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MANAGEMENT AND TECHNICAL RESOURCES, INC.

FINAL DRAFT REMEDIAL INVESTIGATION REPORT

HUGER STREET FORMER MANUFACTURED GAS PLANT
SOUTH CAROLINA ELECTRIC & GAS COMPANY
COLUMBIA, SOUTH CAROLINA

VOLUME I

May 2007

Prepared for:

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CERTIFICATION

"I certify to the best of my knowledge, information, and belief, that the hydrogeology information contained in this report has been prepared in accordance accepted practices of hydrogeology. I further certify that the hydrogeologic elements of the report were prepared by myself or by a subordinate working under my direction."

Mark A. Ferlin
(Name)

Mark A. Ferlin
(Signature)

2332
(South Carolina Registered Professional Geologist Number)

Management and Technical Resources, Inc.
(Company Name)

6/4/07
(Date)

EXECUTIVE SUMMARY

Investigations and a quantitative risk assessment have been performed at the Huger Street former manufactured gas plant (MGP) site (hereinafter Site) located at 1409 Huger Street, Columbia, South Carolina. The Site currently houses the Columbia Area Regional Transit Authority (CARTA) maintenance and dispatching operations. The Site consists of two parcels (Parcel "A" and Parcel "B"); however the focus of the RI Report is Parcel "A" and the Culvert Outfall Area, since investigative and remedial activities have been completed on Parcel "B".

REGULATORY FRAMEWORK AND AGREEMENTS

Voluntary Cleanup Contract (VCC)

On August 19, 2002, SCANA Corporation (SCANA) [on behalf of its primary subsidiary, South Carolina Electric & Gas (SCE&G)] and the South Carolina Department of Health and Environmental Control (SCDHEC) executed a Responsible Party Voluntary Cleanup Contract (VCC) #02-5295-RP for the Columbia Fleet Maintenance Site, also referred to as the former Huger Street Manufactured Gas Plant (MGP) facility. The VCC lists specific requirements that SCE&G must perform to complete the investigation and remediation of the Site.

Cleanup Levels

It is recognized by all project stakeholders that remediation of the Site to residential standards Site wide would be extremely difficult, costly and unnecessary. The VCC acknowledged the likelihood that constituents may remain on-Site, post-remediation, and that land use restrictions may be required:

> *If hazardous substances in excess of residential standards exist at the Site after SCE&G has completed the actions required under this contract, land use restrictions shall be defined in the Certificate of Completion and the Department (SCDHEC) shall enter into a restrictive covenant with SCE&G prior to issuance of the Certificate of Completion.*

SCE&G has an agreement to transfer ownership of the property to the City of Columbia in 2010, after remediation activities have been completed. SCE&G and the City of Columbia have agreed to a cleanup standard consistent with the VCC. An excerpt from the agreement states:

> *The Parties (SCE&G and the City of Columbia) agree that the Huger Street Property will be cleaned up to a standard consistent with nonresidential uses; provided, however, that such uses shall not contemplate child care, health care, or other longer term human uses. Upon completion of the contract (VCC), SCE&G shall request a Certificate of Completion from DHEC.*

Based on the VCC, and consistent with SCE&G's agreement with the City of Columbia, all parties concur that a nonresidential future use scenario and cleanup standard is appropriate. Additionally, SCDHEC will use the CERCLA remedial process to select a final remedy for the Site.

RI FINDINGS

Historical Operations

The former MGP operated from 1906 through 1954. There were a total of three above-grade gas holders at the Site along with tar tanks, pressure vessels, purifiers and other apparatus. After 1954, MGP operations were terminated and the Site was redeveloped to the current day grade and utilized for bus transit operations by CARTA.

Geologic/Hydrogeologic Setting

The Site geology is complex and is largely influenced by past regrading and backfilling activities, and natural geologic processes (e.g., fluvial reworking). The general geologic sequence consists of unconsolidated to semi-consolidated sediments of varying lithologic characteristic overlying consolidated bedrock. Shallow groundwater at the Site is unconfined at a depth of approximately 6 to 25 feet below ground surface (bgs) with flow directed generally to the south.

Impacts to Site Media

Groundwater

Benzene and naphthalene are the primary constituents of potential concern (COPC) for groundwater, are generally limited to the Site (Parcel "A"), are typical of former MGP and UST constituents and have been decreasing with time. MTBE was detected on-Site and off-Site (but below the SCDHEC action level of 0.040 mg/L) and is likely attributable to a gasoline UST.

Soil

The highest concentrations and widest spatial distribution of soil impacts were generally found in the 2-15 feet bgs interval. Soil impacts are generally limited to on-Site, and most prevalent in the central Site area under the existing maintenance building. More recent impacts from the USTs have commingled with the previous soil MGP impacts on-Site. Soil impacts appear to be related to former and/or potential existing sources and to residuals from historical operations. Some impacts to soil were redistributed as the fill was regraded on-Site.

Culvert Water – On-Site

The non-detect constituent concentrations in culvert water samples supports the findings from the culvert video inspection that indicates little to no groundwater is discharging into the 72-inch buried culvert pipe.

Outfall Area

Reconnaissance of the discharge point for the 72-inch culvert pipe (located approximately 1,200 feet south west of Parcel "A") indicates the presence of minor amounts of tar in the sediments. Forensic tests suggest a potential link to a pyrogenic source.

Surface water at the Culvert Outfall Area did not indicate the presence of COPC. For soil adjacent to the Outfall Area, some COPC were detected in both surface and one subsurface soil sample and the source of the COPC are likely from sediments derived from either construction of the outfall or overflow

conditions. As distance increased from the unnamed tributary, COPC and concentrations in soil were found to decrease and when detected are likely from sources independent of the unnamed tributary.

Sediment quality was found to improve as distance increased from the outfall pool area. Sediment samples from the outfall pool indicated the presence of COPC, and visual and olfactory observations of MGP residuals. The source of MGP residuals is speculated to occur as seepage of weathered tar through cracks or joints in the buried culvert (between Parcel "A" and the outfall) and secondarily via undercutting of impacted sediments under the concrete apron.

Soil Gas

The soil gas analytical results indicate a general increase in constituent concentrations with depth. The presence of an urban cover and greater thicknesses of fill material may be contributing to the elevated soil gas concentrations by restricting the soils ability to vent.

NAPL

No dense non-aqueous phase liquids (DNAPL) or light non-aqueous phase liquids (LNAPL) accumulation was observed in any Site monitoring well. DNAPL has been noted in lithologic samples and is most prevalent in the central eastern Site area. The presence of a low K clay, saprolite, or granite layer below the higher K unconsolidated sediments will generally act to impede the vertical movement of DNAPL.

To the north and west of this Site area, DNAPL presence is more sporadic and to the south DNAPL is found at depth. DNAPL impacts in the southern Site area are believed to represent residuals from the former MGP that were redistributed through Site regrading and backfilling. When observed, the DNAPL appears to be highly weathered and sometimes brittle.

Source Areas

The potential extent of source areas is approximate and includes former MGP structures, existing or abandoned USTs and associated equipment, and the presence of free-phase and/or residual DNAPL in lithologic samples.

RISK ASSESSMENT

The Risk Assessment is comprised of four parts, including:

1. Identification of COPCs for Parcel "A" and the Outfall Area are listed on Tables ES-1 and ES-2, respectively;
2. Exposure assessment;
3. Toxicity assessment; and,
4. Risk characterization.

COPC in the various media include the volatiles BTEX, styrene, MTBE, and 1,2,4-trimethylbenzene; various PAH compounds, and the following metals: arsenic, cadmium, chromium, copper, mercury, and thallium.

SCDHEC follows the National Contingency Plan (NCP) guidance that defines 1 x 10^{-6} as the point of departure for risk level. The NCP recommends use of the 1 x 10^{-6} risk level as a point of departure for determining remediation goals for alternatives when ARARs (Applicable or Relevant and Appropriate Requirements) are not available or not sufficiently protective because of the presence of multiple contaminants or multiple exposure pathways. However, EPA does state the use of 1 x 10^{-6} expresses EPA's preference for remedial actions that result in risks at the more protective end of the risk range but does not reflect a presumption that the final remedial action should attain such risk levels. Therefore, for purposes of the RI, the point of departure risk level of 1 x 10^{-6} is used to evaluate the risk assessment results. The final risk level achieved is a delicate balance of practicability, effectiveness, and cost to achieve a risk level appropriate for the future Site use and amenable to the Parties involved and could include a target risk level of 1 x 10^{-4}, which falls within EPA's acceptable risk range of 1 x10^{-6} to 1 x 10^{-4}, and a target hazard index of 1. Table ES-3 and ES-4 lists the receptors, pathway, and subsequent estimated risk level and hazard index for Parcel "A" and the Outfall Area, respectively.

CONCLUSIONS

Based on this RI Report and the Site-specific Risk Assessment, the following conclusions are provided for:

Parcel "A"

- Off-Site groundwater is not impacted.
- Groundwater is minimally impacted on-Site and constituent concentrations appear to be decreasing over time. Remedial actions for source material (DNAPL and/or impacted soil), both saturated and unsaturated, will likely be completed, which may result in further decreases of dissolved phase constituents in Site groundwater.
- Surface soil is impacted and will require remedial action, in areas to be determined.
- Subsurface soil is impacted and will require remedial action, in areas to be determined.
- Numerous receptors have estimated risk levels and/or hazard indices above the point of departure value of 1 x 10^{-6} and/or 1, respectively.

Outfall Area

- Culvert water and surface water are not impacted.
- Visual and olfactory observations of sediments in the outfall pool area indicate the presence of MGP residuals, which may require a remedial action.
- Surface soil adjacent to the outfall pool may require remedial action.
- Only one receptor [recreational user (1-6 years old)] was found to exceed the point of departure value of 1 x 10^{-6} and the hazard index was not exceeded.

FUTURE ANTICIPATED ACTIVITIES

Sediment

A video survey will be used to confirm or refute the presence of tar seeps in the buried culvert extending from Parcel "A" to the outfall location. If tar seeps are present this information will be used in evaluating remedial options.

Soil

The presumptive soil remedy is excavation. Additional soil delineation will be performed to define excavation boundaries and represents an element of remedial design. The use of a risk-based approach to define horizontal excavation extent in surface soil will be used to the extent practicable.

Remedial Action Objectives

Mutually agreeable Remedial Action Objectives (RAOs) will be developed for the Site after SCDHEC has an opportunity to review and comment on the RI Report and the risk assessment. As discussed, for RI purposes, the risk levels will be compared to the point of departure value 1×10^{-6} and hazard index of 1. The RAOs will be developed in a manner that is commensurate with a remedial alternative that balances practicability, effectiveness, and cost to achieve a risk level appropriate for future Site use and amenable to the Parties involved. Since the intended future use of the Site may be mixed use (i.e., different receptors and exposure scenarios may be present on various portions of the Site), the RAOs will be developed to be protective of each receptor that may have potential exposures at the Site. Therefore, it is anticipated that the final remedial action objectives could represent a range of risk levels and may also consider institutional controls if the cost and/or technology is not sufficient in achieving an expected beneficial risk level.

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1.0 INTRODUCTION

1.1 Purpose

This document presents the Huger Street former Manufactured Gas Plant (MGP) Remedial Investigation Report (RI Report) prepared for South Carolina Electric & Gas Company (SCE&G) a major subsidiary of SCANA Corporation (SCANA). The Huger Street former MGP is located in Columbia, South Carolina as shown on Figure 1-1.

In general, RI reports provide a concise understanding of the nature and extent of impacts, physical setting of the Site and factors influencing constituent migration, and potential receptors and the risk(s) posed to receptors. This information is used to develop remedial action objectives and ultimately provides the basis for potential remedial approaches evaluated in the feasibility study (FS).

This RI Report is intended to meet the following specific objectives:

- Consolidate existing Site data;
- Refine the physical Conceptual Site Model (CSM);
- Develop a Human Health and Ecological CSM; and
- Develop a Quantitative Risk Assessment.

An extensive analytical and physical database exists from previous investigations. To the extent practical, the information from various investigations has been incorporated into a unified data set representative of a particular media (e.g., soil analytical data). Previous investigations have been useful in characterizing subsurface conditions and geologic conditions potentially influencing the vertical and horizontal extent of impacts.

1.2 Regulatory Background

This RI Report meets one requirement of the Responsible Party Voluntary Cleanup Contract (VCC) #02-5295-RP, executed by the South Carolina Department of Health and Environmental Control (SCDHEC) on August 19, 2002 and SCE&G. Originally, the VCC incorporated two parcels of land owned by SCE&G, totaling approximately 7 acres, which are referred to as Parcel "A" and Parcel "B" as shown on Figure 1-2. Parcel "A" is 5.88 acres in size and represents the operational site of the former MGP. Parcel "A" is the focus of this RI report.

The VCC enumerates specific requirements that SCE&G must perform to complete the investigation and remediation of the Huger Street former MGP site (Site). Submittal of the RI report, including the quantitative risk assessment is a major step within the VCC process. In addition, an agreement exists between SCE&G and the City of Columbia (The Parties). The agreement indicates "The Parties agree that the Huger Street property will be cleaned up to a standard consistent with non-residential uses; provided, however, that such uses shall not contemplate child care, health care, or other longer term human uses. Upon completion of the contract, SCE&G shall request a Certificate of Completion from DHEC." SCDHEC will use the CERCLA remedial process to select a remedy for this Site.

Parcel "B" is 1.11 acres in size and is located to the south of Parcel "A" and Williams Street. Parcel "B" did not contain any MGP operations. More recently, Parcel "B" has been the subject of additional investigations due to redevelopment interests and is being reported to SCDHEC separately. Therefore, Parcel "B" is not addressed in this RI Report, but relevant information is available within the public record.

1.3 Site Background

1.3.1 Site Location

The Site is located at 1409 Huger Street in Columbia, South Carolina. The Site is situated in the western portion of the City of Columbia, near the Congaree River as shown on Figure 1-1. The former MGP operations were generally situated on a city block (Parcel "A"), which is bounded by Huger Street to the east, Washington Street to the south, Williams Street to the west, and Hampton Street to the north (Figure 1-2). Existing structures on Parcel "A" are also shown on Figure 1-2. Parcel "B" is located to the south of Parcel "A" and is bounded by Huger Street to the east, Williams Street to the north, Kline Steel Property to the south and SCE&G property to the west.

1.3.2 Site History

The following Site history was summarized from the "Final Report Subsurface Investigation of a Former Manufactured Gas Plant Site at the South Carolina Electric & Gas Columbia Fleet Maintenance Center, Columbia, South Carolina" (META 1998).

Manufactured gas plant operations were started at the Site as early as 1906 and were discontinued in 1954. Initially, the Columbia Railway Gas and Electric Company (a corporate predecessor to SCE&G) operated the Huger Street MGP. Over the approximate 48-year operational period, gas was produced initially by the coal gas process and later primarily by the carbureted water gas process until the plant was shut down in 1954. Figure 1-3 shows the location of the former structures associated with the MGP process during the operational period.

Review of Sanborn maps show that in 1910, several MGP features were noted and included a 60,000 cubic foot gasholder (Gasholder #1), gas works building, rail lines, and a coal trestle (Appendix A). Between 1910 and 1919, a second gasholder (Gasholder #2) with a capacity of 300,000 cubic feet was added, the coal trestle was extended to the southern property edge near Washington Street, and several oil tanks were observed near the gas works building. In addition, the Columbia Granite Company occupied the northwestern portion of the property and coke piles could be observed in the northeastern portion of the property.

From the 1920's through the 1940's rapid expansion of the plant continued. A third gasholder (Gasholder #3) with a capacity of 500,000 cubic feet was added in 1921. Other MGP structures constructed included retort house, high-pressure gas tank, and two coke trestle extensions (between retort building and gas works building, and west from retort house to Williams Street). By 1950, the Columbia Granite Company and Electric Plant structures were demolished and the Site was listed as being owned by South Carolina Electric and Gas Company. A 1950 Sanborn Map showed two tar tanks just to the south of the gas works building complex. The highest gas production for the Site occurred between 1940 and 1950.

Gas operations decreased from 1950 to 1954 as gas production was replaced with natural gas service via interstate pipelines. By 1954, continuous natural gas distribution commenced and presumably the Site

was converted into a stand-by facility. Little change appears to have occurred at the Site from 1954 to 1959. Between 1959 and 1966 Gasholder #1, several buildings (retort house and buildings associated with gas works complex), gas tanks, tar tanks, and oil tanks appear to have been removed.

By 1970, only one gasholder and several smaller buildings remained on-Site and a maintenance garage was erected. Currently, the Site is used by the Columbia Area Regional Transit Authority (CARTA) for bus operations and maintenance.

1.3.3 Previous Investigations

The following studies, investigations, and monitoring events were reviewed and incorporated into this RI Report.

Soil Gas

- 1995 – Passive and active soil gas survey completed with GORE-SORBERS (W.L. Gore & Associates and Atlantic Environmental Services, Inc.)
- 2005 - Soil Gas Study (MTR)

Surface and Subsurface soil

- 1996 – Phase I investigations performed (META)
- 1997 – Phase II investigations performed (META)
- 2005 – Data Gaps and Risk Assessment (META)
- 2005 - RI borings and well installations (MTR)

Groundwater

- November 1996 – Comprehensive groundwater monitoring event (META 1997)
- June 1997 – Comprehensive groundwater monitoring event (META 1998)
- April 1998 – USGS monitoring
- June 2002 – USGS monitoring
- June 2003 – USGS monitoring
- April 2004 – USGS monitoring
- June/July 2004 – Confirmatory sampling
- January 2006 - RI sampling
- January 2006 - RI confirmatory sampling

1.4 Report Overview

This RI report is comprised of nine sections including this introduction. Section 2.0 summarizes the completed field activities starting with passive soil gas surveys performed in 1995 and culminating with investigative activities at the Outfall Area of the 72-inch buried culvert pipe in March 2007. Section 3.0 provides the physical characteristics of the Site. Section 4.0 presents the extent of impacts in the various environmental media. The conceptual site model (CSM), including physical migration and fate of constituents is discussed in Section 5.0. The quantitative risk assessment is presented in Section 6.0.

Section 7.0 presents an assessment of various state and federal Applicable or Relevant and Appropriate Requirements (ARARs). A Summary and Conclusions is provided in Section 8.0. Section 9.0 cites the references used to complete the RI Report.

2.0 FIELD INVESTIGATIONS

A chronological narrative of relevant field investigations for the Site is provided below.

2.1 Gore & Associates and AES Soil Gas Studies 1995

Passive and active soil gas surveys were performed from October 1995 through November 1995 by W.L. Gore & Associates (November 1995) and Atlantic Environmental Services, Inc. (May 1996) for purposes of identifying BTEX (benzene, toluene, ethylbenzene, and xylenes) hot spots. The passive soil gas survey employing GORE-SORBERS was performed from October 10 to November 1, 1995. The GORE-SORBERS were installed at a depth of one to two feet below ground surface. A total of 147 GORE-SORBER modules were retrieved and analyzed. The active soil gas survey was performed from October 31 to November 5, 1995. The survey involved the installation of slotted tubing to a depth of 5 feet bgs, soil gas was evacuated with a pump, and a sample was obtained in a gas-tight syringe. A total of 89 active soil gas samples were collected.

Analytical results from the GORE-SORBERS were reported on a mass basis and the active soil gas samples were reported in volt seconds, consequently making a comparison between the two methods difficult (AES May 1996). The AES report found that both methods were effective in identifying BTEX "hot spots", with the active method more sensitive to benzene, and the passive method more sensitive to ethylbenzene and xylene. The 1995 soil gas data was not reported as a concentration but rather in volt second or mass and was deemed to be qualitative and therefore, was not considered further in this report.

2.2 META Environmental

2.2.1 META Phase I Investigations 1996

META Environmental, Inc. (META 1997) performed a Phase I Subsurface Investigation during the week of October 7, 1996 and October 28 through November 4, 1996 to provide data to define extent of impacts in soil and groundwater, determine subsurface geology and hydrogeology, assess GC/FID fingerprints, assess potential soils that may fail TCLP for benzene, and assess remedial measures if possible. The META study involved review of historical information and field implementation tasks. A total of 201 soil samples were collected from 28 soil borings and four groundwater monitoring wells (MW-1 through MW-4) were installed. The monitoring wells were constructed of 2-inch inside diameter (ID) PVC and the screening strategy varied with well location and desired data. Figure 2-1 shows the soil boring locations and Figure 2-2 shows the monitoring well locations.

Soil samples were analyzed for monocyclic aromatic hydrocarbons (MAHs) and polycyclic aromatic hydrocarbons (PAHs) by microscale solvent extraction (MSE) during the Phase I investigations. The MSE methods (MET2508 and MET4007) not only provide a means to quantify constituents but can also

be used to fingerprint the observed constituent. The Phase I samples were analyzed on-Site in a temporary laboratory and a fraction of the soil samples were also analyzed by a South Carolina DHEC approved laboratory using EPA Methods 8260 (volatile organic compounds [VOC]) and 8270 (semi-volatile organic compounds [SVOC]) and for confirmation by GC/MS. Tables 2-1 through 2-3 list the soil samples collected.

One round (November 1996) of groundwater samples were collected from on-Site wells (MW-1 through MW-4) and analyzed for VOC (EPA Method 8260), SVOC (EPA Method 8270), and CLP metals (EPA Methods 3010/6010(a)). The groundwater samples were also analyzed via the MSE Method and the data compared to EPA Methods 8260 and 8270.

Additional details related to soil screening, lithologic logging, well installation, QA/QC, etc. can be found in the META reports (1997 and 1998). The boring logs for M1 through M28 and well construction diagrams for MW-1 through MW-4 are included in Appendix B.

2.2.2 META Phase II Investigations 1997

META phase II investigations (META 1998) were performed during the weeks of June 15 and June 22, 1997. The primary objective of the Phase II investigations was to assess groundwater quality downgradient and off-Site in the vicinity of the former drainage channel, collect on-Site soil samples to fill data gaps, and collect soil samples along the Williams and Washington Street Site boundaries where impacts were observed in shallow soils. The Phase II investigations involved drilling 19 soil borings (M-29 through M-41), collecting 108 soil samples, installing nine additional monitoring wells (MW-5S, 5M, 5D, MW-6 through MW-11) with all but MW-9 installed off-Site, and one complete round of groundwater sampling. Figures 2-1 and 2-2 show the boring and monitoring well locations, respectively. Tables 2-1 through 2-3 list the soil samples collected.

Similar to the Phase I, soil samples were analyzed for MAHs and PAHs via MSE however; the soil samples were analyzed at META's laboratory in Watertown, Massachusetts. A fraction of the samples were also analyzed by a SCDHEC approved laboratory and duplicate samples were also collected for GC/MS confirmation of the MSE results.

Groundwater samples were collected from each monitoring well (MW-1 through MW-11). Samples from both the on-Site and off-Site wells were analyzed for MAHs (EPA Method 8260) and PAHs (EPA Method 8270) by an approved SCDHEC laboratory. Groundwater samples from on-Site wells were also analyzed for PCBs and pesticides (EPA Method 3510/8080) and CLP metals (EPA Method 3010/6010(a)).

Details related to soil screening, lithologic logging, well installation, QA/QC, etc. can be found in META 1997 and 1998 reports. Boring logs and well construction diagrams are provided in Appendix B.

2.3 USGS Groundwater Sampling Events

The United States Geologic Survey (USGS) sampled groundwater at the Site on four separate occasions from 1998 to 2004. The USGS sampled each monitoring well (excluding MW-9) on April 9, 1998. A total of eight wells were sampled on June 13, 2002, June 19, 2003, and April 9, 2004 and included MW-1, MW-2, MW-3, MW-5D, MW-6, MW-8, MW-10, and MW-11. In addition, well MW-4 was sampled on June

19, 2003 and a sample labeled as MW-1R was collected on June 13, 2002 and is assumed to be MW-1. The samples were collected using polyethylene bailers.

The samples from April 9, 1998 were analyzed for benzene, toluene, ethylbenzene, xylenes (BTEX), methyl-tert-butyl-ether (MTBE), and PAHs. The samples collected in 2002, 2003 and 2004 were analyzed for a variety of VOCs and SVOCS. Each sample collected from 2002 and 2003 was analyzed for methane. Some of the 2002 samples were analyzed for trace metals, manganese, and iron.

2.4 MTR Studies and Investigations

2.4.1 Groundwater Sampling 2004

MTR sampled the Site monitoring wells (MW-1 through MW-11) over a two-day period on June 30, 2004 and July 1, 2004, using modified low flow techniques. The groundwater samples were analyzed for BTEX (EPA Method 8260B), PAHs (EPA Method 8270C) and available cyanide (Method OIA 1677). The findings from this groundwater sampling event were provided to SCDHEC in August 2004 (MTR August 2004).

2.4.2 Subsurface Investigation and Utility Identification March 2005

In December 2004, a work plan to further investigate soils was submitted to the SCDHEC (MTR December 2004). The work plan was approved on January 5, 2005.

In March 2005, a total of 19 soil borings (B-1 through B-19) were advanced generally to groundwater using direct push technology (DPT) at locations shown on Figure 2-1. Generally, one surface (approximately 0-2 feet bgs) and one unsaturated subsurface soil sample was collected for laboratory analyses of BTEX (Method 8260B), polynuclear aromatic hydrocarbons (PAHs) and acid extractable phenolics (AEP) by Method 8270C, priority pollutant metals (various 6000/7000 methods), and available cyanide (OIA 1677). Also, samples for geotechnical analyses (porosity, bulk density, and grain size) were collected at a depth of 1-3 feet bgs at soil boring B-10 and 1.5-3.5 feet bgs at soil boring B-12. In addition, samples for total organic carbon analyses were collected from soil boring B-10 (24-24 feet bgs) and B-12 (10-12 feet bgs). Table 2-1 and 2-2 list the samples collected. The findings from the March 2005 subsurface investigation were reported to SCDHEC in May 2005 (MTR, May 2005).

2.4.3 Remedial Investigation

A Draft Remedial Investigation Work Plan (Draft RIWP) was submitted to the SCDHEC for review and approval in September 2005 (MTR, September 2005). SCDHEC provided comments in November 2005 and the Revised RIWP was approved by SCDHEC in December 2005 (MTR, November 2005). The goal of the investigations was to further evaluate groundwater quality conditions on-Site through the installation of seven additional monitoring wells (MW-12 through MW-18), installation of two piezometers (PZ-01 and PZ-02), assess soil gas at seven locations (SG-1 through SG-7), evaluate water quality in a 72-inch buried culvert pipe at an upstream and downstream location (CW-1 and CW-2 within or adjacent to Parcel "A"), and perform two rounds of groundwater quality sampling to further assess groundwater quality conditions.

Monitoring Well and Piezometer Installation

Monitoring wells MW-12 through MW-18 and piezometers PZ-01 and PZ-02 were installed during the week of December 5, 2005 (Figure 2-2). The wells and piezometers were installed with 4¼-inch ID

hollow stem augers. The wells and piezometers were constructed of 2-inch ID schedule 40 – PVC with screen slot openings of 0.01 inches. Each was constructed with a sand pack, bentonite pellet seal, high solids bentonite grout to the surface, and completed as flush mount with surface casing and 2-foot square concrete pad. Downhole drilling equipment was cleaned between each monitoring well location using a high pressure and temperature wash. Based on existing knowledge of the Site geology, split spoon samples were generally collected on 5-foot intervals. Lithologic data from borings B-12 and B-8 were used to install wells MW-12 and MW-15, respectively, since the wells were located in close proximity to these borings. The boring logs and construction diagrams for the monitoring wells and piezometers are contained in Appendix B and the water well records are contained in Appendix C.

Approximately 48 hours after installation, each well was developed by removing approximately 10 well volumes or until the developed groundwater water cleared.

Slug Testing

Each newly installed well (MW-12 through MW-18) was slug tested so groundwater displacement with time data could be collected to determine the hydraulic conductivity (K) of the saturated geologic media screened by the well. Generally, rising head slug tests were performed since typically the groundwater level intersected the well screen. The slug test was performed by lowering a solid slug into the water column, displacing the water and permitting the groundwater level to return to equilibrium, then rapidly removing the slug and activating the *In-Situ* Mini-Troll (pressure transducer) to begin collecting displacement data with time. The test was ended once groundwater levels reached static conditions. In general, two tests were performed at each well. The solid slug, pressure transducer and cable were decontaminated between each well by wiping with a detergent wash, tap water rinse, pesticide grade acetone rinse and tap water rinse.

Culvert Water Sampling

On December 8, 2005, the 72-inch buried culvert pipe was sampled at two locations, one upstream (CW-1) and one down stream of Parcel "A" (CW-2). Figure 2-2 shows the location of the culvert water samples. The water samples were collected approximately two days after a rainfall event (last observed event December 5, 2005) and therefore the samples were not likely influenced from surface water runoff. A peristaltic pump (with dedicated tubing) was used to sample each location. The depth to water was not measured. The catch basin bottom at each sampling location was measured: 16.35 feet (CW-1) and 23.45 feet (CW-2) bgs. Based on visual observations, the water flowing through either location appeared to be less than 0.5 feet deep.

The culvert water samples and analytical parameters are provided on Table 2-4.

Soil Gas Sampling

Soil gas sampling was performed on December 9, 2005, and December 11 and 12, 2005 at seven locations (SG-1 through SG-7) shown on Figure 2-2. The soil gas samples were generally collected on 5-foot intervals (starting at approximately 5 feet bgs) to a maximum depth of 15 feet bgs to provide a vertical profile of soil gas quality. A total of 16 samples were collected and are listed on Table 2-5.

A typical sample was collected by placing a temporary stainless screen inside a DPT macro-core barrel, driving to the desired depth, then pulling the rods back approximately 1 foot to expose the screen. Dedicated polyethylene tubing was placed down the rod to the approximate mid-point of the screen. The

top of the rod's annular opening was sealed with a cork stopper and hydrated bentonite. The annular opening between the rods and ground was also sealed with hydrated bentonite. The "hole" was then purged (with a personal air sampling pump) of at least one volume then the SUMMA canister connected and sampling initiated. A 6-liter SUMMA canister equipped with a flow regulator for a one-hour sampling interval was used to collect the VOC sample. The SVOC sample was collected after VOC sampling was complete. The SVOC sample was collected by attaching the PUF/XAD cartridge to the polyethylene tubing and pulling the soil gas through the PUF/XAD cartridge with a low flow personal air sampling pump. Generally, the flow rate was maintained at approximately 0.8 liters/minute though at some locations lower flow rates (approximately 0.5 liters/minute) were required. With the exception of SG-7-5, approximately 100 liters of soil gas was pulled through the cartridge. Due to pump difficulties encountered at SG-7-5, only 75 liters were pulled through the PUF/XAD. The downhole equipment was cleaned between each sampling location with a detergent wash, tap water rinse, pesticide grade acetone rinse, distilled water rinse and permitted to air dry.

The analytical suite (select VOC and select PAHs) was selected based on the parameter screening provided in the Draft RIWP (MTR, September 2005), augmented with constituents recommended by the SCDHEC, and further refined after reviewing the groundwater analytical results (i.e., MTBE). Table 2-5 lists the analytical parameters and methods. Samples were shipped under chain of custody protocol and analyzed by Analytical Laboratory Services, Inc. (ALSI) in Middleton, Pennsylvania.

Groundwater Sampling

Groundwater was sampled on two occasions in January 2006. The first event (baseline) was completed on January 5 and 6, 2006 and included sampling the newly installed wells (MW-12 through MW-18), obtaining depth to water (DTW) measurements in each on-Site and off-Site monitoring well, and checking for the presence of LNAPL and DNAPL. The second event was performed on January 30 and 31, 2006 and included a confirmatory second round for the newly installed wells (MW-12 through MW-18), sampling existing on-Site wells MW-1 through MW-4, and MW-9, and sampling off-Site wells MW-5S and MW-7. During each event, the depth to groundwater was measured and presence or absence of LNAPL or DNAPL determined. Groundwater purging and sampling was performed using modified low flow techniques. Table 2-6 list the wells sampled and corresponding analyses.

72-Inch Buried Culvert Outfall/Unnamed Tributary Assessment

The 72-inch buried culvert outfall was inspected on December 13, 2005 to assess potential Site-related impacts. The outfall is located approximately 1,200 feet to the southwest of the Site (Figure 1-2). Water flowing in the culvert pipe discharges to an unnamed tributary that ultimately flows to the Congaree River. The unnamed tributary is approximately 500 feet long from the pipe to the river (Figure 1-2).

The assessment involved visually inspecting sediments for the potential presence of MGP or other residual materials and collecting four sediment samples (S-1 through S-4) for fingerprinting forensics by META Environmental (Figure 2-3). A fifth sample (S-5) of weathered tar was also collected from a stone wall of what appeared to be a former bridge. The origin of the weathered tar is uncertain and it is speculated that it may have been applied as a water proofing agent for the stone wall or via surface water transport (and subsequent deposition) from an upstream source.

Investigative Derived Waste

Investigative derive waste (IDW) generated during the December 2005 activities included soil from monitoring well and piezometer installation; and water from decontamination, well development, and well purging. Soil cuttings were placed in a roll-off box and disposed of as a non-hazardous waste at Waste Management's Richland County Landfill located in Elgin, South Carolina. Water was contained in 55-gallon drums and disposed at Nu-Way Environmental Services in Lexington, South Carolina. Nu-Way Environmental Services performed the disposal activities and Appendix D provides the documentation for disposal.

2.4.4 Remedial Investigation Culvert Outfall Area

A Draft RIWP to further investigate the Culvert Outfall Area (Outfall Area) was submitted to SCDHEC in February 2007 for review and approval (MTR, February 2007). SCDHEC provided comments to the Work Plan on March 13, 2007. A letter concurring with the comments was forwarded by SCANA on March 14, 2007. The field activities were performed during the week of March 26, 2007. This investigation involved collecting surface water, sediment, and soil samples to assess the quality of these media and provide data for a quantitative risk assessment. The samples collected are shown on Table 2-7 and were analyzed for BTEX and PAH by Shealy Environmental located in Cayce, South Carolina.

Surface Water Sampling

Surface water samples SW-01 through SW-04 were collected from the Outfall Area on March 27, 2007 during apparent base flow conditions. Surface water sample SW-01 was located at the outfall and represents the upstream background location. SW-02 and SW-03 were located within the middle segment of the unnamed tributary and were sampled above (SW-02) and below (SW-03) the waterfalls. Sample SW-04 was the furthest downstream sample and was collected prior to the confluence with the Congaree River. Figure 2-4 shows the approximate locations. Samples were collected by submerging a one-liter amber sample container to the midpoint of the water column, opening the lid and filling the container. To prevent loss of the acid preservative, BTEX samples were obtained by gently pouring the contents of the one-liter container into the 40mL BTEX sample vial. The PAH samples were obtained by submerging a one-liter amber sample container to the midpoint of the water column, opening the lid, and filling the container. Sample SW-03, located below the waterfall was obtained above the water column mid-point due to water depth (deep) at that location.

Sediment Sampling

Sediment samples SD-01 through SD-04 were collected at the same locations (or as close as possible) as surface water samples SW-01 through SW-04 (Figure 2-4). Sediment samples SD-05 through SD-11 were collected from the outfall pool, which is located immediately below the outfall's concrete apron and above the waterfalls (Figure 2-4). Sample SD-11 was collected from a depth of 1 to 1.5 feet into the sediment. Samples SD-01 through SD-10 were sampled over a depth interval from 0 up to 1.0 feet below the unnamed tributary bottom. All of the sediment samples collected were submerged.

Sediment samples SD-01 through SD-04 were obtained by scooping sediment directly with disposable plastic sampling scoops. The sediment was placed into a stainless steel mixing bowl and immediately sampled for BTEX. The remaining sediment was then homogenized and the PAH sample was obtained. A dedicated acetate liner was used to obtain sediment samples at SD-05 through SD-11. The liner was driven to the desired depth, retrieved and then the contents transferred into a stainless steel mixing bowl.

The BTEX sample was collected first, then the remaining sediment was homogenized and PAH sample collected.

Soil Boring Drilling and Sample Collection

A total of twelve soil borings (SS-1 through SS-12) were advanced adjacent to the Outfall Area using DPT drilling methods or via hand augering (Figure 2-4). Soil borings SS-7, SS-9, SS-10, and SS-11 were drilled with DPT and the borings were continuously sampled (with a macrocore sampler) to a depth of 15 feet bgs or until refusal was encountered. On the north side of the Outfall Area, soil borings SS-1 through SS-6, and SS-12 were advanced with a hand auger (equipped with a 0.5 foot long bucket) since this area could not be accessed with the DPT rig. A hand auger was also used to advance SS-8 since the DPT rig could not access this location.

For the DPT borings, each acetate liner was opened, screened with a MiniRae (photoionization detection [PID] meter equipped with a 10.6 eV lamp), visual and olfactory observations noted (if any), lithologically described, and sampled (if necessary). Soils that were collected continuously with the hand auger were screened using a similar process. Geologic logs for both DPT borings and hand auger borings are provided in Appendix B.

The soils samples collected for laboratory analyses of BTEX and PAHs included surface, subsurface unsaturated, and subsurface saturated (Table 2-7).

In-Stream Sediment Probing

Sediment in the outfall pool was physically evaluated for the presence of MGP residuals. The investigations involved establishing 4 transects located approximately 5, 10, 15, and 20 feet downstream from the edge of the concrete apron. A probe (PVC pipe) was then used to manually penetrate and disturb the sediment. Observations from the physical agitation (i.e., sheens, blebs, etc.) were recorded. The sediment was probed every two feet along the transect. Figure 2-5 shows the probing locations.

Investigative Derived Waste

IDW included soil cuttings and decontamination water. Both of these media remained segregated and placed in 55-gallon drums. The drums were staged in a locked building located on Parcel "A" for future proper disposal.

3.0 SITE PHYSICAL CHARACTERISTICS

3.1 Surface Features

The Site (i.e., Parcel "A") is currently used by the CARTA for bus repair, maintenance, and parking and occupies the area between Huger, Washington, Williams, and Hampton Streets. In support of the transportation activities, the majority of the Site is paved and includes a number of buildings with offices, garages, storage, etc. The Site is surrounded by a chain link fence bordering the aforementioned streets. Grass and gravel cover may be found in the northwestern Site area, and to the north and west of the chain link fence between Hampton and Williams Streets. The ground surface elevation ranges from

approximately 182 feet in the southern and approximately 203 feet in the northern Site areas. Figure 3-1 shows the surface features and a large-scale topographic map is included in Appendix A.

Historically, the Site topography consisted of a ravine (and likely flowing stream) trending from the east central to southwestern Site area. Based on review of aerial photographs and Sanborn maps (Appendix A), it appears that the ravine was filled in approximately 1967 to 1970 and included installing a 72-inch reinforced concrete culvert to convey flow from the former stream, which drained the upland areas of Columbia. The approximate location of the ravine and former channel may be inferred by the trace of the 72-inch buried culvert (Figure 3-1). Catch basins CW-1 and CW-2 were surveyed and depth to bottom of basins were measured at 16.35 and 23.50 feet, respectively. Bottom elevations were 171.41 feet (CW-1) and 159.05 feet (CW-2).

In addition, Figure 3-1 shows the location of other above ground or below grade utilities. In general, the majority of the utility locations have been surveyed while others (e.g., fiber optic line) have been approximately located. Additional, unknown or abandoned utilities may also be present in the subsurface.

3.2 Meteorology

The Site climate may be characterized as humid subtropical (Newcome 2003). Summers tend to be hot and humid, average 80.5° F, with temperatures rarely exceeding 100° F. Conversely, the winters tend to be mild with an average temperature of 48.6° F. July is usually the hottest month and January is typically the coldest month.

According to Newcome, the long-term average rainfall is 45 inches per year. Rainfall is well distributed throughout the year with the highest rainfall amounts (5.54 inches) falling in July and the lowest rainfall amounts (2.26 inches) falling in October.

3.3 Surface Water

A surface water body does not exist on or adjacent to the Parcel "A". The Columbia Canal and Congaree River are located approximately 800 feet to the west of the Site (Figure 1-1). As previously described, a former ravine and stream channel existed during the operational period of the former MGP. A 72-inch culvert pipe was likely placed in the former channel and backfilled to existing grade. Water found in the culvert pipe likely emanates as urban run-off from rainfall events and upstream groundwater discharges to open channel areas, or potentially through upstream culvert openings. The culvert discharges approximately 1,200 feet to the southwest of the Site into an unnamed tributary that flows to the Congaree River.

The 72-inch buried culvert outfall discharges onto a concrete apron that was constructed when the culvert was extended to this off-Site area (Figures 2-3 and 2-4). The culvert outfall provides the head waters for the unnamed tributary which is approximately 300 feet in length, is deeply incised, and flows into the Congaree River (Figure 2-4). The unnamed tributary consists of a pool near the outfall formed by sediment scouring during storm events. The unnamed tributary bottom slopes gradually to the man made waterfalls. From the waterfalls, the unnamed tributary slopes steeply towards the Congaree River. The confluence of the unnamed tributary with the Congaree River is characterized by a standing pool of water near the eastern bank of the Congaree River. The bottom of the unnamed tributary is comprised of rocks

and finer grained sediments. In general, the water current can be relatively fast due to the steep sloping bottom of the unnamed tributary.

3.4 Geology and Hydrogeology

3.4.1 Geology

The Site is situated in the Upper Coastal Plain Province (Johnson 1972) and south of the Fall Line separating Cambrian Carolina Slate Belt crystalline rocks from unconsolidated sediments. Subsurface investigations performed by META and MTR (META 1996 and 1997; MTR March and December 2005) focused on the unconsolidated sediments.

The Site geology is characterized by five distinct lithostratigraphic units (granite, saprolite, fluvial deposits, coastal terrace deposits, and fill) deposited unconformably over-time (Figure 3-2 through 3-6). The general stratigraphic sequence is characterized by unconsolidated sediments overlying saprolite (or at some locations regolith) that generally is found over crystalline bedrock. The crystalline bedrock is the oldest geologic unit (Paleozoic) and generally consists of granite (Columbia) intruded during the Hercynian age (META, March 1998). The saprolite represents weathered crystalline rock and given the presence of foliation and clay in a number of samples logged suggests a parent rock of granite or gneiss. At limited locations, regolith was also encountered. Saprolite was generally encountered in the northern and southern Site areas at a depth ranging from 10-30 feet bgs and may be absent in the former stream channel due to down cutting of the stream. Granite crystalline rock was encountered in a limited number of locations and appeared to be more prevalent in the southern Site area in the vicinity of the former stream channel since it may have provided a competent surface preventing or minimizing down cutting of the former stream channel.

Three separate unconsolidated units have been identified for investigative purposes and include fill, fluvial deposits, and coastal terrace deposits. Due to the Site depositional history and anthropogenic influences, correlation of unconsolidated units can be difficult. The following discusses each unconsolidated unit, starting with the oldest (fluvial) and proceeding to the youngest (fill).

The naturally occurring unconsolidated sediment correlation can be difficult given that the Site area is located near the boundary of the Upper Coastal Plain Province (Tertiary) and Cambrian Crystalline Bedrock and likely influenced by Quaternary reworking of sediments via surface water bodies (i.e., Congaree River and tributaries). The Site location with respect to the physiographic provinces suggest that depositional boundaries are likely fluvial and marine. The following presents the depositional history interpretation and is provided in an effort to stratigraphically correlate the "major" unconsolidated units.

Two depositional periods of fluvial deposits are believed to have occurred at the Site. Fluvial deposition is typically characterized by a fining upward sequence, can have abrupt lithologic changes over a short distance, and typically shows a concave upward shape. The oldest fluvial deposits lie unconformably above the saprolite, regolith and granite bedrock (generically Low K layer). These deposits are lithologically characterized by brown, tan, orange fine to coarse sand (with trace gravels, silt, clay), are generally persistent over the Site, can have variable thickness and in some locations may be absent. On-Site, the bottom elevation of the fill layer is approximately 170 feet. The most significant down cutting appears to have occurred just off-Site in the vicinity of MW-5S/M/D where a distinct asymmetrical concave upward expression of the fluvial deposits are noted as well as increased thickness of the fluvial

deposits. The actual age of the fluvial deposits is not known but is believed to be Tertiary (possibly Cretaceous). The extent of the fluvial deposits is shown on Figure 3-3 through Figure 3-6.

Lying above the fluvial deposits is a red sand and clay (with varying amounts of sand and clay), which is encountered near surface in the northern and southeastern Site areas. The actual depositional environment and age of this unit is not well known but is believed to be related to coastal plain deposition. Johnson (1972) shows the presence of Cretaceous coastal plain sediments over the Site whereas Aucott et. al. (USGS 1987) provides a description of Quaternary coastal terrace deposits that are similar to those (i.e., red sand and clay) observed at the Site. In addition, Maybin and Nystrom (1995) show coastal plain Quaternary Pleistocene sediments potentially present (due to the scale of the map) at the Site and could support the description provided by Aucott. To add another interpretation, Johnson (1961) specifically cites "red loess deposits and clay sands" while conducting a field trip and traveling north on Huger Street and indicates that not much work has been performed on this unit and speculates that the deposits are Pleistocene estuary or well developed paleosols. Based on the description provided by Aucott and potential extent shown by Maybin and Nystrom (1995) and speculation provided by Johnson (1961) it is believed that the red sand and clay is Quaternary (Pleistocene age) and deposited during a transgressive/regressive sequence of the Atlantic Ocean. It is possible that at some Site locations, sediments comprising the coastal plain terrace deposits were reworked by natural or anthropogenic processes, constructing buildings, fill, etc.

Following deposition of the coastal terrace deposits, it appears that the Site geology was further influenced by another episode of fluvial erosion and deposition. This fluvial erosive sequence is evidenced by the downcutting of the coastal terrace and subsequent deposition in the southern on-Site (paleo stream channel) and off-Site areas. Borings logs reviewed do not show a distinct difference in lithology to separate the older fluvial sediments from the younger. Therefore, the fluvial deposits are correlated collectively with the younger deposits believed to be more recent (Quaternary age).

Anthropogenic fill completes the Site geology and may include borrow material used to fill the former ravine, reworked naturally unconsolidated or consolidated (granite) sediments, former MGP residuals, debris, etc.

3.4.2 Site Hydrogeology

The shallow groundwater bearing unit at the Site (Parcel "A") is unconfined and may be encountered at depths ranging from approximately 9.0-23.5 feet bgs (Tables 3-1 and 3-2). The depth to groundwater is influenced by Site topography and hydraulic influences of the paleo stream channel. The shallow groundwater bearing unit matrix on-Site is comprised primarily of the unconsolidated sediments ranging from the fluvial deposits to fill. At Site locations where former bedrock relics are preserved and were not downcut by fluvial processes e.g., MW-2, MW-13 and MW-18), groundwater is found in saprolite. The saturated thickness on-Site can range from approximately 2 to 11 feet (Figure 3-3 through 3-6). Off-Site and to the south (MW-5S/M/D, MW-6, MW-10, MW-11), the shallow groundwater bearing unit is more developed in the fluvial deposits attaining a saturated thickness of approximately 5 to 14 feet. Therefore, given the complexity of the geology, no specific geologic unit is designated as the groundwater bearing unit but rather is characterized by wells that have screens intersecting the groundwater table or are fully screened in unconsolidated deposits (fluvial, fill or coastal terrace).

Based on observations made during drilling, clay (likely kaolonite) saprolite, regolith, and granite exist at depth at the Site. The saprolite will yield water but given the lithologic fraction of the parent rock (primarily silt, clay), it is believed that the yield from this unit is low. Horizontal hydraulic conductivity (K) measurements from wells MW-2 and MW-13, which are partially and fully screened in the saprolite yielded hydraulic conductivity measurements of approximately 0.5 feet/day (Table 3-3 and META 1998). In comparison, wells screened in fluvial or fill/fluvial deposits (MW-5, 5M, 12, 14, 15, 16, and 17), yielded K of 2.7 feet/day to 82.7 feet /day (Table 3-3 and META 1998). The regolith should show similar to lessened hydraulic characteristics. The granite bedrock would likely yield the lowest quantities of water and only if fractures or joints are developed and encountered. Therefore, it is believed that with depth at the Site, the ability of a well to yield water will become increasing difficult.

Slug testing was performed at the newly installed wells (MW-12 through MW-18) to provide data to estimate hydraulic conductivity (K). Rising head test were performed on wells MW-12, MW-14, MW-15, MW-17, and MW-18 since the water table intersected the well screen. Both rising and falling head slug test were performed on MW-13 and MW-16 since the well screen was situated just below the water table. At least two tests were performed at each well. The estimated K was found to range from 0.5 feet/day (MW-13) to 82.7 feet/day (MW-16). Well MW-13 screened in the saprolite yielded the lowest estimated K whereas paleo stream channel deposits (MW-16) yield the highest K. Table 3-3 provides the estimates of K and associated hydrogeologic unit and Appendix E provides the displacement with time plots and subsequent curve matches. Slug test data from well MW-18 was not used since limited displacement occurred during the test due primarily to the limited saturated thickness at this well.

Groundwater level measurements from January 5, 2006 and January 30, 2006 were used to determine groundwater elevations to develop groundwater contour maps (Figure 3-7 and 3-8). Figures 3-7 and 3-8 indicate groundwater flow converges in the area of the paleo stream channel deposits and 72-inch buried culvert. Groundwater convergence is believed to be influenced by the presence of high K fill material comprising the paleo stream channel deposits (MW-16 and MW-17, Table 3-3), increased fluvial deposit thickness (Figure 3-6) and the presence of horizontally bounding low K units. The 72-inch buried culvert is not believed to have a significant role on influencing groundwater flow since results of the video survey performed in June 2005 indicated that coal tar was not present in the pipe and only minor water seepage was observed and manifested as "leached lime" residue (MTR September 2005). As distance increases to the south on-Site, less of the 72-inch buried culvert is submerged in groundwater (Figure 3-6 through 3-8), which would further minimize the potential of the culvert to act as a discharge point for groundwater. The resultant effect is the paleo channel deposits can transmit water more easily and may influence saturated thickness and gradients observed over the Site area. The hydraulic gradient in the southern Site area in the vicinity of the 72-inch buried culvert was found to be 0.018 feet/feet whereas the hydraulic gradient measured in the western Site area from MW-13 to near CB-13 was found to be 0.047 feet/feet. Hydraulic gradients are good qualitative indicators of K since steeper gradients suggest low K material and shallower gradients may suggest higher K material. Groundwater flow in the northern Site area does not appear to be influenced by the paleo channel deposits and flow is generally directed to the south.

Linear groundwater flow velocity was calculated to range from 0.8 feet/day to 5.0 feet/day. The higher linear groundwater flow velocity is found in the area of the 72-inch buried culvert and is attributed to K (82.7 feet/day) measured at MW-16. The lower groundwater linear flow velocity was calculated in the western Site area using the average K (5.0 feet/day) between MW-13 and MW-14. An assumed effective

porosity of 0.3 was used. Constituent velocity would be less than linear groundwater flow velocity due primarily to adsorption.

4.0 NATURE AND EXTENT OF IMPACTS

Impacts at the Site can be generically described as volatile and semi-volatile petroleum hydrocarbon compounds associated with by-products (i.e., coal tar) generated by the production of coal gas. Historic releases from underground storage tanks, inadvertent spills, etc. associated with the bus maintenance facility may have also impacted the Site. Since MGP residuals and petroleum products are chemically similar, an attempt to differentiate constituent origin was not made.

4.1 Soil

The soil analytical results are presented on Table 4-1 (surface soil), Table 4-2 (subsurface unsaturated soil), and Table 4-3 (saturated subsurface soil). These tables provide the analytical results and a comparison to U.S. EPA Region 9 PRGs for residential direct contact and soil to groundwater values. This comparison to PRGs was provided as a preliminary screen for the soil data and the potential risks associated with soils will be further explained in Section 6.0. In addition, a summary of the analytical data (i.e., minimum and maximum concentrations, constituents detected, percentage of constituents exceeding screening values, etc.) is presented on Tables 4-1A and B, 4-2A and B, and 4-3A and B.

Given the voluminous soil analytical database, a software package (Visual Groundwater) was used to conceptually present the soil data. The extent of potential impacts and benzo(a)pyrene analytical results in surface soil are shown on Figures 4-1 and 4-2, respectively. Extent of potential impacts in subsurface soil includes: Figure 4-3 (subsurface unsaturated soil 2 to 15 feet), Figure 4-4 (subsurface unsaturated soil 15 feet to groundwater) and Figure 4-5 (saturated soil). As with most computer software, inherent program limitations exist and the boundaries defined may not agree with the data interpretations made manually. Therefore, the graphical representations shown on Figures 4-1, and 4-3 through 4-5, and in Appendix F, are viewed as illustrations with the objective of providing an overall understanding of soil impacts. Figures 4-1 through 4-5 do not differentiate between MGP and petroleum related impacts. Potential sources are discussed further in Section 4.5.

For convenience, marker constituents were selected to show potential impact extent and include benzene, naphthalene, and benzo(a)pyrene. Benzene and naphthalene were selected since these two constituents are commonly associated with coal tar and petroleum residuals, whereas benzo(a)pyrene was included since this constituent typically represents a conservative risk driver. The isopleth interval was selected for ease of presentation.

4.1.1 Surface Soil

Surface soils are defined as those extending from ground surface to an approximate depth of 2 feet bgs. The horizontal extent of surface soils showing marker constituents above the isopleth range identified on Figure 4-1 is generally bounded to the area of the former MGP operations, UST/fuel islands, and portion of the Site backfilled during the 72-inch culvert installation and grading. The areal extent of benzene is limited when compared to naphthalene and benzo(a)pyrene, which appear to have similar areal

coverage. Figure 4-2 provides the available surface soil benzo(a)pyrene analytical results spatially over the Site. The southeastern and northwestern Site areas are noticeably absent of marker constituents above 1 mg/Kg.

4.1.2 Subsurface Soil

Figure 4-3 shows the spatial extent of marker constituents exceeding the defined isopleth concentration range in the 2-15 feet bgs range. Similar to surface soils, impacted subsurface soils demonstrate a northeast/southwest trend with the broadest extent in the central Site area. Naphthalene and benzo(a)pyrene show similar extent; however, the areal extent of benzene is smaller. The highest and most prevalent trends tend to be found in the central Site area under and just to the north and south of the maintenance building. The influence of redistributing MGP impacted material as fill (for the former stream valley) is observed in the southwestern Site area, which was devoid of MGP operations.

Horizontally, numeric dispersion (i.e., over-estimating from software code numerical operations) is noted at several on-Site and off-Site areas in the vicinity of southern Williams Street, and east of the office as shown on Figure 4-3. Over-stating the extent also occurs to the south and western off-Site areas where both naphthalene and benzo(a)pyrene isopleth boundaries extend to boring locations B-14 and B-15 (located on Williams Street) though the analytical data indicated both constituents were either non-detect or found at a concentration below the minimum isopleth range of 1 mg/kg.

Vertically, concentration variability can exist at a boring and over the Site as shown on the fence diagrams contained in Appendix F. Generally, the number of borings demonstrating sustained and elevated concentrations of marker constituents are limited and tend to be found in the general vicinity of the maintenance building and southwestern Site area. Of the marker constituents, naphthalene is the most persistent showing vertical and lateral consistency at depth. Benzo(a)pyrene shows moderate vertical and horizontal continuity with extent in both dimensions less than naphthalene. Benzene impacts tend to be limited and concentrations exceeding 100 mg/Kg are isolated.

4.1.3 Unsaturated Subsurface Soils > 15 Feet BGS

Figure 4-4 shows the horizontal and vertical extent of marker constituents in unsaturated soils at a depth of greater than 15 feet bgs. It should be noted that unsaturated subsurface soil greater than 15 feet bgs only exists in the southern Site area.

Figure 4-4 indicates benzene is below 1 mg/Kg at this depth interval and benzo(a)pyrene does not exceed 10 mg/Kg. Naphthalene is generally characterized by concentrations ranging from 1 to 10 mg/Kg with an isolated concentration occurrence above 10 mg/Kg south of the office building.

4.1.4 Saturated Soils

Figure 4-5 shows the horizontal and vertical extent of impacts in saturated soils. Similar to the previous depth intervals, naphthalene is the most persistent and prevalent marker constituent followed by benzo(a)pyrene, then benzene. The elevated concentrations of naphthalene and benzo(a)pyrene, and to a lesser degree benzene, may be attributed to samples containing source material (tar, residual DNAPL, stains, etc.). The vertical extent of impacts appear to be limited with concentration decreases vertically, which may be characteristic of samples containing source material (e.g., weathered DNAPL).

Another example of the numeric dispersion and over-estimating extent by the presentation software can be noted in the southern Site area and the horizontal extent defined for naphthalene. Based on review of the analytical and boring log data, only the sample from M19 indicated the presence of potential source material (i.e., tarry sand at about 25 feet) and the sample collected from this depth interval indicates elevated naphthalene concentrations.

The tarry sands noted at M19 are likely a remnant of the former stream channel and represents past releases of process water containing DNAPL or DNAPL that settled on the bottom of the former stream. Therefore, since it is believed that the DNAPL is limited to the former stream channel and could also represent accumulation in a depression or topographic low, the horizontal extent is expected to be less than that shown.

4.2 Groundwater

4.2.1 Data Overview

Groundwater analytical data from the July 2004 and two RI groundwater sampling events (i.e., January 5 and January 30, 2006) were used to interpret the extent of dissolved phase constituents. The January 30, 2006 groundwater sampling event was performed to accomplish two objectives; confirm the January 5, 2006 results from the newly installed wells and enhance the database for on-Site and select off-Site wells. Table 4-4 provides the groundwater analytical results and Table 4-4A provides a comprehensive summary of the analytical data (i.e., minimum and maximum concentrations, constituents detected, percentage of constituents exceeding screening values, etc.). Table 4-5 summarizes the historical and January 2006 benzene and naphthalene groundwater analytical results. Appendix G provides the groundwater analytical results. For some of the USGS data, the list of parameters was streamlined to be more consistent with the current constituents of interest. Figures 4-6 and 4-7 are tag maps showing benzene and naphthalene analytical results (and where analyzed, results for MTBE and lead) for July 2004 and the January 2006 groundwater sampling events, respectively.

4.2.2 Extent of Impacts

Figure 4-8 shows the potential extent of impacts in groundwater from the former MGP and from petroleum sources potentially related to USTs. The approximate boundary extent for MGP related impacts were based on the detection of benzene and/or naphthalene in groundwater samples from 2004 and/or 2006. The potential extent of petroleum related impacts is based primarily on the presence of MTBE (and to a lesser degree lead) since MTBE was an additive to gasoline and is not associated with MGP residuals. In the absence of MTBE it may be difficult to separate MGP impacts from petroleum impacts since benzene can be found in MGP residuals, gasoline, and diesel; and naphthalene can be found in MGP residuals and diesel. A number of observations for Site-wide groundwater may be inferred from Figures 4-6 through 4-8 and include:

- MGP-related constituents were not detected off-Site and when detected on-Site were generally found at low concentrations (i.e., approaching detection limits or near groundwater criteria). A petroleum related constituent (MTBE) was found on-Site, and was detected just off-Site and to the south;
- The groundwater analytical results from well MW-13 indicates a higher concentration of COPC from the other on-site wells and is discussed further in this section;

- The northern and southern extent of MGP impacts appear to be limited to the Site, whereas the western and eastern boundary is inferred since physical obstructions (e.g., streets, underground utilities, etc.) preclude installing wells to the east of MW-12 and west of MW-13;
- The western and eastern extent of MGP related impacts is not believed to be extensive given the concentrations detected and groundwater flow pattern at these two Site areas (Figures 3-7 and 3-8);
- Petroleum impacts (MTBE) appear to be horizontally limited;
- Extent of dissolved phase constituents generally coincide with extent of soil impacts;
- Groundwater analytical results are less than anticipated when compared to subsurface observations; and
- Decreasing concentration trends with time.

The following elaborates further on the above points.

Explanation

The potential sources of MGP or petroleum related groundwater impacts may be described as "point" versus "non-point". Potential "point" sources are specific structures that may have housed materials or products associated with a process or in support of an activity and through handling, corrosion, etc. may have released constituents to the environment. The best example of "point" sources are the USTs, tar wells, tar tanks, etc. Potential "non-point" sources may be characterized by inadvertent releases, re-distribution of MGP residuals and may be exemplified by MGP residuals contained in fill, presence of residual or free-phase DNAPL, accidental and inadvertent spills during filling, etc. The 'non-point" sources tend to be distributed over a larger areal extent when compared to "point" sources.

Three constituents were used to assess groundwater quality conditions and include benzene, naphthalene, and MTBE. Lead was also included as a minor indicator. The analytical results are provided on Tables 4-4 and 4-5, shown spatially on Figures 4-6 through 4-8 and indicate the following:

- General decrease of constituents with time;
- Relatively low constituent concentrations with respect to subsurface conditions observed; and
- Minimal horizontal extent.

Temporally, the concentration of benzene and naphthalene has varied with time with a generally decreasing trend (Table 4-5). The decreasing trend may be attributed to natural attenuation processes or could represent seasonal variability.

Dissolved phase benzene and naphthalene appears to be low when subsurface observations are qualitatively compared to the groundwater analytical results. It is believed that the presence of the asphalt paving, concrete surfaces, and buildings over the majority of the on-Site area minimizes vertical infiltration (of precipitation) and subsequently reduces constituent leaching from vadose zone soils. Given the minimal vertical infiltration hypothesis, the resultant groundwater flux would tend to be horizontal with successive flushing and minimal contribution (other than fluctuating water table), which may account for the lower than anticipated dissolved phase benzene and naphthalene constituent concentrations. The exception to the minimal vertical infiltration hypothesis is MW-13 where benzene and naphthalene concentrations are higher when compared to other on-Site wells. Monitoring well MW-13 is located near

a slight drainage swale and topographically downgradient from an above ground diesel storage tank. Inadvertent spills and drips may have become entrained in surface water, which could have migrated through cracks in the asphalt and vertically to groundwater in the vicinity of MW-13.

The horizontal extent of MGP and petroleum related impacts are predominantly limited to the Site. Figure 4-8 was developed to show the approximate extent of impacts and the boundaries were developed based on the detection of benzene, naphthalene, or MTBE. The MGP boundary tends to be widespread and limited to the on-Site area and subsequently suggests MGP residuals with embedded potential point sources (e.g., former structures, DNAPL). MTBE data was used to approximate a point source contribution from a UST located to the south of the maintenance garage.

The hydraulically downgradient segment of the MGP boundary tends to narrow and the petroleum boundary maintains a relatively narrow and long boundary. The hydraulically downgradient segment of both boundaries are influenced by the higher K material of the paleo channel deposits. Typically "plumes" in high K material will manifest as long narrow features whereas low K material will tend to yield broader "plumes". The geologic sediments comprising the paleo channel deposits display high K characteristics and therefore it is expected that the boundaries would be long and narrow.

The attenuative capacity of the shallow groundwater bearing unit can also be observed by the decreasing constituent concentration trend observed along the length of the paleo channel deposits. Figure 4-8 shows a decrease in benzene and naphthalene concentrations from MW-17 to MW-16 and to ultimately non-detect concentrations at MW-5S/M/D, located off-Site. MTBE tends to be more recalcitrant with the highest concentration detected in MW-5S. However, the extent of MTBE appears to be limited since historical data indicates that MTBE was detected at only one well (MW-6) located hydraulically downgradient from MW-5S, on only one occasion (July 1997), and at a low concentration (21 ug/L). Table 4-6 summarizes detected MTBE concentrations. As can be noted on Table 4-6, the MTBE concentrations are below the SCDHEC action level of 40 ug/L.

4.3 Culvert Water

For Parcel "A", the 72-inch buried culvert pipe was sampled at one upstream (CW-1) and one downstream (CW-2) location (Figure 2-2). Analytical results from both samples indicated that constituents were not detected (Table 4-7). Table 4-7A provides a summary of the analytical data. The absence of constituents may be attributed to a lack of pronounced seepage points (i.e., evidence of water trickling, flowing, etc. from the culvert sidewalls) along the culvert as evidenced by the video survey performed in June 2005 and reported to SCDHEC in September 2005 (MTR September 2005). Figure 3-7 and 3-8 shows the groundwater elevation and the inferred invert culvert elevation and indicates an approximate maximum submerged depth of approximately four feet at CW-1 and approximately 0.5 feet at CW-2. The depth of submergence would vary depending on groundwater table fluctuations. Since it appears the culvert is partially submerged in groundwater, the lack of pronounced seepage points may be attributed to the integrity of the concrete pipe.

Groundwater contour patterns may be used to assess the influence of the 72-inch culvert on groundwater flow. Groundwater contours would inflect over the trace of the subsurface structure if the 72-inch culvert was acting as a discharge point to groundwater. The groundwater contour pattern shown on Figures 3-7

and 3-8 do not indicate this inflection, but rather shows inflections to the south of the 72-inch culvert adding further evidence that the culvert does not act as a groundwater discharge point.

4.4 Soil Gas

The soil gas analytical results are shown on Table 4-8 and a summary of the data is provided on Table 4-8A. The MTBE results should be viewed as estimated concentrations since hydrocarbons were found to co-elute with the MTBE. Benzene and naphthalene represent the primary constituents of interest. Analytical results from three locations SG-1, SG-3, and SG-6 indicate non-detect to low concentrations of benzene and naphthalene. The remaining soil gas locations, SG-2, SG-4, SG-5 and SG-7, indicate elevated concentrations of benzene and naphthalene. Figure 4-9 summarizes the results. Four geotechnical samples were obtained at two boring locations and analyzed for total organic carbon, bulk density, and grain size. The results are summarized in Table 4-9 and were used in the vapor intrusion model.

The general vertical trend indicates an increase in constituent concentrations with depth at SG-2, SG-4, SG-5, and SG-7. The results are not unexpected since SG-2 is located near the former tar tanks and tar wells and residual to free-phase DNAPL was observed in lithologic samples collected from SB-4 and the soil gas analytical results likely confirm conditions at this Site area.

SG-4 is located near MW-16, PZ-02, and the buried 72-inch culvert. Observations of subsurface soil conditions at MW-16 and PZ-02 did not indicate the presence of visual or olfactory impacts. Subsurface observations from M19 indicated tar was observed in the tip of spoon over the 24-25 feet bgs interval. Two theories are provided to explain the soil gas analytical results observed in SG-4. The first associates the transport of dissolved phase constituents through the high K paleo channel deposits with subsequent volatilization. Credence for the first theory is substantiated by the presence of MTBE. The second theory associates volatilization of MGP constituents from MGP residuals potentially present on the bottom of the former stream channel. The MGP residuals were likely deposited during the operational period of the former MGP.

Soil gas sampling location SG-5 is located near the former fuel island and former USTs, and the analytical results from SG-5 are not unexpected given the location.

The soil gas data from SG-7 appears to be anomalous when compared to recent (2004 and 2006) groundwater monitoring data from MW-2. However, historical groundwater data from MW-2 indicated elevated concentrations of both benzene and naphthalene until 1998 (Table 4-5 and Appendix G). The concentration of both constituents in groundwater decreased significantly after 1998 and may be related to experimental remedial actions performed by the USGS and The University of South Carolina (USC). Therefore, the analytical results from SG-7 are not unexpected in light of the historical groundwater quality data from MW-2.

The elevated soil gas analytical results from SG-2, SG-4, SG-5, and SG-7 may be interpreted as volatilization of subsurface MGP and petroleum residuals migrating through the vadose zone to the ground surface. Given the presence of asphalt and concrete surfaces and buildings (also referred to as the urban cover), it is believed that the analytical results may represent conservative concentrations since the urban cover may act as a barrier preventing efficient migration of soil gas through the vadose zone to

ground surface and ultimately to the atmosphere. A greater thickness of soil can also act as a partial barrier to escaping vapors.

4.5 Potential Source Areas

Potential source areas are defined based on historical or current use of structures (includes former MGP and petroleum USTs), experience with operations of former MGPs, and the presence of DNAPL. It should be noted that the former MGP structure locations are approximate. Figure 4-10 shows the approximate location and extent of potential source areas.

4.5.1 MGP Potential Sources

Several structures associated with the former MGP have been identified as potential sources. Currently it is not known whether these structures still exist within the subsurface or were removed when the maintenance building was constructed. Two purifier boxes were identified in the northern Site area and based on evidence from boring B-1 it appears that at least one of the purifier boxes is still in place since refusal was encountered at 12.5 feet bgs. Subsurface observations from B-1 suggest potential impacts from 6.8-12.5 bgs. A boring drilled within the limits of the reservoir basin indicated refusal at 9 feet bgs and at a depth interval of 8.8-9.0 feet bgs the appearance of weathered DNAPL with a "taffy-like" consistency was observed. The former use of the reservoir basin is not known. A number of tar wells, tar tanks, and oil tanks are noted in the eastern limits of the maintenance building and the current status (in-place or removed) of these structures is uncertain since the presence of the maintenance building prohibited further investigating these structures. In addition, accessible former gasholder foundations were investigated with four test pits (TP-1 through TP-4) to assess presence of visual MGP residuals (Figure 2-1). Observations from the test pits did not indicate the visual presence of MGP residuals near the former gas holders.

The presence of DNAPL in the subsurface may act as a source of impacts to groundwater or soil gas. DNAPL has been observed in the subsurface with physical characteristics ranging from highly weathered, vitreous, conically fractured solids, to free-phase liquids (observed when placed in a sample container). The highly weathered, vitreous, conically fractured DNAPL is typically associated with fill in the southern portion of the Site and based on appearance is not believed to act as a source to groundwater or soil vapor. In addition, since this highly weathered DNAPL is associated with fill, the horizontal and vertical consistency tends to be random and variable.

The second "class" of DNAPL observed in the subsurface is loosely characterized as that displaying a range of viscosities and descriptively includes semi-solid "taffy-like" to flowing (when placed in a container) free-phase DNAPL. The potential for these DNAPL types to act as a continuing source is not known. Review of borings logs indicate that a number of isolated occurrences of potential DNAPL sources exist over the Site at limited vertical intervals and at some locations have been observed in the saprolite. In the east central Site area and in the vicinity of the maintenance building, subsurface observations indicate the presence of a less viscous DNAPL, found at various degrees of saturation, which is laterally continuous, and vertically is observed over a greater depth interval. In the general vicinity between the maintenance building and the 72-inch buried culvert, the thickness of DNAPL impacts decreased and were found at greater depth.

The potential for vertical movement of DNAPL to greater depths is believed to be minimized due to the presence of low K layers (e.g., clay, saprolite, granite) and absence of DNAPL accumulation in Site monitoring wells (Tables 3-1 and 3-2). Though DNAPL has been observed in some of the low K layers (Table 4-10) this observation is not that unusual since limited quantities of DNAPL may move through fractures, joints, etc as long as sufficient pool height exist to overcome entry pressures.

4.5.2 Petroleum Potential Sources

The potential petroleum sources are primarily USTs and associated equipment used to store gasoline, diesel fuel, waste oil and motor oil and were generally used to support the bus operations (Figure 4-10). Some USTs are still intact, some have been abandoned in place, and some have been removed. An internal SCANA memo (Appendix H) indicates that historical releases have occurred and SCDHEC was involved in the remediation process. The memo generally does not identify specific tanks. The assumed status of the tanks are also shown on Figure 1-3. Monitoring wells located in the vicinity of the USTs did not indicate the presence of light non-aqueous phase liquids (LNAPL).

4.6 Outfall Area Reconnaissance and Investigations

The following provides observations from the December 2005 reconnaissance and forensic sediment sampling, and results of the field investigations performed in March 2007.

4.6.1 December 2005 Reconnaissance

Observations

Visual inspection of the culvert sidewalls at the outfall indicated that tar was not found on the bottom or sidewalls and is consistent with the video inspection performed on the pipe within Parcel "A" in June 2005 (MTR September 2005). Based on a visual inspection of the general area surrounding the outfall and the unnamed tributary, observations of concrete, building demolition debris, wood, asphalt and general fill indicate that this area has also been filled overtime.

Inspection of the sediments in the unnamed tributary indicted the presence of tar blebs and when some of the sediment in the outfall pool was disturbed, tar blooms and sheens were noted (Figure 2-3). The presence of tar blooms and sheens was more notable in the northern half of the unnamed tributary. A sand bar immediately downstream of the concrete apron and located at the northern most extent of the outfall pool indicated the presence of blebs, sheens, and odors (Figure 2-3). Inspection of sediment downstream and below the waterfalls (approximately 50 feet downstream of the outfall) did not indicate the presence of tar and very minor sheens and very faint odors were noted in a limited number of small "puddles" isolated from the primary stream channel. The downstream observations were not pervasive and were limited in extent. In addition, a rock wall located approximately 50 feet downstream of the outfall was observed to have tar coating the surface. It is unknown whether the tar was applied as a waterproofing agent or represents accumulation via transport of the former stream channel from the former MGP. A tar sample was collected from a rock believed to be from the wall.

Forensic Results

Appendix I provides a copy of the Environmental Forensic Report prepared by META Environmental and Figure 2-3 provides the sample locations. In summary, the forensic interpretation provided by META indicated two samples (S-2 and S-4) were classified as mixed sources with a tentative identification of

urban background. Samples S-1 and S-3 were classified as pyrogenic with a tentative identification of tar. Sample S-5 was obviously collected from tar on a rock believed to be from a wall located downstream of the outfall. The origin of the tar is not known but is speculated to be associated with "water proofing" or potentially as a result of transport and deposition from an upstream source.

META further summarizes that "overall, the data indicate that the pyrogenic material in the soil samples is most likely from mixed sources, such as urban runoff, combustion-related sources and potentially MGP residuals. The sources of PAHs in S-2 and S-4 and possibly S-3 appear unrelated to the S-5 sample, however, some fraction of the PAHs may be MGP related".

4.6.2 March 2007 Investigations

Generalized Suburface Observations – Soil

Figure 4-11 provides a topographic view of the Culvert Outfall Area and the approximate soil sampling locations. A total of 12 soil borings were completed in this area. Appendix A provides the boring logs for SS-1 through SS-12. The area to the north and south of the unnamed tributary may be characterized as isolated fill deposits overlying unconsolidated clay, silt, and/or sand that are fluvial in origin. Saprolite likely exists under the fluvial deposits and although not noted lithologically, the presence is attributed to refusal in some of the DPT borings. Olfactory evidence of MGP residuals were not noted during drilling. Asphaltic material was noted at a depth of approximately 1.5 feet bgs in SS-05 and naturally organic occurring "spots" were observed in SS-03 and SS-05.

Analytical Results

The analytical results for surface, unsaturated and saturated subsurface soil samples obtained in the Outfall Area are provided on Tables 4-11 through 4-13, respectively. A summary of the analytical data is provided on Tables 4-11A and B through 4-13A and B. The areal and vertical extent of marker constituents (benzene, naphthalene, and benzo(a)pyrene) are shown on Figure 4-11

The surface soils indicate BTEX is below detection limits and also the presence of some PAH constituents. The PAH constituents detected (in both surface samples) may be related to constituents found in sediment and originated as overbank deposits from flooding events or potentially from material "dredged" during the construction of the concrete apron. The presence of asphlatic material in SS-05 could also contribute to the PAH concentrations observed at this boring location.

The unsaturated [SS-10(2-3)] and saturated [SS-08(5-6)] subsurface soil samples collected to the south of the unnamed tributary did not indicate the presence of BTEX and PAHs constituents (Tables 4-12 and 4-13 and Figure 4-11). Conversely, the unsaturated [SS-03(2-4)] and saturated [SS-05(3-4.2)] subsurface soil samples collected to the north of the unnamed tributary indicated the presence of constituents. Given the sampling depth, the constituents detected at SS-05 may be related to historic overbank deposits or dredging activities. SS-03 is located in an area where fill was observed and may be unrelated to conditions within the unnamed tributary. The origin of the fill is not known.

Surface Water Analytical Results

BTEX and PAH constituents were not detected in the surface water samples (Table 4-14). A data summary is provided on Table 4-14A. Figure 2-4 provides the approximate surface water sampling locations.

Sediment Analytical Results

A total of 11 sediment samples were collected from the unnamed tributary. The sediment analytical results are provided on Table 4-15, a summary of the data is provided on Table 4-15A, and the sampling locations are shown on Figure 2-4. In review, SD-01 was collected from sediments found on the concrete apron. Sediment samples SD-02 and SD-03 were collected above and below the waterfalls, respectively; and SD-04 was collected near the confluence with the Congaree River. The sediment analytical results indicate a decrease in concentration with distance (from the outfall) with the highest PAH concentrations found in SD-01 and the lowest found in SD-04. BTEX was not detected in SD-02, SD-03, and SD-04 and ethylbenzene and total xylenes were found in SD-01. A tar bleb and sheens were noted in the sediment sample collected from SD-01. Visual and olfactory observations were not noted in sediments collected at SD-02 through SD-04. Sediment samples SD-05 through SD-10 were collected from within the outfall pool located immediately downstream from the concrete apron and at depth intervals ranging from 0 to 1.0 feet into the sediment layer (Figure 2-4). Sample SD-11 was collected at a depth of 1 to 1.5 feet into the sediment layer. Visual and olfactory evidence of MGP residuals were noted in sediment samples SD-06, SD-08, and SD-10 located in the outfall pool. Additional observations include:

- Urban runoff likely contributes to some of the PAH concentrations detected;
- With the exception of SD-10, only PAH constituents were detected. Toluene was the only BTEX constituent detected and was only found in sample SD-10;
- With the exception of SD-11, the PAH constituents detected were similar between samples;
- The highest PAH concentrations were generally found in SD-10 and the highest concentration detected was 6.3 mg/Kg (acenaphthene) in SD-08;
- The analytical results from SD-10 are very similar to SD-01. SD-10 is located approximately 10 feet downstream of the outfall and SD-01, and tar blebs were observed in both samples;
- Horizontally, no definitive trend is noted; and
- Vertically and based only on one sample (SD-11), the number of PAH constituents above detection limits were found to decrease and when detected the concentration range was similar to those found at other locations.

Outfall Pool Sediment Probing

A total of four north-south trending transects were established in the outfall pool to investigate the presence of MGP residuals in sediments using only physical methods that included visual and olfactory observations. The investigative points were located on 2-foot centers and were performed by manually inserting a probe into the sediment and recording observations (i.e., sheens, tar blebs, etc.) that would manifest on the water surface (Figure 4-12). The manual probing method was employed since the DPT rig could not access locations in the unnamed tributary to gain deeper subsurface lithologic samples.

The findings indicated the outfall pool bottom is comprised of unconsolidated sediments or rocks. The probe could not be advanced through the rocks and therefore observations at these locations are not recorded. Table 4-16 list the locations and observations, and Figure 4-12 shows the locations and provides a compilation of the observations.

MGP residuals were not noted in the northern or southern limits of the outfall pool. The southern limits of the outfall pool, especially transects 1P and 2P, had a greater concentration of rocks and therefore the

observations may be biased towards the absence of MGP residuals. Evidence of MGP residuals appears to be the most prevalent in sediments located in the middle of the pool.

The specific depth of MGP residuals (i.e., tar blebs) is more difficult to discern due to depth of water and the probing method employed. Tar blebs were observed at 14 locations, and at least at two of the points on each transect. In addition, at eight of the locations, the maximum probe depth ranged from 0.3-0.5 foot into the sediment layer. The actual elevation of each location is uncertain since these points were not surveyed, but in general the deepest part of the pool is located midpoint on transect 1P and 2P and the shallowest pool and subsequently highest bottom elevation is found on the outer edges of each transect and in the direction of transect 3P and 4P. Therefore, the tar blebs appear to accumulate in the lower elevations and at a depth of at least 0.3 feet (Table 4-16). The presence of tar blebs in near surface sediments suggest deposition via surface water transport versus subsurface migration, which is discussed in the following section.

Transport Mechanism

In this section, potential industrial sources and transport mechanisms contributing to impacts observed at the outfall are explored.

Potential Sources

Historic information was reviewed to assess potential sources of the MGP residuals observed at the outfall. The review involved searching historical archives at public libraries to gain a better understanding of industries that may have been located in the unnamed tributary watershed. The results of the search identified the following potential sources:

- Parcel "A";
- A petroleum distribution facility located just to the north of Gist Street and near the Outfall Area;
- A rail line traversing Columbia and located approximately 3,000 feet to the east of the outfall; and
- A former MGP located on Lady Street.

Based on the topographic maps reviewed, it is difficult to discern whether the Lady Street former MGP is located within the unnamed tributary drainage area. In addition, it is also uncertain whether any of these historical industries contributed to observed impacts at the Outfall Area.

The forensic analytical results indicated at least two samples were classified as mixed source with a tentative identification of urban background. The other two samples were classified as pyrogenic with a tentative identification of tar. The fifth sample was collected from tar found on a rock and the results confirmed the observation (i.e., tar). Therefore, based on the forensic results, the constituents likely originated from a MGP with influences from urban runoff.

Transport

The transport process described below is hypothetical and is based on observations made at Parcel "A" and those noted at the outfall. The occurrence of MGP residuals in sediments at the outfall may be related to historic operations at the Huger Street former MGP and contributions from urban runoff and potentially from other former industries should not be discounted.

As previously discussed, the trace of the 72-inch buried culvert was a former open stream channel that extended from Parcel "A" to Gervais Street where it entered a culvert and discharged in the vicinity of the current outfall. The former stream channel likely received process water and/or impacted soil that contained MGP residuals (i.e., coal tar) and transport in the stream was likely a function of tar released, viscosity, flow conditions, and stream channel character. It is speculated that over time, MGP residuals were distributed sporadically throughout the stream channel.

The presence of MGP residuals in sediments at the outfall are believed to have been derived from two different mechanisms. The first mechanism is based on analytical data and observations from SD-01, which indicate elevated PAH concentrations and the presence of sheens and tar blebs. Under the first mechanism, tar would gradually migrate into the buried culvert via openings (fractures or pipe joints). Since it is likely that the tar is weathered and therefore fairly viscous, baseflow conditions are not sufficient to entrain the tar and/or sediment. However, during storm events, flow velocity significantly increases and the tar and/or sediment become suspended and transported downstream where it deposits at the outfall when surface water energies wane. Evidence supporting this mechanism includes observation of tar blebs at eight of 14 locations at depths ranging from 0.3-0.5 foot into the sediment. The shallow depth of these observations suggest surface deposition. In addition, one deeper sediment sample collected indicated a decrease in the number of PAH constituents detected, which would also support surface deposition. The interior of the culvert pipe from Parcel "A" to the outfall has not been visually inspected and therefore, location(s) where tar seepage may occur have not been evaluated.

The second potential transfer mechanism involves scouring of the former stream channel bottom with minimal continuing contribution from migrating tar. Under this mechanism, it is assumed that the former stream channel was open from Gervais Street to the current outfall location. Tar was deposited during the operation of the former MGP, and exists in sufficient volume that minor migration occurs in the direction of the concrete apron. During storm events, the stream velocity increases significantly and eddies form that under cut the concrete apron and transport sediment and/or tar to the outfall pool. Similar to the above, as energies wane, the sediment and/or tar fall out of suspension and are deposited.

5.0 CONCEPTUAL SITE MODEL

The conceptual site model (CSM) focuses on the interaction of the physical media with constituents from the operation of the former MGP and/or presence of existing or former USTs. The CSM provides an opportunity to synthesize discrete observations and data to formulate a more "global" understanding of the processes that influence the presence of COPC from source introduction through attenuative destruction and/or stability. Figure 5-1 provides a graphical representation of the CSM and depicts the Site with the former MGP structures.

5.1 Sources and Introduction

The potential sources of COPC were discussed in Section 4.5 and are shown graphically on Figure 5-1. For the CSM, constituents were either introduced to the environment through a number of actions including spills, leaks, operation processes, etc. and derived from (or were) separate phase liquids and dissolved in process or wastewater. In addition, the lateral extent of impacts will be a function of the

spatial distribution of source material and it appears that MGP impacts exist over a wider Site area than petroleum impacts. However, since some of the COPC (benzene and naphthalene) are similar between MGP and petroleum residuals, it may not be possible to separate contributing sources. MTBE does provide a good indicator of gasoline related impacts to groundwater.

5.2 Constituent Characterization and Persistence

The primary COPC tend to be those constituents characterized as volatile and semi-volatile organic compounds typically associated with former MGP and petroleum products. Other constituents (e.g., available cyanide, metals) were analyzed but did not tend to be significant in extent, were found at relatively low concentrations, and currently are not believed to be a major risk driver at the Site. The volatile and semi-volatile organic compounds tend to be found dissolved in groundwater, adsorbed onto soil particles, or entrained in soil gas. Given the chemical structure of the COPC some general characteristics can be attributed to these constituents and are discussed below.

The volatile organic COPC are focused to BTEX since these constituents appear to be most persistent and found at the highest concentrations. MTBE is also included since it is a good indicator of groundwater impacts emanating from gasoline. It should be noted that though detected, MTBE was found at low concentrations. Each of these COPC can be found dissolved in groundwater (solubilities tend to be high), entrained in soil gas (high vapor pressures), or adsorbed to soil particles. BTEX compounds tend to be attenuated, and if suitable subsurface conditions exist (aerobic conditions), can be degraded biologically. On the other hand, attenuation of MTBE is poor and subsequently can be more persistent in the environment as demonstrated by detections in off-Site wells.

The semi-volatile COPC include the polynuclear aromatic hydrocarbons (PAHs). The PAHs are characterized by higher molecular weight compounds (when compared to BTEX), constructed of multiple benzene rings, and generally are classified by ring structures. In general, the lower ring PAHs (e.g., naphthalene) tend to have similar characteristics to BTEX but due to the molecular weight tend to be less soluble and mobile in groundwater, lower vapor pressures limit concentrations that may be found in soil gas, can be more adsorbtive and may be attenuated biologically. As the number of rings increase, (e.g., benzo(a)pyrene) solubility decreases, volatility decreases, mobility in groundwater decreases, adsorption increases, and molecular size may inhibit biological degradation.

Residual, weathered and free-phase DNAPL has been observed at the Site. The presence of DNAPL may act as a source of constituents in groundwater. However, free-phase DNAPL has not been observed to accumulate in monitoring wells located on-Site or off-Site. LNAPL has not been observed in the subsurface or found to accumulate in monitoring wells.

5.3 Migration Pathways

This section summarizes the pathways for constituent migration to potential receptors. The pathways are discussed by media and include groundwater, soil, and soil vapor, and are based on the current understanding of Site conditions.

5.3.1 Groundwater

Transport of COPC in groundwater incorporates source contribution, transport of dissolved phase constituents through the groundwater bearing unit and discharge at groundwater boundaries. Source contribution qualitatively evaluates the interaction of infiltrating precipitation and/or horizontally migrating groundwater through a "source" term and its ability to leach constituents resulting in dissolution of COPC. Factors influencing COPC migration include groundwater flow direction, groundwater velocity, attenuative capacity of the groundwater bearing unit, and partitioning of the COPC with respect to the groundwater bearing unit matrix. Discharge point evaluation discusses naturally occurring discharge boundaries.

COPC are found dissolved in groundwater through a complex partitioning of constituents adsorbed onto soil particles in the saturated and unsaturated zone, from separate phase liquids (e.g., DNAPL), or from COPC found in the vapor phase. The general rule is BTEX will more readily partition to groundwater than the lower molecular weight PAHs (e.g., naphthalene), which will partition more readily than the higher molecular weight PAHs (e.g., benzo(a)pyrene).

For the Site, the dissolved phase COPC concentrations are lower than what may be expected given the soil concentrations and the presence of DNAPL in the central-eastern Site area (i.e., eastern maintenance building). A potential explanation is that the urban cover minimizes vertical infiltration of precipitation and subsequent leaching in the unsaturated (vadose) zone. The dissolved phase constituent concentrations detected likely represent horizontal movement of groundwater through the shallow groundwater bearing unit and partitioning of saturated adsorbed phase COPC into groundwater. Dissolved phase concentration variability is expected seasonally especially as the groundwater table height increases and potentially contacts unsaturated impacted media which could result in the partitioning of adsorbed phase constituents to the aqueous phase.

The dissolved phase constituents will be transported via advective groundwater flow and will follow the groundwater flowpaths shown in Figures 3.7 and 3.8. The velocity of dissolved phase COPC (with the exception of MTBE) will be less than that for groundwater due to adsorption of dissolved phase constituents to saturated soil media. Generally, BTEX will have higher velocities than the lower molecular weight PAHs with the slowest velocities expected from the heavier molecular weight PAHs. MTBE, since it is not readily attenuated, would exhibit velocities similar to that for advective groundwater flow.

The absence of dissolved phase benzene and naphthalene off-Site and hydraulically downgradient and to the south of Parcel "A" demonstrates the attenuative capacity of the shallow groundwater bearing unit. The BTEX and PAHs constituents are attenuated through a variety of mechanisms that include adsorption, biological degradation, diffusion, dilution, dispersion, etc. The actual mechanisms contributing to attenuation were not studied; although it is believed that the aforementioned mechanisms coupled with reduced flux (minimal vertical infiltration resulting from the urban cover) contribute to reduced COPC concentrations on-Site and therefore absence of MGP COPC off-Site. The western and eastern MGP COPC horizontal extent (in the proximity of MW-12 and MW-13) may be limited due to the groundwater flow pattern in the vicinity of these wells.

MTBE was found in the MW-5 series wells and is not unexpected since this constituent is not easily attenuated. The historical data indicates that MTBE was not detected in groundwater monitoring wells located hydraulically downgradient from the MW-5 series wells with the exception of one detection in MW-6 in 1997. Subsequent historical data indicated that MTBE was not detected in this well.

Since the general groundwater flow direction is to the south-southwest towards the Congaree River, the Congaree River and/or Columbia Canal may act as the groundwater discharge point. MGP related COPC has not been detected in off-Site monitoring wells and the extent of MTBE off-Site appears to be limited. Therefore, the existing hydrogeologic and groundwater analytical database indicates that minimal potential exists for impacted groundwater to reach the off-Site surface water bodies including the unnamed tributary.

5.3.2 Soil

Soil at the Site represents an immobile media since the only process that may influence soil transport would be erosion through wind or water. The presence of the urban cover minimizes erosion. Transport of soil would only occur if the surface is disturbed and erosive forces activate the soil particles. Therefore, the primary transport mechanism would be direct contact or through excavation activities.

5.3.3 Soil Vapor

Similar to groundwater, COPC would become entrained in soil vapor through a complex interaction of constituent partitioning from adsorbed phase constituents in the vadose zone, capillary fringe, or saturated zone, dissolved phase constituents in groundwater, and from separate phase sources occurring in various physical states (i.e., residual or free phase). Soil vapor would migrate vertically towards the ground surface and will generally take the path of least resistance and may include vertical movement through the vadose zone or through highly permeable backfill used for utilities. The general trend observed is the increase of COPC concentrations with depth.

Four potential "source" locations were identified and include the area of the former tar wells and tanks, the fuel pump island and associated USTs, buried 72-inch culvert, and monitoring well MW-2 location. The "source" material contributing to the soil vapor concentrations observed in the area of the tar wells may be attributed to DNAPL since DNAPL has been observed in the subsurface at this soil gas location (SG-2). Soil gas concentrations observed at the fuel island are attributed to inadvertent overflows while filling and/or potential leaks from USTs or lines. The soil gas concentrations observed near the 72-inch buried culvert are attributed to partitioning of COPC from DNAPL that potentially exist in the trace, or outline, of the former stream channel or from dissolved phase constituents found in groundwater. Finally the soil gas concentrations in the MW-2 area are believed to represent relic impacts from operation of the former gas holder though test pitting in this general area did not indicate visual impacts.

The urban cover (asphalt and concrete covers and buildings) is believed to act as a barrier preventing the effective venting of soil vapors and subsequently the soil gas concentrations observed may represent conservatively high concentrations. In the absence of the covers and buildings, it is believed that soil vapor COPC concentrations would decrease due to more efficient venting and attenuative interactions with infiltrating groundwater. Conversely, it is speculated that should the soil cover thickness be increased, venting may be less efficient.

5.4 Non-Aqueous Phase Liquids

5.4.1 DNAPL Behavior

A discussion of LNAPL is not presented since evidence of this liquid (i.e., floating product layer) does not exist at the Site. DNAPL when released to the ground surface will migrate vertically under the same influences as water. The actual path that DNAPL travels is dependent on the subsurface soils with

preferential vertical flow through high K soils and flow impeded vertically by lower K soils. DNAPL migration will progress vertically as long as sufficient volume exists to move the DNAPL as one continuous mass. DNAPL migration ceases when the continuous mass of DNAPL is interrupted or depleted, resulting in the development of residual phase DNAPL. Residual phase DNAPL is not mobile and will act as a long-term source for groundwater impacts. The ability of DNAPL to migrate as a continuous mass is a function of the soil to retain DNAPL, volume and duration of release. In the event that sufficient DNAPL mass exists, vertical migration would be maintained through the unsaturated zone and groundwater bearing unit until a low K layer is encountered (potentially bedrock, clay, saprolite). Once a low K layer is encountered, DNAPL would migrate in the direction of the stratigraphic or structural dip of the low K layer. Horizontal DNAPL migration would be maintained as long as sufficient DNAPL pool height exists to promote movement. In general, DNAPL migration would cease once the DNAPL pool height is diminished or the DNAPL is confined by the areal development of the stratigraphic low. In addition, the potential presence of fractures in the bedrock and/or saprolite could also act as a pathway for DNAPL migration and the ability of DNAPL to migrate into and through fractures is also dependent on the DNAPL pool height to overcome entry pressures associated with the fracture apertures.

5.4.2 DNAPL Occurrence and Migration – Parcel "A"

The presence of non-aqueous phase liquids (light and dense) has not been observed in monitoring wells installed on-Site or off-Site. However, coal tar DNAPL has been observed in subsurface lithologic samples obtained from borings in the central-eastern maintenance building area and limited areas to the north and south of the maintenance building. The inability to access this area due to the presence of buildings prevented drilling more borings or installing wells to further assess the potential of the central-eastern maintenance building area to be a DNAPL entry location and whether it currently represents an area where a DNAPL pool may exist. Based on observations from boring B-4, free phase DNAPL exists. Observations from boring B-10 indicate a thin layer of residual DNAPL at the base of the boring immediately above the granite bedrock low K surface. Therefore, it is possible that the former tar well area acted as a DNAPL entry location, providing DNAPL in sufficient quantity to promote migration stratigraphically downgradient to the area of the former stream channel (boring B-10). Boring B-10 is located near the former stream channel and existing 72-inch buried culvert. Once the former MGP operations ended, the source of DNAPL providing the driving mechanism to promote migration was ended, and subsequently DNAPL migration began to wane. Currently, DNAPL migration has likely ended since DNAPL input has been removed and limited free phase DNAPL exist that is likely not sufficient to maintain the DNAPL head necessary to maintain migration. The DNAPL observations observed in M19 (located near the 72-inch buried culvert and former stream channel) suggest transport in the former stream channel since a leaf was found coincident with this DNAPL observation, suggesting past surface deposition. Therefore, the evidence suggests both subsurface migration and potential discharge to the former stream channel during the operational period of the former MGP.

5.4.3 DNAPL Occurrence – Former Stream Channel and Outfall Area

The presence of MGP residuals (blebs and sheens) at the outfall are associated with historical discharges to the former stream channel versus continuous and ongoing migration from Parcel "A". Other historical industries existed in close proximity to the outfall or potentially within the drainage area that may have contributed MGP residuals or constituents with chemical signatures similar to MGP residuals. DNAPL accumulation likely occurred in low lying sections of the former stream channel. The former stream was culverted and through time cracks and joints developed. The presence of tar blebs at the outfall of the

72-inch culvert potentially suggests that there is a segment of the culvert where DNAPL may exist in sufficient volume that seepage can occur. Since the DNAPL is likely highly weathered and viscous, transport occurs during rainfall events when the energies are high and sufficient to entrain and transport the DNAPL. DNAPL deposition likely occurs when energies wane. The second mechanism also involves historic deposition and sediment reworking under the concrete apron, which occurs during periods of heavy rainfall with subsequent deposition when energies wane.

5.5 Present and Future Migration Pathways

Currently, the Site is at equilibrium with the presence of the urban cover. The urban cover is believed to be positively contributing to equilibrium conditions by minimizing infiltration of precipitation, which minimizes leaching of constituents through the unsaturated zone and subsequently reduces overall flux to the shallow groundwater bearing unit. The urban cover also has the effect of maintaining a barrier to soil and generally minimizing direct contact with soils. Conversely, the cover and buildings may act to increase soil gas concentrations since these barriers could reduce the ability of soil gas to vent.

Conceptually, if the urban cover was removed, equilibrium conditions would be disturbed followed by a period of non-equilibrium and re-establishment of equilibrium conditions. Future remedial activities must consider the potential adverse affects of disturbing the urban cover including increasing the potential for constituent migration.

In the event that a DNAPL pool exists at the Site, the extent would be limited and the potential for further migration is minimal since the source of the DNAPL was removed when MGP operations were ended in the early 1950's.

Conditions at the outfall are expected to continue as long as sufficient DNAPL source exists to maintain seepage into the culvert and/or undercutting of the concrete apron continues to occur. Anticipated remedial actions will address the present and future migration pathways.

6.0 RISK ASSESSMENT

The Site-specific risk assessment has been prepared in accordance with applicable state and federal guidance, such as the United States Environmental Protection Agency (U.S. EPA) Risk Assessment Guidance for Superfund (RAGS) Parts A (U.S. EPA 1989) and E (U.S. EPA 2004a), the U.S. EPA Region 4 Human Health Risk Assessment Bulletin (U.S. EPA 2000) and additional guidance documents as necessary which are specifically referenced throughout this section. Supporting documentation for the risk assessment has been included in Appendix J of this report.

Risk assessments estimate current and future risks for various receptors exposed to Site media. In order to satisfy this objective, a human health CSM for Parcel "A" was developed that identifies COPC, migration routes for constituents, receptors (including environmentally sensitive areas) and their associated exposure pathways (based on current and future land use). As presented in the Draft RIWP (MTR, September 2005), assessment of nearby environmentally sensitive areas concluded there were none identified on or adjacent to the Site within the appropriate search distances. The investigations

identified in the Draft RIWP – Culvert Outfall Area (MTR, February 2007) were focused to gathering data to better understand conditions at and mechanisms contributing to the impacts at the Outfall Area and secondly, provide data to perform a quantitative human health risk assessment.

This section identifies and quantifies potential risks associated with Parcel "A" and the Outfall Area. Separate risk analyses were performed for these two areas since:

- The areas are separated by an approximate distance of 1,200 feet; and
- The exposure scenarios and assumptions are unique to each area.

6.1 Parcel "A"

6.1.1 Identification of COPC

SCDHEC uses the screening process presented in the U.S. EPA Region 4 Human Health Risk Assessment Bulletin (U.S. EPA 2000) as a guideline to select COPC. Constituent concentrations in each of the Site media are compared against the appropriate U.S. EPA or SCDHEC criteria, as described for each medium below, in order to identify COPC for the Site. Any constituent exceeding a relevant criterion in a particular medium is considered a COPC at the Site.

In order to select direct contact and soil to groundwater COPC at the Site, the screening process presented in the U.S. EPA Region 4 Human Health Bulletin (U.S. EPA 2000) was followed. In order to select indoor air COPC, the screening process presented in the U.S. EPA Draft Guidance for Evaluating the Vapor Intrusion to Indoor Air Pathway from Groundwater and Soils (U.S. EPA 2002) was followed. Overall a conservative approach was taken to select COPC, such as retaining a constituent as a COPC based on constituent class (e.g., a constituent was retained as a COPC if the constituent was detected and another constituent in the same class [monocyclic aromatic compounds, polycyclic aromatic compound] exceeded its associated screening value). The detailed COPC screening process is presented in text and tables in Appendix J-1.

Section 4.0 of this report (and subsequent tables) presented the analytical data for Site media, which includes surface soil, unsaturated subsurface soil, saturated subsurface soil, groundwater, culvert water and soil gas. Also included on these tables is a sample-by-sample comparison to the applicable screening values, as identified below.

Soil

The screening values for direct contact exposures to soil were the U.S. EPA Region 9 PRGs for residential soil where carcinogens are based on 1×10^{-6} risk and noncarcinogens are based on a hazard quotient of 0.1 (U.S. EPA 2000).

In accordance with U.S. EPA Region 4 Human Health Bulletin, only direct contact standards (not soil to groundwater standards) were used to select soil COPC for inclusion in the risk assessment. Groundwater-related pathways that are potentially complete are evaluated in this risk assessment using measured groundwater data, rather than extrapolating from soil data to groundwater. Table 6-1 presents a summary of the direct contact COPC by soil interval that are included in the quantitative risk assessment.

Groundwater

The groundwater screening values are the SCDHEC Maximum Contaminant Levels (MCL) in Drinking Water as presented in Regulation 61-58 (SCDHEC 2003). If a SCDHEC drinking water standard was not available for a particular constituent, the groundwater screening value was the U.S. EPA Region 9 PRG for tap water where carcinogens are based on a 1×10^{-6} risk and non-carcinogens are based on a hazard quotient of 0.1 (U.S. EPA 2000). The tap water PRGs are derived for exposures associated with the use of water as a potable source in a residential setting. Table 6-1 presents a summary of the groundwater COPC that are included in the quantitative risk assessment.

Indoor Air

Indoor air COPC were determined using the U.S. EPA Draft Guidance for Evaluating the Vapor Intrusion to Indoor Air Pathway from Groundwater and Soils (U.S. EPA 2002). U.S. EPA guidance was followed to select indoor air COPC, as SCDHEC currently does not have indoor air guidance or screening values. The selected screening values were the target deep soil gas concentrations corresponding to target indoor air concentrations where the soil gas to indoor air attenuation factor equals 0.01 and are based on 1×10^{-6} risk and a hazard index (HI) of 1. Table 6-1 presents a summary of the indoor air COPC for the Site.

Culvert Water

Sample results for culvert water were conservatively compared to National Recommended Water Quality Criteria (U.S. EPA 2006) in order to select COPC. The culvert water does not represent surface water, and is accurately described as urban run-off from rainfall events and upstream groundwater discharges to surface water. The culvert daylights approximately 1,200 feet south of the Site and the water discharges to an unnamed tributary that ultimately flows to the Congaree River.

As indicated on Table 4-7 constituents were not detected in either sample, therefore, no COPC were identified for the culvert water (Table 6-1).

6.1.2 Exposure Assessment

Exposure assessment identifies potential receptor populations and exposure pathways to determine whether potentially complete exposure pathways exist. An exposure pathway is considered complete if all four of the following elements exist: 1) a source of COPC; 2) a potential transport mechanism; 3) contact between a potential receptor and the medium (exposure); and, 4) an uptake mechanism associated with the potential receptor.

Direct contact (e.g., ingestion, dermal contact and inhalation) and indoor air COPC were identified in Section 6.1 for soil and groundwater. Potential transport mechanisms associated with the COPC and potential exposure pathways and receptors are evaluated in this section in order to determine whether a complete exposure pathway exists.

Once complete exposure pathways are identified, intakes (i.e., doses) are estimated. This section concludes with the estimation of exposure point concentrations (EPC) for the COPC at the Site.

Current and Future Site Use

The Site location and current use were described in Section 1.0.

SCE&G and the City of Columbia agree that the Site will be cleaned up to a standard consistent with nonresidential uses. Therefore, the most likely primary receptors are the current Site users under the nonresidential scenario. The intended future Site use is also nonresidential; however, the Site will likely be redeveloped from its current use. While a design for redevelopment has not yet been determined, the redevelopment use assumes razing the existing buildings and developing commercial property. The Site would likely contain some small landscaped or park areas; however, the majority of the Site would be covered by buildings. The evaluation of a potential future residential scenario was requested by SCDHEC and the risk results for the residential scenarios are provided in Appendix J-5. However, residential use is not the intended future use of the property according to the aforementioned agreement with the City. The inclusion of a residential scenario evaluation is to establish baseline conditions for comparison purposes only. These data will be used to quantify current existing uncertainties at the Site and are not intended to be used in developing remedial action objectives. Therefore, the remainder of the risk discussion presented in the text focuses on the primary or nonresidential receptors (including the recreational user).

Groundwater Use

A potable water supply evaluation was conducted for the Site and surrounding area to determine the location of surface water and groundwater supplies utilized for potable water within a 1-mile radius of the Site.

The City of Columbia's public water supply draws water from the Broad River and from Lake Murray. The Broad River is located north of the Site and discharges into the Congaree River upstream of the Site. Lake Murray is located over 10 miles northwest and upstream of the Site. Neither surface water body will be affected by groundwater from the Site since both are located upstream from the Site.

A well survey was obtained from Environmental Data Resources, Inc. (EDR) to determine potential wells within a 1-mile radius of the Site (Appendix K). The survey concluded that there are no known potable groundwater wells reported in the state database within a ½-mile radius of the Site. A public water supply intake is identified as located approximately ½-mile northwest of the Site, (upgradient), near the confluence of the Broad River and the Congaree River. One well identified as "domestic" is also located approximately ½-mile east and upgradient of the Site. Another well also identified "domestic" was located across the Congaree River, and a third well (with a "PS" designation) is located greater than ½-mile east (and upgradient) of the Site. Eight additional wells were identified between ½-mile and 1-mile from the Site to the south, east, and west (across the river). Therefore, based on this survey and the hydrogeologic analysis, none of these wells appear to have the potential to be impacted by historic Site operations.

Source Media of Interest

Source media of interest at the Site include soil and groundwater. Section 3.0 of this report presented the Site-specific geology and hydrogeology.

Once media of interest and COPC have been identified, it is important to evaluate the environmental fate and potential transport of the COPC in media that are receiving or may receive the Site-related constituents. In order to perform this evaluation, physical and constituent parameters of COPC (e.g., molecular weight, boiling point) along with environmental fate parameters (e.g., solubility, Henry's Law Constant and diffusivity) were reviewed. The transport mechanisms evaluation also included the

topography of the Site, local climate, characteristics of the native soil and fill material and potential subsurface conduits (e.g., preferential pathways for COPC transport)

Table 6-2 lists the potential sources and the transport pathways evaluated for Site source media. The rationale for retaining specific transport pathways is presented in this table.

Potential Receptors and Exposure Pathways

Potential receptors are selected to represent individuals who are most likely to come into contact with COPC during current and future use of the Site. As described under Section 6.2.1 and in Table 6-3, the current scenario and future nonresidential scenarios have been evaluated as part of the risk assessment.

Receptors and exposure pathways have been identified for the Site under the current and future use scenarios. The receptors are presented in Table 6-3 for each scenario and include:

- On-site worker
- Recreational user
- Off-site receptor
- Trespasser
- Groundskeeper
- Construction worker
- Utility worker

Table 6-3 presents a detailed evaluation of the exposure pathways considered for each receptor, whether or not pathways were retained and the rationale for this decision. Descriptions of each of the receptors with at least one retained exposure pathway are provided below. For comparison purposes, residential use scenarios and receptors used to establish baseline conditions at the Site are discussed in Appendix J-5.

On-Site Worker

Two types of on-site workers, outdoor and indoor, are potential receptors under the current and future use scenarios.

An outdoor on-site worker works outdoors on a full-time basis. Since buildings or asphalt paving currently covers the majority of the Site, the outdoor worker would only be potentially exposed to Site COPC in surface soil under a future use scenario. Intrusive activities conducted by this receptor are not expected to occur below two feet; therefore, surface soil would be the only medium of exposure. Table 6-3 provides the detailed exposure pathway evaluation for the outdoor on-site worker.

An indoor on-site worker is a current and potential future receptor who is presumed to be an office worker who spends all their time inside a building (with the exception of negligible time spent walking to and from the parking lot). Therefore, this receptor may be exposed to Site COPC in indoor air as a result of vapor intrusion from the subsurface into a building. Table 6-3 provides the detailed exposure pathway evaluation for the indoor on-site worker.

Since there is a potential for redevelopment of the Site, it is possible that a new office structure may be built on the Site and/or soil may be removed from the Site during construction activities consequently changing (e.g., lower) the Site elevation. Therefore, to evaluate the impact of vapor intrusion under these scenarios, soil gas samples were collected at different depths and one current and two potential future use scenarios were considered. All three scenarios are described in detail in Section 6.2.7.

Recreational User

Based on the potential future redevelopment of the Site as mixed commercial/residential area, a recreational user has been identified as a potential receptor. This scenario assumes that a small portion of the Site will be developed for recreational purposes. The receptor was identified as a 1 to 6 year old individual who may use the recreational area and will be accompanied by an adult for the period specified by the exposure duration. This receptor is considered to be conservative for this identified potential future use. Based on expected activities for this receptor, the recreational user may be exposed to Site COPC in surface soil.

Off-Site Receptor

An off-site receptor was also evaluated. However, the exposure pathways for this receptor are considered incomplete and this receptor will not be evaluated further.

Trespasser

A trespasser could potentially have unauthorized access to the Site. Under the current conditions, any potential exposure pathways are not likely to be complete since most of the Site is covered. Under future use scenarios, a trespasser would have exposures that are less than a future recreational user; therefore, the trespasser is not explicitly evaluated in the quantitative risk assessment.

Groundskeeper

The groundskeeper is an individual who only works outdoors and would be responsible for outdoor maintenance activities at the Site such as lawn cutting, tree planting, and/or snow removal. This receptor differs from the outdoor worker primarily by the amount of time spent outdoors at the Site. The groundskeeper is expected to spend much less time at the Site performing these outdoor activities. Under the current Site use and conditions (i.e., nonresidential and Site covered with buildings or asphalt), the groundskeeper is not a likely receptor, but may become a receptor under potential future use scenarios. Activities of the groundskeeper may result in exposure to COPC in surface soil.

Construction Worker

A construction worker is a worker that would be involved in construction and/or excavation activities at the Site under the current or any of the future use scenarios. Intrusive activities conducted by this receptor may result in exposure to COPC in surface soil, subsurface soil and groundwater.

Utility Worker

The utility worker is defined as a receptor who would be involved with repairing and maintaining utility lines under the current or any of the future use scenarios. This receptor is not expected to be involved in the installation of new lines, as this is assumed to be performed by a construction worker (where the construction worker scenario assumptions reflect this potential exposure scenario). Intrusive activities conducted by this receptor may result in exposure to COPC in surface soil, subsurface soil and groundwater.

Intake Assumptions

Receptor specific assumptions are used to calculate constituent intakes for receptors with complete exposure pathways identified in Section 6.2.5 and Table 6-3. Equations used to calculate intakes or doses are discussed by exposure pathway (e.g., incidental ingestion of soil, dermal contact with groundwater) and are provided in Appendix J-2.

The receptor specific intake assumptions quantify activity patterns and body characteristics for each of the receptors, such as, the amount of time a receptor may spend at a site, the frequency of the receptor visits, body weight of the receptor, inhalation rates and soil ingestion rates. Receptor specific intake assumptions were selected using U.S. EPA recommended values, when available. Otherwise, alternate sources were used, such as recommended values from other state program guidance, or professional judgment (based on-Site-specific information) to select appropriate intake assumptions. Receptor specific intake assumptions for each of the on-site receptors retained for analysis in the quantitative risk assessment are presented in text and tables provided in Appendix J-2.

Exposure Point Concentrations

This section presents the exposure point concentrations (EPCs) for each of the COPC retained in the quantitative risk assessment used to estimate intake. Exposure point concentrations have been derived separately for the direct contact COPC (soil and groundwater) and indoor air COPC.

Direct Contact

Average Site concentrations for soil were calculated by following the latest EPA guidance (U.S. EPA 2004b) on calculating the 95% Upper Confidence Limits on the Mean (95% UCL) and for groundwater the maximum concentration was conservatively used as the EPC. A detailed discussion on the calculation of EPCs is presented in text and tables in Appendix J-3. As discussed in this Appendix, the soil and groundwater EPCs are adjusted by an applicable transfer factor in order to relate concentrations in soil and groundwater to concentrations in outdoor air. Selection of EPCs are receptor specific and are based on the complete exposure pathways for each receptor. Also, the selection of EPC in soil are based on the soil interval (surface and/or subsurface soil) the receptor will contact based on the activities conducted while at the Site. The receptor specific EPC selection process is presented in text and tables (Appendix J-3). Appendix J-3 also presents the exposure point concentrations for the direct contact COPC at the Site by receptor.

Indoor Air

The Johnson and Ettinger Model (Version 3.1, February 2004) (U.S. EPA 2004c) was used to estimate indoor air concentrations based on soil gas data. The indoor air concentration was then used as the EPC to determine potential risk. Appendix J-3 describes the process used to convert soil gas to an indoor air concentration and the assumptions used in the model. The maximum concentrations of each constituent in soil gas were used as input in the model. Based on potential future Site redevelopment, one current and two future scenarios were considered, and different EPCs in air were calculated for each scenario, as described below.

In the current Site use scenario (Current Soil Gas Scenario 1), the existing building dimensions and the shallow soil gas samples (4-5 feet bgs) were used to determine EPCs in indoor air. In Future Soil Gas Scenario 1, the Site grade remains the same; however, it is assumed that a new office building is constructed. The default building dimensions provided by U.S. EPA (U.S. EPA 2004c) for the Johnson

and Ettinger Model are used along with the shallow soil gas samples (4-5 feet bgs) to calculate EPCs in indoor air to evaluate Future Soil Gas Scenario 1.

In Future Soil Gas Scenario 2, soil is removed from the Site in the course of redevelopment or for the purpose of remediation. In this scenario, the exact depth and dimensions of any excavated area can not be pre-determined; therefore, it is assumed that the concentrations of constituents of interest used to evaluate vapor intrusion in Scenario 1 (shallow soil gas samples from 4-5 feet bgs) are no longer representative of concentrations in the subsurface closest to a potential new building. In this Scenario, the default building dimensions provided by U.S. EPA (U.S. EPA 2004c) for the Johnson and Ettinger Model are used along with the soil gas samples from 8-10 feet bgs to calculate EPCs in indoor air. This method is extremely conservative since it assumes that the soil removed from the Site will not be replaced with clean fill and the concentrations of volatile constituents in subsurface soil will be under a new building constructed on the Site. However, since it is not possible to predict soil gas concentrations in the upper soil stratum even if backfill is used to regrade the Site to the existing grade, this conservative measure is necessary to evaluate potential future risk.

Appendix J-3 presents the estimated exposure point concentrations for the indoor air COPC in soil gas at the Site under Scenarios 1 and 2. See Appendix J-3 for input parameters used to derive the exposure point concentrations.

6.1.3 Toxicity Assessment and Other Chemical-Specific Parameters

All toxicity values (carcinogenic and noncarcinogenic) are presented in tables provided in Appendix J-4 and sources of the values are referenced accordingly.

For this risk assessment, verified toxicity values (e.g., cancer slope factors and reference doses) were obtained from U.S. EPA's *Integrated Risk Information System* (IRIS 2006). These toxicity values and other constituent-specific information are included in IRIS after a comprehensive review of toxicity data by work groups of U.S. EPA health scientists. Verified toxicity values are the most reliable for estimating carcinogenic and noncarcinogenic risks due to constituent exposure. If the compound was not found in IRIS at the time of the search, the U.S EPA hierarchy for selecting toxicity values was followed. A secondary source, the U.S. EPA Provisional Peer Reviewed Values (values obtained via the U.S. EPA Region 9 PRG table or Region III Risk-Based Concentration (RBC) table) and tertiary sources, such as, National Center for Exposure Assessment (NCEA) values, Agency for Toxic Substances and Disease Registry (ATSDR) *Minimal Risk Levels (MRLs) (ATSDR 2004), Health Effects Assessment Summary Tables* (HEAST) (U.S. EPA 1997), the California EPA toxicity database, or alternative toxicity values were used. Alternative toxicity values include route-to-route extrapolated values as referenced in the U.S. EPA 2004 Region 9 PRG table.

Oral to dermal conversion factors were used to adjust oral reference doses and slope factors, in accordance with U.S. EPA Risk Assessment Guidance Part E, (U.S. EPA 2004b). This adjustment was performed for cadmium only (see Table 1 of Appendix J-4). An oral to dermal conversion factor of 1.0 was used to derive dermal toxicity values for the remaining COPCs. Toxicity equivalent factors were used for the ingestion and inhalation pathway, as applicable, in accordance with Region 4 Human Health Risk Assessment Bulletin (U.S. EPA 2000).

Other constituent-specific parameters include absorption adjustment factors and permeability constants. Absorption adjustment factors are needed for the various exposure pathways and are used to reflect the desorption of the constituent from soil and the absorption of the constituent across the skin and into the blood stream (U.S. EPA 1989). For this evaluation, the absorption adjustment factor for soil ingestion is 1.0 for all constituents, which implies all the constituent is absorbed and therefore is conservative. Similarly, the absorption adjustment factor for inhalation is 1.0 for all constituents, which implies all the constituent is absorbed and therefore is conservative. Dermal contact absorption adjustment factors to account for absorption through the skin are constituent dependent and are presented in Appendix J-4 of this report.

Permeability constants (PC) are used to evaluate dermal contact with water. These constants describe the rate at which the COPC are absorbed through skin that is in contact with water. For this evaluation, permeability constants (PC) were assumed to equal permeability coefficients (Kp). The Kp values used in the analysis were obtained from U.S. EPA's RAGS E (U.S. EPA 2004b). Permeability constants are presented in tables located in Appendix J-4 of this report.

6.1.4 Risk Characterization

This section presents the general risk framework used to quantify risk for the receptors at the Site followed by the Site-specific risk results. Risks were calculated for each complete exposure pathway and for each receptor. Risk calculation support information, including the detailed risk calculations, are presented in text and tables located in Appendix J-5.

Risk Calculation Framework

Direct Contact

Two types of potential direct contact human health effects are calculated in the risk assessment: cancer risks and non-cancer hazard indices.

Cancer risks are estimated as the incremental probability of an individual developing cancer over a lifetime as a result of exposure to a potential carcinogen. In order to estimate the cancer risk, the intake is multiplied by the cancer slope factor (CSF):

$$CancerRisk = Intake_c x CSF$$

For each pathway, this calculation is performed for each constituent considered to be potentially carcinogenic, and the risks are summed across all constituents and pathways to obtain the total risk for a specific receptor.

Potential noncarcinogenic effects were evaluated by calculating a hazard index. For a single compound and intake route, the hazard quotient (HQ) is the ratio of the intake to a reference dose (RfD):

$$HQ = \frac{Intake_n}{RfD}$$

For each pathway, a HQ is derived for all appropriate constituents. HQs for all constituents and exposure pathways are summed to obtain the total hazard index (HI) for that receptor.

Indoor Air

The risk associated with an exposure or intake for the indoor air pathway is calculated using the following equation:

$$R = I_{inhal_c} \bullet URF \bullet 1000 \frac{ug}{mg}$$

where:

R	=	risk (unitless)
$I_{inhal-c}$	=	intake for potential carcinogenic effects (mg/m^3)
URF	=	inhalation unit risk factor (m^3/ug)

The hazard index associated with a chronic or long-term exposure to indoor air is calculated using the following equation:

$$HI = \frac{I_{inhal_{NC}}}{RfC}$$

where:

HI	=	hazard index
$I_{inhal-NC}$	=	intake for potential noncarcinogenic effects (mg/m^3)
RfC	=	reference concentration (mg/m^3)

Risk Results

This section presents the calculated cancer risks and non-cancer hazard indices for the retained receptors and exposure pathways associated with the Site. These Site-related risks and hazard indices are summarized on Table 6-4. Appendix J-5 presents the detailed risk calculations results.

The estimated risks were compared to the NCP guidance point of departure value of 1×10^{-6} and the estimated hazard indices were compared to a U.S. EPA benchmark of 1. Baseline quantitative risks were calculated and are presented in Appendix J-5 and Table 6-4. The following paragraphs present the results of a benchmark comparison for each receptor.

On-Site Worker

Risks were quantified to evaluate direct contact to surface soil and/or indoor air for the on-site worker. As described in Section 6.2.5, two separate on-site workers were evaluated in the quantitative risk assessment: an indoor on-site worker (current and future receptor) and an outdoor on-site worker (future receptor).

The indoor on-site worker was evaluated for the indoor air pathway as a result of vapor intrusion from the subsurface into the current on-site building (Current Soil Gas Scenario 1). Since the current building is smaller than the default size building used for indoor air modeling (see Appendix J-3, Attachment 4, Table 1), a second scenario is also evaluated using the default parameters for a building (Future Soil Gas

Scenario 1). Based on this assessment, the carcinogenic indoor air risks under both building scenarios are above the point of departure value of 1×10^{-6} for cancer risk, but the noncarcinogenic risks were below the hazard index of 1.0. The COPC risk driver is benzene for carcinogenic exposure.

In Future Soil Gas Scenario 2, soil is removed from the Site to some undetermined depth, bringing subsurface soil (which has higher concentrations of some volatile constituents) closer to the surface. In this case, deeper soil gas samples from between 8 and 10 feet bgs are used to evaluate potential risk to an indoor worker. In this potential future scenario (Soil Gas Scenario 2), the risk to the indoor worker from vapor intrusion into indoor air exceeds the point of departure value of 1×10^{-6} for cancer risk and the benchmark noncarcinogenic values of 1. The COPC risk driver is benzene for both carcinogenic and noncarcinogenic exposure.

The outdoor on-site worker was evaluated for direct contact to surface soil. Carcinogenic risks were above the point of departure value of 1×10^{-6} and the noncarcinogenic risks were above the benchmark hazard index of 1.0. The carcinogenic exceedance was attributable to the ingestion and dermal contact pathways with PAHs, primarily benzo(a)pyrene, being the COPC risk drivers for both pathways. The noncarcinogenic exceedance was attributable primarily to the inhalation of volatile constituents from soil pathway with 1,2,4-trimethylbenzene, 2-methylnaphthalene, and naphthalene as the COPC risk drivers.

Recreational User

Risks were quantified to evaluate direct contact to surface soil for a future recreational user. Carcinogenic risks for both receptors (1 to 6 years and 7 to 30 years) were above the point of departure value of 1×10^{-6} and the noncarcinogenic hazard index benchmark of 1.0 was exceeded for both receptors. The carcinogenic exceedance was attributable to the ingestion and dermal contact pathways with PAHs, primarily benzo(a)pyrene, being the COPC risk drivers for both pathways. The noncarcinogenic exceedance for both receptors was attributable primarily to the inhalation of volatile constituents from soil where for the child (1 to 6 years) receptor the COPC risk drivers were identified as 1,2,4-trimethylbenzene, 1 and 2-methylnaphthalene, and naphthalene; for the adult (7 to 30 years) receptor the COPC risk drivers were identified as 1,2,4-trimethylbenzene and naphthalene.

Groundskeeper

Risks were quantified to evaluate direct contact to surface soil for the groundskeeper. Carcinogenic risks were above the point of departure value 1×10^{-6} and were attributable to the ingestion and dermal contact pathways with PAHs, primarily benzo(a)pyrene, being the COPC risk drivers for both pathways. The noncarcinogenic hazard index benchmark of 1.0 was exceeded for the groundskeeper. The noncarcinogenic exceedance was primarily attributable to the inhalation of volatile constituents from soil with 1,2,4-trimethylbenzene as the COPC risk driver.

Construction Worker

Risks were quantified to evaluate direct contact to soil (surface and subsurface) and groundwater for the construction worker. Carcinogenic risks were above the point of departure value of 1×10^{-6} point of departure and were attributable to the ingestion and dermal contact pathways, with benzo(a)pyrene being the COPC risk driver for both pathways. The noncarcinogenic hazard index benchmark of 1.0 was exceeded for the construction worker. The noncarcinogenic exceedance was primarily attributable to the soil direct contact pathways (e.g., incidental ingestion, dermal contact and inhalation of volatiles), as most exposure routes exceed the acceptable level of 1.0. The COPC risk drivers were identified as thallium

(incidental ingestion), 2-methylnaphthalene, naphthalene and dibenzofuran (dermal contact) and benzene, styrene, xylenes, 1,2,4-trimethylbenzene, 1 and 2-methylnaphthalene, and naphthalene (inhalation of volatiles).

Utility Worker

Risks were quantified to evaluate direct contact to soil (surface and subsurface) and groundwater for the utility worker. Carcinogenic risks were above the point of departure value of 1×10^{-6}. The carcinogenic risks were attributable to the ingestion and dermal contact pathways, with benzo(a)pyrene being the COPC risk driver for both pathways. Noncarcinogenic risks were below the benchmark hazard index of 1.0.

Uncertainty Analysis

The risk assessment process presented herein uses a considerable number of conservative assumptions regarding exposure and toxicity to ensure that potential risks are not underestimated. A qualitative review of the types of assumptions and how these assumptions result in a high degree of confidence that potential Site-related risks are not underestimated is presented in Appendix J-6.

In addition to uncertainty inherent in the risk calculations, there may be limitations in the use of the baseline risk calculations caused by data gaps for evaluation of future Site use. The concentrations in the soil represent the available data collected based on the present Site configuration. There are data gaps regarding concentrations in soil located under current structures on the Site. Presently, these structures represent a barrier to direct contact with the soil under the structure; therefore, the direct contact pathways to soil under the structures are currently incomplete. Soil gas samples have been collected to evaluate the indoor air pathway and the risk evaluation has determined that the current scenario does not represent a significant adverse risk. Future surface soil sampling is expected and likely in areas that could not be accessed or where data gaps exist. The objective of this data collection effort will be to support the presumptive soil excavation remedy during the remedial design period when excavation limits are defined and likely developed using a risk based approach. The risk-based presumptive remedy will balance practicability, cost, and protectiveness in arriving at a solution that is mutually beneficial to all parties involved.

6.2 Outfall Area Risk Assessment

6.2.1 Identification of COPC

SCDHEC uses the screening process presented in the U.S. EPA Region 4 Human Health Risk Assessment Bulletin (U.S. EPA 2000) as guideline to select COPC. Constituent concentrations in each of the Outfall Area media are compared against the appropriate U.S. EPA criteria for protection of human health, as described for each medium below, in order to identify COPC for the Outfall Area. Any constituent exceeding a relevant criterion in a particular medium is considered a COPC at the Outfall Area.

In order to select direct contact COPC at the Outfall Area, the screening process presented in the U.S. EPA Region 4 Human Health Bulletin (U.S. EPA 2000) was followed. Overall, a conservative approach was taken to select COPC, such as retaining a constituent as a COPC based on constituent class (e.g., a constituent was retained as a COPC if the constituent was detected and another constituent in the same class [monocyclic aromatic compounds, polycyclic aromatic compound] exceeded its associated

screening value). The detailed COPC screening process for the Outfall Area is presented in text and tables in Appendix J-7.

Section 4.0 of this report (and subsequent tables) presented the analytical data for the Outfall Area media, which include surface soil, subsurface soil, sediment and surface water. Also included on these tables is a sample-by-sample comparison to the applicable screening values, as identified below.

Soil

The screening values for direct contact exposures to surface soil were the U.S. EPA Region 9 PRGs for residential soil where carcinogens are based on 1 x 10^{-6} risk and noncarcinogens are based on a hazard quotient of 0.1 (U.S. EPA 2000). Only the construction worker would be exposed to subsurface soil; therefore, screening values for direct contact exposures to subsurface soil were the U.S. EPA Region 9 PRGs for industrial soil (U.S. EPA 2000). There are no exceedances of industrial screening values in subsurface soil.

In accordance with U.S. EPA Region 4 Human Health Bulletin, only direct contact standards (not soil to groundwater standards) were used to select soil COPC for inclusion in the risk assessment. Table 6-5 presents a summary of the direct contact COPC by soil interval that are included in the quantitative risk assessment.

Sediment

Since constituents in sediments are being evaluated for human health impacts, the screening values for direct contact exposures to sediment were the U.S. EPA Region 9 PRGs for residential soil where carcinogens are based on 1 x 10^{-6} risk and noncarcinogens are based on a hazard quotient of 0.1, as recommended by U.S. EPA Region 4 (U.S. EPA 2000).

In accordance with U.S. EPA Region 4 Human Health Bulletin, only direct contact standards were used to select sediment COPC for inclusion in the risk assessment. Table 6-5 presents a summary of the direct contact COPC in sediment that are included in the quantitative risk assessment.

Surface Water

Sample results for surface water from the Outfall Area were conservatively compared to National Recommended Water Quality Criteria (U.S. EPA 2006) in order to select COPC. The Outfall Area surface water discharges from the 72-inch buried culvert and flows to an unnamed tributary and then to the Congaree River.

As indicated on Table 4-15 constituents were not detected in the surface water samples, therefore, no COPC were identified for the outfall surface water (Table 6-5).

6.2.2 Exposure Assessment

Exposure assessment identifies potential receptor populations and exposure pathways to determine whether potentially complete exposure pathways exist. An exposure pathway is considered complete if all four of the following elements exist: 1) a source of COPC; 2) a potential transport mechanism; 3) contact between a potential receptor and the medium (exposure); and, 4) an uptake mechanism associated with the potential receptor.

Direct contact (e.g., ingestion, dermal contact and inhalation) COPC for the Outfall Area were identified in Section 6.2.1 for soil and sediment. Potential transport mechanisms associated with the COPC and potential exposure pathways and receptors are evaluated in this section in order to determine whether a complete exposure pathway exists to soil and sediment in the Outfall Area.

Once complete exposure pathways are identified, intakes (i.e., doses) are estimated. This section concludes with the estimation of exposure point concentrations (EPC) for the COPC at the Outfall Area.

Current and Future Use of Outfall Area

Since the Outfall Area is not immediately adjacent to the Site, and different receptors may visit the Outfall Area than those who may visit the Site, the current and future use of the Outfall Area is evaluated separately from Parcel "A". Due to the distance separating the Outfall Area from Parcel "A", it is not believed that the risks from exposure at these two areas are cumulative.

The Outfall Area is located at an off-site location that may be redeveloped as part of an area-wide redevelopment plan. Existing plans show a parking lot located near the Outfall Area. While it is not known whether recreational activity will be permitted in the Outfall Area, recreational use represents a conservative scenario for evaluation of potential risks to recreational receptors. The water in the culvert, or at downstream locations, is not used as a source of drinking water.

Source Media of Interest

Source media of interest at the Outfall Area include surface soil and sediment.

Potential Transport of Site COPCs

Once media of interest and COPC have been identified, it is important to evaluate the environmental fate and potential transport of the COPC in media that are receiving or may receive the Site-related constituents. In order to perform this evaluation, physical and constituent parameters of COPC (e.g., molecular weight, boiling point) along with environmental fate parameters (e.g., solubility, Henry's Law Constant and diffusivity) were reviewed. The transport mechanisms evaluation also included the topography of the Site, local climate, characteristics of the native soil and fill material and potential subsurface conduits (e.g., preferential pathways for COPC transport).

Table 6-6 lists the potential sources and the transport pathways evaluated for Outfall Area source media. The rationale for retaining specific transport pathways is presented in this table.

Potential Receptors and Exposure Pathways

Potential receptors are selected to represent individuals who are most likely to come into contact with COPC during current and future use of the Outfall Area. As described under Section 6.2.2 and in Table 6-7, the current scenario and future scenarios have been evaluated as part of the risk assessment.

Receptors and exposure pathways have been identified for the Outfall Area under the current and future use scenarios. The receptors are presented in Table 6-7 for each scenario and include:

- Recreational user
- Construction worker
- Utility worker

Table 6-7 presents a detailed evaluation of the exposure pathways considered for each receptor, whether or not pathways were retained and the rationale for this decision. Descriptions of each of the receptors with at least one retained exposure pathway are provided below. Appendix J-7 provides descriptions of the current and future use scenarios and the receptors used to establish conditions at the Outfall Area.

Recreational User

Based on the current redevelopment of the Site and surrounding area, a recreational user has been identified as a potential receptor in the Outfall Area. This scenario assumes that a recreational use of the Outfall Area and downstream areas will be permitted. The receptor was identified as a child who may use the recreational area and will be accompanied by an adult for the period specified by the exposure duration. While it is likely that a child who may enter the stream and come into contact with sediments would be of an age appropriate for wading and/or swimming, an individual of 1 to 6 years of age was selected for evaluation. This receptor is considered to be the most conservative for this identified potential future use. Based on expected activities for this receptor, the recreational user may be exposed to COPC in Outfall Area surface soil, sediment, and surface water.

Construction Worker

A construction worker is a worker that would be involved in construction and/or excavation activities within or surrounding the stream channel under the current or future use scenarios. Under a future use scenario, activities may be conducted within the stream channel that require dewatering the stream, thereby exposing sediment which normally would be below the water level. Intrusive activities conducted by this receptor may result in exposure to COPC in surface soil, subsurface soil, sediment, and surface water.

Utility Worker

The utility worker is defined as a receptor who would be involved with repairing and maintaining utility lines under the current or future use scenario. This receptor is not expected to be involved in the installation of new lines, as this is assumed to be performed by a construction worker. Intrusive activities conducted by this receptor may result in exposure to COPC in surface soil, subsurface soil, sediment, or surface water.

Intake Assumptions

Receptor specific assumptions are used to calculate constituent intakes for receptors with complete exposure pathways identified in Section 6.2.2.4 and Table 6-3. Equations used to calculate intakes or doses are discussed by exposure pathway (e.g., incidental ingestion of soil) and are the same as those used for Parcel "A", which are provided in Appendix J-2.

The receptor specific intake assumptions quantify activity patterns and body characteristics for each of the receptors, such as, the amount of time a receptor may spend at a Outfall Area, the frequency of the receptor visits, body weight of the receptor, inhalation rates and soil ingestion rates. Receptor specific intake assumptions were selected using U.S. EPA recommended values, when available. Otherwise, alternate sources were used, such as recommended values from other state program guidance, or professional judgment (based on-Site-specific information) to select appropriate intake assumptions. Receptor specific intake assumptions for each of the Outfall Area receptors retained for analysis in the quantitative risk assessment are presented in text and tables provided in Appendix J-7.

6.2.3 Exposure Point Concentrations

This section presents the exposure point concentrations (EPCs) for each of the COPC retained in the quantitative risk assessment used to estimate intake. EPCs have been derived separately for the direct contact COPC for soil and sediment for the recreational user, construction worker, and utility worker.

A detailed discussion on the calculation of EPCs is presented in text and tables in Appendix J-7. Selection of EPCs are receptor specific and are based on the complete exposure pathways for each receptor.

Due to the limited number of surface soil samples collected, the maximum concentrations in surface soil were conservatively used as the EPCs for all receptors. As discussed in Appendix J-7, the soil EPCs are adjusted by an applicable transfer factor in order to relate concentrations in soil to concentrations in outdoor air.

Sediment EPCs are calculated differently depending on the receptor. U.S. EPA Region 4 indicates that, in most cases, it is unnecessary to evaluate human exposures to sediments covered by surface water. Therefore, only those sediment samples collected in areas of the outfall pool that may be subject to low water conditions where sediments are, at certain times, not covered by water were used in the calculation of the EPC for the recreational user. Since this represents only five sediment samples (SD-06 through SD-09, and SD-11) in the outfall pool, the maximum concentration was conservatively used as the EPCs.

The EPCs in sediments for the construction and utility worker were calculated under the scenario assuming that the stream would be dewatered for construction activities to take place. Therefore, all sediment samples were included in the EPC determination. Due to the length of the stream and the sediment sample locations, samples collected above the waterfall (outfall pool) were averaged and 95% UCLs were calculated. The 95% UCL for each constituent was compared to the maximum concentration in the downstream samples, and the maximum of the 95% UCL or maximum downstream concentration was estimated as the EPC for the construction worker. For all constituents, the 95% UCL of the samples in the outfall pool was greater than the concentration in any of the downstream samples.

6.2.4 Toxicity Assessment and Other Constituent-Specific Parameters

The toxicity values and other constituent-specific parameters used for assessment in the Outfall Area are the same as those used for the assessment of Parcel "A".

6.2.5 Risk Characterization and Results

This section presents the Site-specific risk results for the receptors in the Outfall Area. The general risk framework used to quantify risk is consistent with that presented in Section 6.1.4 for Parcel "A". Risks were calculated for each complete exposure pathway and for each receptor. Risk calculation support information, including the detailed risk calculations, are presented in text and tables located in Appendix J-7.

The estimated risks were compared to the point of departure value of 1×10^{-6} and the estimated hazard indices were compared to a U.S. EPA benchmark of 1. Baseline quantitative risks were calculated and are presented in Appendix J-7 and Table 6-8. The following presents the results of the benchmark comparison for each receptor and exposure pathway retained in the Outfall Area.

Recreational User

Risks were quantified to evaluate direct contact to surface soil and sediment for a current or future recreational user. Carcinogenic risks for the adult receptor (7 to 30 years) were below the point of departure value of 1×10^{-6} and the noncarcinogenic hazard index benchmark of 1.0. Carcinogenic risks for the child receptor (1 to 6 years) was only slightly above the point of departure value of 1×10^{-6}, but the noncarcinogenic hazard index was below the benchmark of 1. The carcinogenic exceedance was attributable to the ingestion and dermal contact pathways with benzo(a)pyrene.

Construction Worker

Risks were quantified to evaluate direct contact to soil (surface) and sediment for the construction worker. Risks were below both the carcinogenic point of departure value of 1×10^{-6} and the noncarcinogenic hazard index benchmark of 1.0.

Utility Worker

Risks were quantified to evaluate direct contact to soil (surface) and sediment for the utility worker. Risks were below both the carcinogenic point of departure value of 1×10^{-6} and the noncarcinogenic hazard index benchmark of 1.0.

7.0 APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

The assessment of Applicable or Relevant and Appropriate Requirements (ARARs) is an integral part of the remediation process mandated under Section 121 (d) of CERCLA, as amended by SARA. ARARs are used to develop remedial action objectives (RAOs), determine the appropriate extent of Site cleanup, and govern implementation and operation of the selected remedial action. Specifically, the preamble of CERCLA states, the purpose of the law is "to provide for liability, compensation, cleanup, and emergency response for hazardous substances released into the environment and the cleanup of inactive hazardous waste disposal sites". Remedial actions that "cleanup" hazardous substances at CERLCA sites must comply with state and federal standards and criteria that are legally applicable to the substance, pollutant, or contaminant; or that are relevant and appropriate under the circumstances [42 U.S.C. 9621(d)(2)(A)].

Section 300.430(f)(1)(i) of the NCP provides the criteria for selecting a remedial alternative. One of these criteria states that "overall protection of human health and the environment and compliance with ARARs (unless a specific ARAR is waived) are threshold requirements that each alternative must meet in order to be eligible for selection". An alternative that does not meet an ARAR under federal environmental or state environmental or facility citing laws may be selected under the following circumstances [Section 300.430(f)(1)(ii)(C)]:

- "The alternative is an interim measure and will become part of a total remedial action that will attain the applicable or relevant and appropriate federal or state requirement;
- Compliance with the requirement will result in greater risk to human health and the environment than other alternatives;
- Compliance with the requirement is technically impracticable from an engineering perspective;

- The alternative will attain a standard of performance that is equivalent to that required under the otherwise applicable standard, requirements, or limitation through use of another method or approach; or
- With respect to a state requirement, the state has not consistently applied, or demonstrated the intention to consistently apply, the promulgated requirement in similar circumstances at other remedial actions within the state;

Other federal and state advisory criteria, or guidance, as appropriate, may be considered in formulating the remedial action [Section 300.400(g)(3)]. In determining whether compliance with ARARs is practicable, the lead agency may consider appropriate factors, including:

(1) The urgency of the situation; and

(2) The scope of the remedial action to be conducted.

It should be noted that manufactured gas plant waste is exempt from the toxic characteristic regulations as specified in 40 CFR 261.24(a).

7.1 Definition of ARARs

According to NCP regulations (40 CFR 300.400(g)), a requirement may be either "applicable" or "relevant and appropriate" to a remedial action, but not both. These terms are defined below:

- Applicable requirements are "those cleanup standards, standards of control, and other substantive requirements, criteria, or limitations promulgated under federal environmental, state environmental, or facility citing laws that specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance found at a CERCLA site" [40 CFR 300.5].
- Relevant and appropriate requirements are "those cleanup standards, standards of control, and other substantive requirements, criteria, or limitations promulgated under federal environmental, state environmental, or facility citing laws that, while not 'applicable' to a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a CERCLA site, address problems or situations sufficiently similar to those encountered at the CERCLA site that their use is well suited to the particular site" [40 CFR 300.5].

Once a federal or state law has been classified as applicable or relevant and appropriate its requirements must be distinguished between substantive and administrative. "Substantive" requirements are "those requirements that pertain directly to actions or conditions in the environment. "Administrative" requirements are "those mechanisms that facilitate the implementation of the substantive requirements of a statue or regulation". Compliance with administrative requirements is not mandated for on-site actions (USEPA, 1988). For example, CERCLA specifically exempts on-site actions from federal, state and local permitting requirements [42 U.S.C. 9621(e)(1)]. Furthermore, only those State requirements that are more stringent than Federal requirements are ARAR [40 C.F.R. 300.5]. "More stringent" would also include those state laws or programs that have no federal counterpart as "they add to the Federal law requirements that are specific to the environmental conditions in the State" (USEPA, 1988). State requirements, however, must be adopted by formal means (i.e., promulgated) and applied universally through the state (i.e., not just to Superfund sites, but to all circumstances addressed in the requirement) [42 U.S.C. 9621(d)(2)(C)(iii)(I)].

7.2 To-Be-Considered Criteria

In addition, the NCP identifies a third category of guidance, termed "information to-be-considered" (TBC). The TBC category "consists of advisories, criteria, or guidance that were developed by EPA, other federal agencies, or states that may be useful in developing CERCLA remedies" [40 CFR 300.400(g)(3)]. Because these are not promulgated requirements, TBCs do not have the status of ARARs. However, these guidelines may be used when they are necessary to ensure protection of public health and the environment. If ARARs do not address a particular circumstance at a CERCLA site, then TBCs can be used to establish remedial guidelines or targets.

7.3 Types of ARARs

CERCLA remedial actions may trigger several different types of requirements or ARARs. EPA provides guidance on three categories of ARARs specific to the pollutant, location, or action, as discussed below:

- Constituent-specific requirements set health- or risk-based concentration limits or ranges for specific substances in various environmental media. If a given constituent has more than one such requirement, the more stringent ARAR should be met. Because some media have no promulgated constituent-specific ARARs or have relatively few constituents covered by such pre-established requirements, EPA's ARAR guidance stipulates that it may frequently be necessary to turn to constituent-specific advisory levels, such as carcinogenic potency factors or reference doses, to establish cleanup levels.
- Action-specific requirements set controls or restrictions on specific activities related to the management of hazardous substances (e.g., Resource Conservation and Recovery Act [RCRA] standards for design and operation of hazardous waste management facilities). These requirements are not constituent-specific, but specific to given remedial actions; they may specify acceptable methods that meet technology-based performance standards.
- Location-specific requirements set restrictions on activities according to characteristics of the site or its immediate environs (e.g., regulations pertaining to development in a 100-year floodplain). These requirements may apply if the CERCLA site is located in such a restricted area.

7.3.1 Constituent-Specific ARARs and TBC Guidance

Soil

Neither the federal government nor South Carolina has promulgated constituent-specific standards, requirements, criteria, and/or limitations that are applicable or relevant and appropriate for soil at the Site. TBC guidance includes advisories that have not been promulgated and thus are not enforceable. When compiling constituent-specific criteria, TBCs are useful where ARARs do not exist for a specific-constituent, or where such ARARs are not sufficient to be protective. In the absence of federal or state promulgated ARARs, a Site-specific risk assessment will be used to quantify risks associated with COPC in various media.

Groundwater and Surface Water

Constituent-specific ARARs for groundwater are highly dependent upon the use or potential use of the groundwater resource. Specifically, the U.S. EPA goal at sites is to return groundwater to its beneficial use within a reasonable period of time. Two jurisdictions, federal and state, can enact laws to protect human health and the environment. Section 121 of CERCLA specifies that remedial action for cleanup of hazardous substance must comply with the requirements or standard under federal or more stringent

state environmental law that are applicable or relevant and appropriate to the hazardous substances or particular circumstances at the Site. The federal and state government have promulgated groundwater and surface water standards, requirements, criterion, or limitations that are applicable or relevant and appropriate for the Site. These standards are provided in Table 7-1.

7.3.2 Action-Specific ARARs and TBC Guidance

Action-specific ARARs are promulgated state, or federal laws that set controls or restrictions on activities related to the management of hazardous materials. The remedial alternative for soil and groundwater, except no action, will require "actions" to transpire in the course of successfully instituting the alternative and may be controlled or restricted by action-specific ARARs. Potential action-specific ARARs are presented in Table 7-2. Hazardous waste regulations are not included in Table 7-2, since manufactured gas plant waste is exempt from the Toxic Characteristic regulation as specified in 40 CFR 261.24(a).

7.3.3 Location-Specific ARARs and TBC Guidance

Remedial action alternatives may be restricted or precluded by federal, state, or facility laws based on its location within a site or its immediate environment. Location specific ARARs are designed to protect the local area from potentially damaging remedial actions. For example, altering habitat of an endangered species to construct a treatment facility may jeopardize the survivability of the species. The converse is also true; location-specific ARARs also protect remedial alternatives from the environment. For example, locating a treatment facility within a flood plain without proper engineering precautions may result in structural damage during a flood. Location-specific ARARs are shown on Table 7-3.

8.0 SUMMARY AND CONCLUSIONS

8.1 Summary

The former MGP operated from 1906 through 1954. After 1954, MGP operations were terminated and the Site was redeveloped to the current day grade and utilized for bus transit operations. Currently, the existing buildings and asphalt-covered parking lot provide an "urban" cover for approximately 90 to 95 percent of the Site, effectively reducing surface infiltration, and potential recharge to groundwater.

8.1.1 Hydrogeology

The Site geology is complex and is largely influenced by past regrading and backfilling activities, and natural geologic processes (e.g., fluvial reworking). The general geologic sequence consists of unconsolidated sediments of varying lithologic characteristic overlying consolidated bedrock. The higher K, paleo deposits found in the former channel, located in the southern Site area, appear to be the controlling geologic feature influencing groundwater flow. Shallow groundwater at the Site is found to be unconfined in the unconsolidated sediments, with flow generally directed from north to south. The depth to groundwater ranges from approximately 6-25 feet bgs, across the Site.

8.1.2 Nature and Extent

The potential extent of source areas are shown on Figure 4-10 and include former MGP structures, existing or abandoned USTs, and the presence of DNAPL in lithologic samples. No DNAPL or LNAPL accumulation has been observed in any Site monitoring well. DNAPL occurrence has been noted in

lithologic samples and is most prevalent in the central eastern Site area (i.e., eastern maintenance building). To the north and west of this Site area, DNAPL presence is more sporadic and to the south DNAPL is found at depth. DNAPL, when observed, appears to be highly weathered.

Based on the groundwater sampling completed to date, impacts are generally limited to the Site (Parcel "A") and are typical of former MGP and UST constituents. Benzene and naphthalene are the primary constituents of concern in groundwater at the Site and the concentrations appear to be decreasing with time. Benzene and naphthalene were not found above detection limits in hydraulically downgradient and off-Site wells. More recent groundwater impacts from the USTs have commingled with the former MGP impacts on-Site. MTBE was detected on-Site and off-Site (but below the SCDHEC action level of 0.040 mg/L) and is likely attributable to a gasoline UST.

Based on the extensive soil data set, the highest concentrations and widest spatial distribution of soil impacts were generally found in the 2-15 feet bgs interval. Below a depth of 15 feet bgs impacts and spatial extent tended to decrease. Soil impacts were generally limited to on-Site, most prevalent in the central Site area under the existing maintenance building. More recent impacts from the USTs have commingled with the previous soil MGP impacts on-Site.

The non-detect constituent concentrations in culvert water samples supports the findings from the culvert video inspection that indicates little to no groundwater is discharging into the 72-inch buried culvert from the Site. Surface water samples collected in the unnamed tributary indicate that this media has not been impacted.

Visual and olfactory observations of sediment in the outfall pool indicate MGP impacts exist and forensic tests suggest a potential link to a pyrogenic source. Concentration of constituents in the sediment was noted to decrease as distance increased downstream. Urban runoff may also be contributing to the PAH concentrations observed.

Some soil samples collected in the Outfall Area and near the outfall pool indicate exceedance of screening values.

The soil gas analytical results indicate a general increase in constituent concentrations with depth.

8.1.3 Fate and Transport

DNAPL occurrence at the Site is limited such that there is no free phase accumulation in any Site monitoring well. Multiple occurrences of weathered, residual DNAPL were documented in the boring logs. The presence of a low K clay, saprolite, or granite layer below the higher K unconsolidated sediments will generally act to impede the vertical movement of DNAPL.

The dissolved phase plume, consisting primarily of benzene and naphthalene, is contained to the Site and appears to be decreasing in concentrations. Since the Site is essentially covered with an asphalt cap, surface infiltration and subsequent leaching of impacted soils to groundwater is minimized. Groundwater samples from off-Site monitoring wells are not impacted, indicating that constituent migration and/or attenuation processes are effective in reducing constituent concentrations.

Soil impacts in the southern Site area are believed to represent residuals from the former MGP and were likely redistributed through Site regrading and backfilling.

Culvert water analytical results indicated the absence of constituents and may be attributed to the structural integrity of the 72-inch buried culvert, which significantly reduces the potential for infiltration of impacted groundwater. The lack of constituents in the surface water samples collected from the unnamed tributary indicate adsorbed phase constituents (onto sediments) are not partitioning into water.

Just as the asphalt and buildings have reduced surface water infiltration, likely resulting in lower dissolved phase concentrations in groundwater, the urban covers may have contributed to higher soil gas concentrations by restricting airflow from the unsaturated soil zone.

DNAPL seeps may exist through fractures and joints in the buried culvert (from Parcel "A" to Outfall Area) and during storm events are transported to the outfall where energies wane and deposition occurs. Another possible mechanism is undercutting of the concrete apron and scouring of sediments containing MGP impacts and subsequent redeposition in the outfall pool.

8.1.4 Risk Assessment

Parcel "A"

Based on the available Site data as presented herein, a Site-specific conservative risk assessment was performed using standard methods.

Several Site-related constituents were retained as COPC in the various media and included the volatiles BTEX, styrene, MTBE, and 1,2,4-trimethylbenzene; various PAH compounds, and the following metals, arsenic, cadmium, chromium, copper, mercury, and thallium.

An exposure pathway was considered complete if all four of the following elements exist: 1) a source of COPC; 2) a potential transport mechanism; 3) contact between a potential receptor and the medium (exposure); and, 4) an uptake mechanism associated with the potential receptor.

The following transport pathways were retained for evaluation in the risk assessment:

- Surface Soil via
  - volatilization to outdoor air on-Site and off-Site
  - volatilization to indoor air
  - particulate emission to outdoor air on-Site and off-Site
  - leaching to subsurface soil
- Subsurface soil via
  - volatilization to outdoor air on-Site and off-Site
  - volatilization to indoor air
  - particulate emission to outdoor air on-Site and off-Site
  - leaching to groundwater

- Shallow groundwater bearing unit via
  - migration off-Site
  - diffuse discharge to surface water
  - volatilization to outdoor air on-Site and off-Site
  - volatilization to indoor air on-Site and off-Site

Potential receptors were selected to represent individuals who are most likely to come into contact with COPC during current and future use of the Site.

Receptors and exposure pathways have been identified for the Site under the current and future use scenarios. They include:

- On-Site worker:
  - Ingestion, inhalation, dermal contact of surface soil
  - Inhalation via vapor intrusion from surface soil, subsurface soil and groundwater
- Recreational user:
  - Ingestion, inhalation, dermal contact of surface soil
- Off-site receptor:
  - No exposure pathways retained
- Trespasser:
  - No exposure pathways retained
- Groundskeeper:
  - Ingestion, inhalation, dermal contact of surface soil
- Construction worker:
  - Ingestion, inhalation, dermal contact of surface soil and subsurface soil
  - Inhalation and dermal contact with groundwater
- Utility worker:
  - Ingestion, inhalation, dermal contact of surface soil and subsurface soil
  - Inhalation and dermal contact with groundwater

The risk characterization results were compared to the U.S. EPA benchmark point of departure value of 1 x 10^{-6} and the estimated hazard indices were compared to a U.S. EPA benchmark of 1. The point of departure value and/or hazard index was exceeded for each receptor evaluated as presented on Table 6-4.

Outfall Area

Based on the available Site data as presented herein, a Site-specific conservative risk assessment was performed using standard methods. PAH constituents were retained as COPC in the surface soil and sediment for the Outfall Area.

An exposure pathway was considered complete if all four of the following elements exist: 1) a source of COPC; 2) a potential transport mechanism; 3) contact between a potential receptor and the medium (exposure); and, 4) an uptake mechanism associated with the potential receptor.

The following transport pathways were retained for evaluation in the risk assessment:

- Surface Soil via
  - volatilization to outdoor air
  - particulate to outdoor air
  - erosional transport
- Sediment
  - volatilization to outdoor air

Potential receptors were selected to represent individuals who are most likely to come into contact with COPC during current and future use of the Site. Receptors and exposure pathways have been identified for the Site under the current and future use scenarios. They include:

- Construction worker:
  - Ingestion, inhalation, dermal contact of surface soil and sediment
- Utility worker:
  - Ingestion, inhalation, dermal contact of surface soil and sediment
- Recreational user:
  - Ingestion, inhalation, dermal contact of surface soil and sediment

8.2 Conclusions

The Site data and Site-specific risk assessment allow us to conclude:

Parcel "A"

- Off-Site groundwater is not impacted;
- Groundwater is minimally impacted on-Site. Drinking water is provided by the City of Columbia. Therefore, from a risk-based perspective, no action for groundwater is required. However, remedial action for source material will likely result in a reduction in groundwater impacts;
- Surface soil is impacted and will require remedial action; and
- Subsurface soil is impacted and will require remedial action.

Outfall Area

- MGP residual were observed in sediments at the outfall pool and likely are related to seeps from the buried 72-inch culvert or from undercutting of sediments below the concrete apron. Because of the presence of MGP residuals in the outfall pool sediments, this area will require remedial action;

- Surface soil adjacent to the outfall pool will require remedial action; and
- The culvert water and surface water will not require remedial action.

8.2.1 Future Anticipated Activities

Future data collection activities will be performed as an element of remedial design and includes a video survey of the buried culvert and additional soil sampling for delineation purposes. The video survey will be used to confirm or visually refute the presence of tar seeps (from the outfall location to Parcel "A") and if present used in evaluating remedial options. Soil analytical data will be used to design the extent of surface soil excavation and deeper soil may be delineated in areas currently inaccessible due to physical obstructions. Soil excavation represents a presumptive remedy and the horizontal extent of the surface excavation will be developed using a risk-based approach, to the extent practicable.

8.2.2 Remedial Action Objectives

Mutually agreeable Remedial Action Objectives (RAOs) will be developed for the Site after SCDHEC has had an opportunity to review and comment on the RI Report and the risk assessment. As discussed, for RI purposes, the risk levels will be compared to the point of departure value 1×10^{-6} and hazard index of 1. The RAOs will be developed in a manner that is commensurate with a remedial alternative that balances practicability, effectiveness, and cost to achieve a risk level appropriate for future Site use and amenable to the Parties involved. Since the intended future use of the Site may be mixed use (i.e., different receptors and exposure scenarios may be present on various portions of the Site), the RAOs will be developed to be protective of each receptor who may have potential exposures at the Site. Therefore, it is anticipated that the final remedial action objectives could represent a range of risk levels and may also consider institutional controls if the cost and/or technology is not sufficient in achieving an expected beneficial risk level.

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