. Table 5-4 includes the metal analytical results for the OU1 RI lower fill/natural soil samples. A review of the metal results indicates that many metals are present in the lower fill/natural soil, frequently at concentrations exceeding SSBVs. The most common metals are aluminum, calcium, magnesium, potassium, and sodium. The data do not indicate a trend of elevated metal concentrations associated with specific areas at the site or with specific depth zones between sampling locations.

The SCS report focused on elevated concentrations of arsenic and lead as these metals may be associated with former MGP operations as well as other sources. The seven arsenic concentrations detected above the SSBV in the SCS lower fill/natural soil samples ranged from 14 to 41.1 mg/kg. Arsenic was detected in all but six OU1 lower fill/natural soil samples collected during the RI at concentrations below the SSBV of 13.63 mg/kg. Lead was detected at concentrations exceeding the lead SSBV of 237.2 mg/kg in 13 of the SCS lower fill/natural soil samples. The lead concentrations in the SCS lower fill/natural soil samples ranged from 283 to 1,620 mg/kg. Lead was detected in all of the OU1 RI lower fill/natural soil samples; however, none of the samples contained concentrations above the SSBV of 237.2 mg/kg.

Lower fill/natural soil sample cyanide analytical results are also summarized in Tables 5-3 and 5-4. Figures 5-11 and 5-12 illustrate the distribution of the cyanide analyses for the OU1 lower fill/natural soil samples collected during the RI and the SCS, respectively. The cyanide concentrations detected in the SCS lower fill/natural soils generally ranged from 0.75 to 2.6 mg/kg which is well within the range of the background samples collected for the site. One SCS sample (21PF006) collected from a depth of 13 to 15 ft bgs in the former purifier area contained cyanide at a concentration of 387 mg/kg. Total cyanide was detected in two of the OU1 RI lower fill/natural soil samples. The detected total cyanide concentrations detected in the OU1 RI lower fill/natural soil samples ranged from 0.854 to 1.6 mg/kg. Available cyanide concentrations were reported for 13 of the OU1 RI lower fill/natural soil samples. The available cyanide analytical results were compromised by interferences and, based on a comparison with total cyanide concentrations, do not reflect available cyanide concentrations in the lower fill/natural soil at the site.

5.5 Bedrock Quality

A bedrock investigation was performed at the site during the RI due to the presence of DNAPL suspected to be MGP in nature in the Con Edison steam tunnel recently constructed beneath First Avenue. The bedrock investigation methodologies and results will be presented in the RI report for OU3.

5.6 Groundwater Quality

During the 2006 RI, groundwater quality beneath the site was assessed through the collection and laboratory analysis of groundwater samples from 45 well locations and two direct-push grab sample locations, as discussed in Section 3.8. During the 2008 RI activities, groundwater samples were collected from 35 of the previously sampled monitoring wells and from the six newly installed monitoring wells. Table 5-8 includes a summary of all compounds detected during the SCS and the RI, broken down by BTEX, VOCs, PAHs, SVOCs, metals, and cyanide (total and available). Figure 5-13 presents a summary of typical MGP constituents of interest (COI), including BTEX, PAHs, phenols, and cyanide, detected during the SCS sampling in 2004 and the OU1 RI sampling in 2006 and 2008. Due to the pervasive detection of metals, many above NYSDEC Ambient Water Quality Standards or Guidance Values (AWQSGVs) (typically iron, magnesium, manganese, and sodium) metals results are not included for purposes of discussion as they are not inferred to be related to former MGP operations at the site. This finding is based partially upon reviewing metals results from the most highly impacted wells in each aquifer zone, which revealed a suite of detected metals similar to other site wells including those containing non-detectable COI concentrations.

The groundwater discussion presented below includes limited groundwater quality data from monitoring wells located outside of the limits of OU1. These data are presented on Table 5-8 and several figures to provide a more complete evaluation of the groundwater quality and to allow a limited evaluation of natural attenuation in the site vicinity.

The following subsections provide a summary and discussion of the COI results for each aquifer zone, followed by a baseline natural attenuation (NA) evaluation for each aquifer zone. The presence of free-phase NAPL is also discussed in relation to the analytical findings.

5.6.1 Shallow Zone (5-15 ft bgs)

A total of 21 shallow zone groundwater samples were collected during the 2006 RI and 17 shallow zone groundwater samples were collected during the 2008 RI. In addition, 11 shallow zone samples were collected in 2004 by H&A during the SCS work in 2004. In summary, the typical compounds detected in the shallow aquifer at the water table include low to moderate concentrations of BTEX, PAHs, and total cyanide with lesser detections and concentrations of other VOC and SVOC compounds (Table 5-8). Of the detections, the primary COI that were detected above AWQSGVs included BTEX and PAHs, as expected for a former MGP site.

Because benzene is one of the most common compounds associated with MGP residues and is also one of the most soluble VOCs, iso-concentration contours for benzene were prepared for the shallow zone. The 2006 benzene results are presented on Figure 5-14A and the 2008 benzene results are presented on Figure 514B. Groundwater elevation contours for the shallow aquifer zone are shown on Figure 4-11 for comparison purposes. As shown on Figures 5-14A and 5-14B, benzene concentrations are highest in the former gas holder area in the western portion of the site and in the eastern portion of the site near the former oil tanks and drip tanks. These findings are consistent with visual observations and soil results. They are also consistent with soil gas data in that there is generally a zone of relatively less impacted groundwater at the water table across much of the site due to contaminant location (generally isolated at depth) and downward vertical gradients between the water table and deep aquifer zones. This combination helps to limit the migration of soil vapor from deeper impact zones into the vadose zone.

Also outlined on Figures 5-14A and 5-14B are colored symbols designed to present a rapid visual summary of whether any VOC, SVOC, or total cyanide result was greater than AWQSGVs. Locations where NAPL was detected are also identified on the figure. As shown, the shallow groundwater plume extends past the limits of OU1 to the east and possibly to the north-northeast (Figure 5-14B).

Lastly, comparison of 2004 and 2006 data in shallow wells, where available, revealed that equal or decreasing concentrations of VOCs were noted in 60% of the wells (6 of 10) and equal or decreasing concentrations of total PAHs were noted in 100% of the wells (10 of 10 wells) [Table 5-8]. Comparison of 2006 and 2008 groundwater quality data in shallow wells indicates that equal or decreasing concentrations of VOCs were noted in 82% of the wells (14 of 17 wells). Benzene concentrations increased one to two orders of magnitude between the 2006 and 2008 sampling events in monitoring wells 21MWS04, 21MWS09, and 23MWS12. Concentrations of SVOCs remained similar in 88% of the wells (15 of 17 wells) between 2006 and 2008. SVOC concentrations increased one order of magnitude between 2006 and 2008 in monitoring wells 21MWS04 and 21MWS08.

5.6.2 Intermediate Zone (25-35 ft bgs)

A total of 20 intermediate zone groundwater samples were collected during the 2006 RI and 15 intermediate zone groundwater samples were collected in the 2008 RI. In addition, nine intermediate zone samples were collected in 2004 by H&A during the SCS work. The highest concentrations of COI were detected in this zone compared to the water table and deeper aquifer zone. NAPL was also detected in several wells as summarized in Table 5-7. In summary, the typical compounds detected in the intermediate aquifer zone include moderate to high concentrations of BTEX, PAHs, and total cyanide with lesser detections and concentrations of other VOC and SVOC compounds (Table 5-8). Of the detections, the primary COI that were detected above AWQSGVs included BTEX, PAHs, and occasionally phenols and styrene. This finding is generally consistent with the shallow aquifer zone and with typical MGP sites. In addition, several intermediate zone wells contained chlorinated VOCs from a non-MGP source (Table 5-8).

Benzene iso-concentration contours were also prepared for the intermediate zone for the 2006 data (Figure 5-15A) and the 2008 data (Figure 5-15B). Groundwater contours for the intermediate aquifer zone are shown on Figure 4-11 for comparison purposes. Unlike the 2006 groundwater sampling event, groundwater samples were not collected from monitoring wells which contained indications of NAPL during the 2008 groundwater sampling event. Therefore, 2008 benzene concentrations are not available for developing benzene iso-concentration contours at seven monitoring well locations. The 2008 benzene iso-concentration contours illustrated on Figure 5-15B were generated using the 2006 benzene concentrations at the seven wells that contained NAPL indications in 2008 and are dashed to indicate approximate location. Benzene concentrations are not posted at wells with NAPL indication on Figure 5-15B since the wells were not sampled in 2008.

As shown on Figures 5-15A and 5-15B, benzene concentrations are highest in the former gas holder area in the western portion of the site, extending to the northeast in the direction of groundwater flow. These findings are consistent with visual observations and soil results.

Also outlined on Figures 5-15A and 5-15B are colored symbols designed to present a rapid visual summary of whether any VOC, SVOC, or total cyanide result was greater than AWQSGVs. Locations where free-phase NAPL was detected are also identified on the figure. The source of the free-phase NAPL can be traced to two primary former MGP source areas, including the former gas holder area in the western portion of the site and the former drip tanks/tar separator/oil tank area in the eastern portion of the site. In addition, chlorinated compounds, unrelated to former MGP operations, appear to be prevalent along the southern portion of OU1 and to the south of OU1. As shown, groundwater impacts in the intermediate zone extend to the northern, eastern, and southern limits of OU1.

Lastly, comparison of 2004 and 2006 data in intermediate wells, where available, revealed that equal or decreasing concentrations of VOCs were noted in 100% of the wells (8 of 8) and equal or decreasing concentrations of total PAHs were noted in 100% of the wells (8 of 8 wells) [Table 5-8]. Comparison of the 2006 and 2008 data in the intermediate wells, where available, indicate that equal or decreasing concentrations of VOCs were noted in 91% of the wells (10 out of 11 where trend data are available). The concentration of benzene increased from not detected in 2006 to 9.9 ug/L in 2008 in monitoring 21MWD11. Comparison of the 2006 and 2008 data revealed equal or decreasing SVOC concentrations in 100% of the wells (11 of 11 wells).

5.6.3 Deep Zone (50-70 ft bgs)

A total of 16 deep zone groundwater samples were collected during the 2006 RI and 9 deep zone groundwater samples were collected during the 2008 RI. No deep zone samples were collected in 2004 during SCS work. Moderate to high concentrations of COI were detected in the deep aquifer zone. NAPL was also detected in three wells during the 2006 RI and one well during the 2008 RI. Similar to the shallower aquifer zones, the typical compounds detected in the deep aquifer zone were BTEX, PAHs, and total cyanide with lesser detections and concentrations of other VOC and SVOC compounds (Table 5-8). Of the detections, the primary COI that were detected above AWQSGVs included BTEX, PAHs, and occasionally phenols, styrene, and isopropylbenzene. This finding is also generally consistent with the shallower aquifer zones and with typical MGP sites. In addition, some deep zone wells contained chlorinated VOCs from a non-MGP source (Table 5-8).

Benzene iso-concentration contours were also prepared for the deep zone (Figures 5-16A and 5-16B). Groundwater contours for the deep aquifer zone are shown on Figure 4-11 for comparison purposes. As shown on Figures 5-16A and 5-16B, benzene concentrations are highest in the former gas holder area in the western portion of the site and the former drip tank area near the eastern site boundary. Visible impacts and soil analytical impacts generally do not extend deeper than 20 to 40 ft bgs in the western portion of the site. The deep groundwater impacts in the western portion of the site are likely due to downward groundwater gradients and shallower soil impacts. The deep groundwater impacts in the eastern portion of the site can also be attributed to overlying soil impacts, however, the soil impacts extend as deep as 47 ft bgs near Avenue C.

Figures 5-16A and 5-16B use colored symbols to designate areas in which VOC, SVOC, or total cyanide results exceeded AWQSGVs. Locations where free-phase NAPL was detected are also identified on the figure. The source of the free-phase NAPL in the deep zone is likely related to the former retorts and drip/oil tanks in the eastern portion of the site. As shown, groundwater impacts in the deep zone extend to the northeastern, eastern, and southeastern limits of OU1.

The vertical extent of groundwater impacts was not determined within OU1 at monitoring wells 21MWDD03, 21MWDD04, or 21MWDD08. Based on the distribution of subsurface soil impacts, the OU1 deep groundwater impacts in the western portion of the site are consistent with the magnitude and distribution of the downward vertical hydraulic gradient data and shallower source areas. The magnitude of the vertical hydraulic gradients between the intermediate and deep aquifer zones are significantly lower than the gradients between the shallow and intermediate zones, and occasionally are upward. These vertical groundwater gradients may help to reduce the concentrations of compounds with depth. In the eastern portion of the site, the deep impacts are less related to vertical gradients and more reflective of closer proximity to deeper soil impacts.

Lastly, comparison of 2006 and 2008 data in the deep wells, where available, revealed that equal or decreasing concentrations of VOCs were noted in 43% of the wells (3 of 7 where trend data area available). VOC concentrations increased in four of the deep wells (21MWDD03, 21MWDD08, EBMWDD14, and 23MWDD20) between 2006 and 2008. SVOC concentrations in the deep zone samples collected from 2006 and 2008 decreased or stayed the same in 86% of the wells (6 of 7 wells) and increased in one well (EBMWDD14).

5.6.4 Natural Attenuation Evaluation

Geochemical indicators of NA were measured and evaluated in groundwater during the May 2006 and August/September 2008 groundwater sampling event. Intrinsic biodegradation refers to the removal of environmental contaminants in soil and groundwater through the activity of naturally-occurring microbial populations without the imposition of active, engineered systems or processes. Intrinsic biodegradation is one of several NA mechanisms by which environmental contaminants may be attenuated in the environment. Other such mechanisms include sorption, dissolution, volatilization, and physical/chemical decomposition (i.e., hydrolysis, photolysis). In terms of mass reduction, intrinsic biodegradation is the primary NA mechanism that degrades dissolved organics in groundwater. The following subsections provide a discussion of these parameters and how they correlate with dissolved organic impacts at the Site.

When dissolved oxygen (DO) is present in groundwater at sites impacted by non-chlorinated organic contaminants, microorganisms will preferentially use oxygen as a terminal electron acceptor as they oxidize the organic compounds to carbon dioxide and water. Low levels of DO in groundwater reflect the oxygen consumed during the biodegradation of organic compounds. Low oxidation reduction potential (ORP) measurements indicate that there has been a depletion of oxygen due to increased microbial activities, resulting in reduced conditions. When oxygen is not present or has been consumed, microorganisms may use available alternative electron acceptors (ferric iron, manganese, nitrate, sulfate, and carbon dioxide) to metabolize organic compounds. In the course of this process, electron acceptors are converted to their respective reduced forms (ferrous iron, dissolved manganese, sulfide, nitrogen, and methane), which are then released as byproducts of the metabolic processes. Consequently, measuring the concentrations of potential electron acceptors and their reduced by-products and comparing them to concentrations of dissolved organic constituents, often reveals a pattern indicative of biodegradation activity and provides information on which electron acceptors are "active" at a site.

A summary of the terminal electron acceptor (TEA) and metabolic byproduct data collected as part of the RI (both field and laboratory results) are presented on Table 5-9. Despite expected variability in the data, given the site location (urban setting and urban fill), the results indicate that DO, sulfate, and carbon dioxide (consumed through methanogenisis) are the primary TEAs used by microbes at the site to degrade dissolved phase COI. Alkalinity results are also indicative of reducing conditions within the dissolved plume and support the TEA and metabolic byproduct data distributions. This finding is based on generalized trends in the concentrations of these TEAs and byproducts compared to groundwater flow direction and dissolved COI concentrations within each aquifer zone. A brief discussion of the NA results for each aquifer zone is provided in the following sections.

5.6.4.1 Shallow Aquifer Zone (5-15 ft bgs)

A total of six shallow wells were sampled for TEAs and their byproducts to evaluate the presence of intrinsic biodegradation during both the May 2006 and August/September 2008 sampling events. These wells included upgradient wells 21MWS01 and 23MWS11, cross gradient well 20MWS16, and dissolved plume wells 21MWS03 and 23MWS12, and downgradient well LR02. A summary of the key TEA data is shown on Figure 5-17. As outlined on the figure, the distribution of dissolved oxygen (DO), nitrate, sulfate, dissolved iron, dissolved manganese carbon dioxide, and methane in upgradient and cross gradient wells compared to source area and dissolved plume wells shows a pattern indicative of anaerobic conditions within the plume. For example, average DO, nitrate, sulfate, carbon dioxide, and methane concentrations are lower in plume wells than in outlying areas, while microbial byproducts such as dissolved iron and manganese and methane are elevated in plume wells compared to outlying areas. Alkalinity is also increased within the plume wells, which further supports the presence of reducing conditions within the plume. Considered together, these findings suggest that biodegradation of organic COI are creating anaerobic (methanogenic) conditions within the impacted areas of the shallow aquifer zone.

5.6.4.2 Intermediate Aquifer Zone (25-35 ft bgs)

A total of up to eleven intermediate wells were sampled for TEAs and their byproducts to evaluate the presence of intrinsic biodegradation during both the May 2006 and August/September 2008 sampling events. These wells included upgradient well 21MWD01, cross gradient wells 23MWD11 and 20MWD16; dissolved plume wells 21MWD03, 21MWD07, 23MWD12, and EBMWD13 EBMWD15, and EBMWD18; and downgradient wells EBMWD24 and EBMWD25. A summary of the key TEA data is shown on Figure 5-18. Similar to the shallow zone, sulfate concentrations are generally depleted within the plume compared to outlying areas. There is also some evidence that average dissolved iron concentrations are elevated within the plume wells compared to downgradient wells. Methane concentrations are also elevated within the area of the dissolved phase plume compared to outlying wells. Combined, the overall pattern of data suggest that biodegradation of organic COI is creating anaerobic (methanogenic) conditions within the impacted areas. This finding is also consistent with chlorinated VOC data detected at select wells which shows that reductive dechlorination is occurring in the anaerobic environment of the intermediate aquifer.

5.6.4.3 Deep Aquifer Zone (50-70 ft bgs)

A total of seven deep wells were sampled for TEAs and their byproducts to evaluate the presence of intrinsic biodegradation. These wells were 21MWDD03, 23MWDD12, 23MWDD20, EBMWDD13, EBMWDD18, EBMWDD24, and EBMWDD25. Wells 23MWDD20 and EBMWDD13 are not impacted by the dissolved phase plume. A summary of the key TEA data is shown on Figure 5-19. Methane concentrations from this zone were elevated at plume wells 21MWDD03 and 23MWDD12 compared to outlying wells. No other discernable patterns were noted in the remaining geochemical data. One reason may be that wells screened in the lower portion of the aquifer zone may contain mixed geochemical signatures due to varying well depths and vertical gradients within the aquifer. Despite the less conclusive data from this zone, available methane data suggest that biodegradation of organic COI is creating anaerobic (methanogenic) conditions within the impacted areas of this aquifer zone.

5.6.4.4 Summary

The groundwater monitoring data suggest that naturally occurring biodegradation processes, specifically sulfate reduction and/or methanogenesis, are contributing to some reduction in the concentration of organic constituents within the dissolved phase plume in all aquifer zones at the Site. Additional monitoring (both time series and at alternate well locations) will further develop this baseline dataset for long-term evaluation of NA as a potential supplemental groundwater remedy following active remedial measures at the site.

5.7 Soil Gas Analytical Results

An evaluation of the potential for subsurface vapor intrusion at the Peter Cooper Village Apartment property was conducted by RETEC in June 2003. Additional sampling was performed in August 2003, March 2004, and April 2004. The overall goal of the work was to ascertain whether air quality within the apartment buildings that lie within and adjacent to the boundary of the former MGP was being adversely affected by residual subsurface impacts from the former MGP operations. Based on the results of the sampling events, it was concluded that intrusion of vapors emanating from MGP-related material was not evident.

Although vapor intrusion from MGP-related material was not evident in the buildings at the site, additional soil gas samples were collected along the perimeter of the site during the RI to evaluate the extent and assess the potential migration of soil gas impacts. The OU1 soil gas sample locations are illustrated on Figure 3-1 and include three samples along East 23rd Street (23SG101, 23SG102, and 23SG103) and two samples along First Avenue (FASG101 and FASG102). Two ambient air samples were also collected and analyzed for comparison with the soil gas sample results. Table 5-10 illustrates the OU1 RI soil gas and ambient air sample results.

A tracer gas (helium) was used to determine the integrity of the seal around the soil gas probe during sampling. The samples contained helium at concentrations far below the 20% NYSDOH Guidance standard, indicating that excellent sample integrity was achieved.

The five soil gas samples had VOC concentrations that are within the range of the soil gas concentrations found during the soil gas sampling conducted previously at this site. Sample 23SG103 contained the highest VOC concentrations, with m/p xylenes measured at 1,400 µg/m3. These VOC concentrations are lower than the highest concentrations detected in the soil gas samples during the previous investigations at this site. For example, toluene was detected in the subslab soil gas sample from Building 2 at a concentration of 3,000 µg/m3.

Indan, which has been associated with known MGP-related vapors at other sites, was detected in three of these samples (FASG101, FASG103, and 23SG101). Similarly, indene was detected at FASG102.

Several compounds that are not related to the former MGP operations at the site, including tetrachloroethene and trichloroethene, were detected in one of the eight samples (FASG102) at concentrations above those typically found in urban soil gas based on RETEC's experience.

Results from this sampling event indicate that the soil gas concentrations at the perimeter of the site are lower than the highest soil gas concentrations found at the site during previous investigations. The results from the previous sampling events indicated that the indoor air quality, as measured on each sampling day, was not likely to have been adversely impacted by subsurface intrusion of MGP-related vapors. Based on the results of these sampling events, intrusion of vapors emanating from any MGP-related material that may be present at the site was not evident. There does not appear to be any need for additional indoor air sampling or soil gas sampling for MGP constituents at this time; however Con Edison directed ENSR/AECOM to develop an Interim Remedial Measure work plan for Indoor Air Sampling at the site to continue to evaluate whether air quality within the buildings is adversely affected by residual impacts from historic operations. This work plan was submitted to NYSDEC for review on August 18, 2008.

6.0 Qualitative Human Health Exposure Assessment

This section integrates the data and information gathered during the RI and provides a qualitative assessment of the potential for exposure to MGP-related contaminants that are associated with the environmental conditions encountered at the site. This assessment was performed by identifying potential sources, migration routes for the constituents of concern (COC) discussed in Section 5, potential receptors, and potential exposure pathways at and in the vicinity of the site. The assessment follows guidelines specified in the *NYSDEC DER-10 Draft Technical Guidance for Site Investigation and Remediation* (NYSDEC, 2002).

6.1 Site Setting

A description of the site is presented in Section 2.1. OU1, is comprised of the lands bounded by the south side of East 23rd Street to the north, by the north side of East 20th Street to the south, by the west side of Avenue C to the east, and by the east side of First Avenue to the west. This area encompasses the historic boundary of the former East 21st Street MGP Works and the former MGP's gas production, purification, and storage facilities and structures.

The majority of these lands consist of the Peter Cooper Village which is a residential apartment building complex. The complex is comprised of apartment buildings that are surrounded by grass-covered and landscaped areas, paved recreational areas, playgrounds, and paved walkways and roadways. With one exception, all of the apartment buildings have full basements. The complex is fenced along its perimeter with several gateways for access from the surrounding streets. A commercial building, located at the corner of East 20th Street and First Avenue, is also present within the footprint of the former MGP process area. This building is accessed from the city streets, and is outside of the Peter Cooper Village complex. A discussion of potential pathways and receptors for this building area is included in the OU1 assessment.

6.2 Exposure Assessment

Exposure is the process by which humans come into contact with COC in their environment. Humans can be exposed to COC in a variety of environmental media including surface soil, subsurface soil, surface water, sediment, groundwater, and air. Exposure to these media can occur through several routes including ingestion, dermal contact, and inhalation. The exposure assessment identifies pathways by which humans are potentially exposed to COC. The assessment includes the following:

1) Development of a conceptual site model
2) Discussion of potential sources
3) Discussion of potential release mechanisms
4) Identification of potential human receptors and receptor-specific exposure pathways

Although the potential for exposure to MGP residuals for OU1 includes an evaluation of the potential for exposure to COCs via drinking impacted site groundwater, the City of New York obtains drinking water from sources located in upstate areas. Other than an evaluation of potential incidental ingestion of impacted groundwater during subsurface repair or construction activities, this pathway is not further discussed in this exposure assessment. The NYSDEC groundwater classification for the site area is GA (aesthetic-fresh waters). The management of groundwater impacted by site-related residuals will be addressed in the alternatives analysis report.

6.2.1 Conceptual Site Model

Figure 6-1 presents the conceptual model for the OU1 RI investigation area. Included on the figure is information regarding the known or potential sources of COC, the identified release mechanisms, and the affected source media. The potential migration pathways, the exposure media, and the potential exposure routes are identified. Note that the exposure routes are considered potential unless there is an on-going or documented exposure.

Information regarding the potential receptors identified in each area of interest is presented on Table 6-1.

6.2.2 Potential Sources of Residuals

The sources of environmental impact for the site are residual materials associated with the former MGP structures and process areas. Exposure to surface soil could be a potential exposure pathway; however, the upper 5 ft of soil is believed to have been imported to the site following cessation of the MGP operations, and the concentrations of COC in the surface soil samples collected at the site are generally within the site background study values (H&A, 2004) with total PAH concentrations less than 500 ppm. Hydrocarbon materials, including NAPL, have been observed in subsurface soil of the site. Volatile and semi-volatile compounds in these materials have leached to groundwater and the dissolved groundwater plume extends from the site to the east with likely discharge to the East River. In the MGP-impacted areas, the lower molecular weight hydrocarbons could also volatilize and migrate into ambient and/or indoor air.

6.2.3 Potential Release Mechanisms

As shown on Table 6-1, there are several potential release mechanisms by which the constituents identified in the soil and groundwater may be transported to other media. Each mechanism is considered for the identified media and potential receptor group. Potential release mechanisms for soil include the following:

1) **Fugitive Dust.** Constituents in surface and subsurface soil could be a potential source for fugitive dust via physical disturbance.
2) **Volatilization.** Volatile constituents may potentially be transported from subsurface soil by volatilizing into soil-pore space and eventually emanate into ambient or indoor air.
3) **Leaching.** Constituents in surface or subsurface soil could potentially leach to groundwater.

There are three mechanisms by which constituents in groundwater can be transported to other media. These migration pathways include the following:

1) **Adsorption.** Constituents in groundwater may be sorbed onto subsurface soils.
2) **Volatilization to Ambient Air.** Volatile constituents in groundwater may potentially desorb into soil gas and be transported into ambient or indoor air.
3) **Extraction.** Constituents in groundwater may migrate to other media by extraction and use of impacted groundwater.

Each of these potential release mechanisms is evaluated for each potential receptor group on Table 6-1.

6.2.4 Potential Human Receptors and Exposure Pathways

This section discusses the identified potential receptors and the potential that the receptor may be exposed to Site-related residuals.

6.2.4.1 Operable Unit 1 Receptors

An exposure pathway analysis for receptors in OU1 is summarized in Table 6-1. The analysis includes an identification of each potential receptor group, a listing of each potential exposure media and potential pathway, and a rationale for inclusion or exclusion of each potential receptor in the consideration of remedial actions in the alternatives analysis report. Each of the OU1 receptor groups, and the potential exposure pathways, are identified on Table 6-1. Potential receptor groups and potential exposure pathways that may exist for OU1 are discussed below.

Apartment Building Resident

A resident of the apartment buildings could potentially be exposed to MGP-related COC by the inhalation of impacted indoor air. The results of the soil vapor intrusion (SVI) evaluation sampling performed in each of the buildings at the site indicate that the concentrations of COC in indoor air that could possibly be MGP-related were attributable to other sources within the buildings rather than MGP residuals. Therefore, the potential for a resident to be exposed to air impacted by MGP-related COC is considered to be low under standard conditions.

There are unique considerations when working inside buildings on this site during planned and emergency utility work that involve cutting or drilling into concrete slabs in the basements of site buildings. There is the possibility to temporarily come into contact with potentially MGP and Non-MGP impacted soil and groundwater under the sub-grade concrete slab in the basements of the buildings in OU1. The existing, intact basement floor structures in apartment buildings in OU1 have proven to be effective barriers to stop the migration of subsurface vapors into buildings. Utility or other work that involves cutting or drilling into concrete slabs in the basements of buildings within OU1 may provide a potential pathway for subsurface vapors into these buildings. The potential for a resident to be exposed to air impacted by MGP-related COC during sub-slab activities is considered to be low and any potential exposure would be limited in duration and preventive measures would be used during sub-slab activities. However, the inhalation of VOCs by apartment building residents pathway is considered to be potentially complete and will be addressed in the alternatives analysis report. Additionally, a draft Interim Site Management Plan (ENSR 2008c) has been developed for the site and includes guidance to engineers and contractors for implementing procedures during projects that involve drilling or cutting through the basement slabs to prevent and control the potential for subsurface vapors entering and impacting the indoor air environment of these buildings.

As indicated above, it is believed that surface soil and the upper 5 ft of subsurface soil have been imported to the site following cessation of the MGP operations. Sampling and analysis of surface soils has indicated that the concentrations of VOCs and SVOCs are low and similar to background concentrations. Surface soils at the site are grass-covered or landscaped and the potential for residents to come into contact with surface soils is low. For these reasons, the potential for a resident to be exposed to COCs in surface soil is considered to be low.

Commercial Building Occupant

The commercial building located at the corner of East 20th Street and First Avenue is present within the footprint of the former MGP process area. An occupant of the building could potentially be exposed to MGP-related COC by the inhalation of impacted indoor air. The results of the SVI evaluation sampling performed in this building indicated that the concentrations of COC in indoor air that could possibly be MGP-related are low. Therefore, the potential for an occupant to be exposed to air impacted with MGP-related COC is considered to be low under standard conditions. Similar to the apartment building resident, sub-slab construction within the building may provide a potential pathway for subsurface vapors into the building. Therefore, the inhalation of VOCs by commercial building occupants pathway is considered to be potentially complete and will be addressed in the alternatives analysis report and by the interim site management plan. Since this area is outside of the Peter Cooper Village complex, the potential for an occupant to be exposed to impacted subsurface soil is also low.

Maintenance Workers

A maintenance worker at the commercial building or Peter Cooper Village complex could be involved in indoor and/or outdoor maintenance or construction activities. Based on a reconnaissance of the site buildings, none of the buildings have sumps that contain impacted groundwater. Based on the results of the SVI sampling performed in each of the site buildings (including the commercial building), concentrations of COC in indoor air are within the range considered to be typical of residential buildings at uncontaminated sites or are attributable to non-MGP sources. Therefore, the potential for a maintenance worker to be exposed to groundwater or air impacted with MGP-related COC is considered to be low under standard conditions. However, sub-slab construction within buildings may provide a potential pathway for subsurface vapors into the building. Therefore, the inhalation of VOCs by indoor maintenance workers pathway is considered to be potentially complete and will be addressed in the alternatives analysis report and by the interim site management plan.

Another potential exposure pathway for outdoor maintenance workers is via direct contact with impacted soils (i.e., incidental ingestion, dermal contact, and inhalation of volatiles or particulates) while performing light maintenance activities such as lawn care or landscaping. However, the concentrations of MGP-related COC in surface soils are low, and the soil is covered with grass or landscaping materials. The period of time that a worker would be in contact with subsurface soils is anticipated to be minimal. For these reasons, the potential for an outdoor maintenance worker to be exposed to MGP-related COC in surface and subsurface soils is considered to be low.

Subsurface Outdoor Maintenance or Utility Workers

Outdoor maintenance workers and subsurface utility workers could potentially be exposed to soil containing NAPL and other COC in subsurface soil and groundwater via incidental ingestion, dermal contact, and inhalation of volatiles or particulates if subsurface excavation work is needed to repair or replace underground features such as gas, water or sewer lines, or other utilities or structures at the site. NAPL-impacted subsurface soil was observed in the eastern and southeastern areas of the site in depths less than 20 ft bgs. Impacted groundwater is present in portions of the site in depths ranging from approximately 4 to 70 ft bgs. Only properly trained personnel should complete subsurface work at the site using methods specified in a site-specific HASP, until the area has been cleared of impacted materials.

Site Visitors and Pedestrians

Site visitors and pedestrians could potentially contact surface soil in the landscaped areas of the site, or inhale impacted indoor air while visiting site buildings or surrounding areas. As indicated above, the potential for exposure for each of these media is considered to be low under standard conditions. However, a site visitor could potentially be exposed to impacts to indoor air if sub-slab construction occurs in the building that they visit. Therefore, the inhalation of VOCs by site visitors pathway is considered to be potentially complete and will be addressed in the alternatives analysis report and by the site management plan.

6.3 Conclusions

For OU1, subsurface maintenance or utility workers who perform excavation and/or repair work on the site could possibly be exposed to NAPL, impacted soil, and/or groundwater. A Draft Site Management Plan (ENSR 2008c) (SMP) was developed and submitted to NYSDEC on August 15, 2008. The SMP specifically details institutional controls enacted on the Peter Cooper Village property to protect residents, maintenance, utility and landscape workers from soil impacts present below 5 feet. The plan outlines procedures for detecting and managing impacted air, soil and groundwater if they are encountered. While still draft, property owner personnel are currently operating under these procedures. Therefore, subsurface work should only be performed by properly trained personnel, using methods specified in the draft Site Management Plan (ENSR 2008c).

7.0 Summary and Conclusions

Based on site observations and analytical data, surface soils were imported to the site after the MGP operations ceased, possibly for final grading purposes during the construction of Peter Cooper Village. The upper fill also generally appears to represent imported fill material brought to the site after closure of the MGP operations. The concentrations of compounds detected in the SCS and RI surface soil and upper fill samples were generally consistent with site-background soil concentrations and are considered to be attributable to fill material quality, anthropogenic sources, or sources unrelated to former MGP operations.

No evidence of the oil water underdrain system was found during the investigation. Con Edison and its contractors have advanced 156 soil borings, 28 monitoring wells and 47 test pits (environmental and water valve) in OU1. The oil water underdrain system or anything resembling it has not been encountered. Discussions with property owner's maintenance personnel have also failed to turn up any evidence of the oil water underdrain system.

Lower fill/natural soil has been impacted by former MGP operations. MGP-related impacts are associated with former gas holder structures in the western portion of the site and are concentrated around former retort, drip tank, and oil tank structures in the eastern portion of the former MGP. The impacts in the lower fill/natural soil include lenses of staining, sheen, OLMl, and TLM that appear to migrate horizontally and vertically along pathways of greater permeability relative to surrounding material. Impacts in the western portion of the overburden materials generally did not extend to depths greater than approximately 20 to 40 ft bgs. Impacts in the eastern portion of the former MGP site were observed as deep as 47 ft bgs in overburden soils. The vertical extent of soil impacts has been defined at the site. The horizontal extent of impacts in the lower fill/natural soil extends to the eastern boundary of OU1 along Avenue C, to the northeastern OU1 boundary along the eastern portion of East 23rd Street, and to the southeastern OU1 boundary along the eastern portion of East 20th Street. The nature and extent of lower fill/natural soil impacts in adjacent off-site areas will be presented in the RI report of OU2.

NAPL was noted in some of the monitoring wells at the site. Due to the presence of NAPL in monitoring wells at the site, Con Edison submitted an Interim Remedial Measure work plan for NAPL Monitoring and Recovery (ENSR 2008a). This work plan was submitted to NYSDEC on August 18, 2008.

Groundwater in the shallow, intermediate, and deep unconfined aquifer zones beneath the site has been impacted by former MGP operations. Groundwater in the intermediate and deep zones has also been impacted by an unidentified source of chlorinated compounds. The horizontal extent of the shallow groundwater impacts has been defined by the existing monitoring well network. The general area of intermediate and deep groundwater impacts at the site has been determined. The lateral extent of groundwater impacts in the intermediate and deep aquifer zones reaches to the northeast, east, and southeast of OU1 has not been specifically defined based on comparison with groundwater standards. The vertical extent of groundwater impacts has also not been fully defined in OU1. However, unless the evaluation of remedial alternatives or the implementation of remedial actions requires that the groundwater in the area be more fully delineated, additional fieldwork for delineation is not proposed at this time. If additional groundwater delineation data are necessary for remedial alternative evaluation or remedial action implementation, they would be collected during a pre-design investigation.

Soil gas sampling performed during the RI indicates that the soil gas concentrations at the perimeter of the site are lower than the highest soil gas concentrations found at the site during previous investigations. The results from the previous sampling events indicated that the indoor air quality, as measured on each sampling day, was not likely to have been adversely impacted by subsurface intrusion of MGP-related vapors. Based on the results of these sampling events, intrusion of vapors emanating from MGP-related material that may be present at the site was not evident. There does not appear to be any need for additional indoor air sampling or soil gas sampling for MGP constituents at this time; however, an Interim Remedial Measure work plan for Indoor Air Monitoring was developed and submitted to NYSDEC on August 18, 2008.

A qualitative human health exposure assessment was performed to identify the potential exposure pathways associated with impacted media for workers, residents, and visitors in OU1. For OU1, subsurface maintenance or utility workers who perform subsurface excavation work and/or repairs could possibly be exposed to impacted media and controls are recommended to limit potential exposures in these areas. Additionally, building residents, occupants, visitors, and workers could potentially be exposed to indoor air impacts if sub-slab construction activities are performed and controls are recommended to limit exposure during these activities. Therefore, subsurface work should only be performed by properly trained personnel, using methods specified in the draft interim SMP (ENSR 2008c). Remedial options for these areas will be evaluated in a alternatives analysis report. Exposure of residents and visitors to MGP residuals is considered to be unlikely.

Based on the combined findings of the SCS and RI, additional investigative work is not recommended for surface soil, upper fill soil, soil gas, lower fill/natural soil, or groundwater within OU1. Additional delineation of subsurface soil and groundwater MGP-related impacts is not necessary to begin remedial alternative development and evaluation for impacts identified within OU1.

8.0 Recommendations

Based on the combined findings of the SCS and RI, the following activities are recommended for the site:

- The general delineation of subsurface soil and groundwater impacts associated with the former MGP within OU1 has been completed to a sufficient degree to begin the evaluation of appropriate remedial technologies and the development and evaluation of remedial alternatives for the impacts identified at the site for inclusion in an alternatives evaluation report. It is recommended that the remedial action evaluation for OU1 be initiated. If additional delineation data are necessary for remedial alternative evaluation or remedial action implementation, it is recommended that they be collected during a pre-design investigation.

- Implement the Interim Remedial Measure work plan for NAPL Monitoring and Recovery

- Implement the Interim Remedial Measure work plan for Indoor Air Monitoring

- Perform subsurface work with properly trained personnel and using methods specified in the draft interim SMP

9.0 References

Bouwer, H., 1989. “The Bouwer and Rice Slug Test – An Update”, Ground Water, Vol. 27, no. 3, pp. 304-309.

City of New York Department of Public Works, 1967. Map, Division of Sewage Disposal, Bureau of Sewage Disposal Design P.W. 53 Newton Creek Pollution Control Project, July 1967.

ENSR Corporation, 2007, Interim Remedial Investigation Report, East 21st Street Site, New York, NY, September 2007

ENSR Corporation, 2007, Supplemental Remedial Investigation Work Plan, East 21st Street Site (OU1 and OU2), November 2007

ENSR Corporation, 2008a, Draft Interim Remedial Measure Work Plan Nonaqueous Phase Liquid Monitoring and Recovery, August 18, 2008

ENSR Corporation, 2008b, Draft Interim Remedial Measure Work Plan Indoor Air Sampling, August 18, 2008

ENSR Corporation, 2008c, Interim Site Management Plan for Invasive Activities In and Around Peter Cooper Village and Stuyvesant Town, Manhattan, NY, August 2008

Haley & Aldrich, Inc. (H&A), 2003. Site Characterization Work Plan, January 2003, revised June 2003, revised September 2003.

H&A, 2004. Site Characterization Report Draft, November 22, 2004.

H&A, 2004. Electronic Base Plan: Composite Utility Plan: Figure 1. Map. 2004.

Langan Engineering & Environmental Services, P.C. (Langan), 2001. Report of Geotechnical Study and Preliminary Environmental Evaluation, April 21 2001.

Langan, 2002. MGP Research Report: East 21st Street Works, September 25, 2002.

Langan, 2004. Site Characterization report, Former East 21st Street Works Manufactured Gas Plant Site, Peter Cooper Village Housing Development, New York, New York., 2004.

Leonard J. Strandberg & Associates, Inc, 2002. SCS site map surveys, on behalf of Mathews-Nielsen Landscape Architects, New York, NY and Rose Associates.

Merguerian, Charles, 1996. “Stratigraphy, structural geology, and ductile and brittle faults of New York City”, The Geology of New York City and Vicinity, Field guide and Proceedings, New York State Geological Association, 68th Annual Meeting, Staten Island, NY, p. 53-77.

New York State Department of Environmental Conservation (NYSDEC), 1994. Technical and Administrative Guidance Memorandum (TAGM) 4046, 1994.

NYSDEC, 2002. Draft DER-10 Technical Guidance for Site Investigation and Remediation, December 2002.

Peter Cooper Board of Design, NY, NY, 1947. Site Plan of Outside Utilities. Map. August 21, 1947.

The RETEC Group, Inc. (RETEC), 2004. East 21st Street Works Site Comprehensive Report of Evaluation of Indoor Air and Soil Gas Sampling for Sampling Dates June 2003, August 2, 2003, and March-May 2004, November 2004.

RETEC, 2005. Remedial Investigation Work Plan, East 21st Street Works, NY, NY, November 3, 2005.

RETEC, 2005. Health and Safety Plan for Site Characterization Study, East 21st Street Works, NY, NY, November 11, 2005.

RETEC, 2006, Draft Remedial Investigation Report, Former East 21st Street Works, New York, NY, October 2006

Robert S. Murray L.L.S, P.C., 2006. Survey/Map. East 21st Street (former MGP Site). July 14, 2006.

LiRo Engineers, Inc., 2006. Quarterly Monitoring Report, Stuyvesant Cove Park, April 18, 2006.

York Laboratories, Inc. 2004. Technical Report LiRo Kassner, Inc. Air Results Influent and Effluent Extraction, June 3, 2004.

United States Environmental Protection Agency (USEPA), 1989. Risk Assessment Guidance for Superfund, Volume I. Human Health Evaluation Manual (Part A), Office of Emergency and Remedial Response: Washington, DC, EPA 540/1-89/002, 1989.

USEPA, 1991. Risk Assessment Guidance for Superfund, Volume 1: Human Health Evaluation Manual-Supplement Guidance. “Standard Exposure Factors.” Office of Solid Waste and Emergency Response Directive, 1991.

USEPA, 1997. “Health Effects Assessment Summary Tables (HEAST).” Annual FY 1994, Office of Emergency and Remedial Response, Washington, DC, March 1997.

USEPA, 1999. Integrated Risk Information System (IRIS) [On-line Database]. Office of Health Effects Assessment, Washington, DC, 1999.