Remedial Alternatives Analysis

Central Hudson Gas & Electric Corporation

Catskill Former Manufactured Gas Plant Site

Catskill, NY

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Table of Contents

Table of Contents

Table of Contents

Table of Contents

Table of Contents

1.0 Introduction

Central Hudson Gas & Electric Corporation (Central Hudson) is proposing to remediate the former Catskill Manufactured Gas Plant (MGP) site located along Water Street in Catskill, New York (see Figure 1-1). The work is being completed pursuant to a signed Brownfield Cleanup Agreement (BCA; Index Number A4-0553-0606) between Central Hudson and the New York State Department of Environmental Conservation (NYSDEC). As part of the agreement, Central Hudson was required to identify and delineate MGP-impacts on the property. The NYSDEC and the New York State Department of Health (NYSDOH) approved the May 2010 Remedial Investigation (RI) Report in a July 23, 2010 letter to Central Hudson, and requested that a Remedial Alternatives Analysis (RAA) Report be prepared. Their letter also stated that "… the Departments have concluded that the site poses significant threat to public health and the environment" based on the detection of MGP related by-products in the soil, groundwater and adjacent creek sediments.

The remainder of this document outlines the tasks, which were completed in accordance with applicable portions of Chapter 4 (Remedy Selection) of NYSDEC Division of Environmental Remediation (DER)-10 Technical Guidance for Site Investigation and Remediation dated May 2010 to determine a technically sound and cost effective remedial alternative to address MGP-impacted media at the site. Each MGP-impacted media (soil, groundwater, and sediment) is addressed within this Report and a remedial alternative is selected and presented.

1.1 SITE LOCATION

The site is located in the Village of Catskill, Greene County, New York (see Figure 1-1). The site is approximately 3.7 acres in size and is located along Water Street in the Village of Catskill. The site is comprised of three separate areas upon which two gas manufacturing facilities operated during two different periods in time (see Figure 5-1). The areas include: Area A – original gas plant property; Area B – referred to as the art studio property; and Area C – the parking lot for Greene County employees.

1.2 OUTLINE OF RAA REPORT

The RAA Report is organized as follows:

- **Section 1: Introduction** — Discusses the site location and outline of the Report.
- **Section 2: Site Description and History**— Describes the description of the site and a brief history of the MGP operations at the site.

- **Section 3: Summary of RI and Exposure Assessment** — Summarizes the findings of the RI as contained within the NYSDEC-approved RI Report and identifies potential sources, migration pathways, exposure pathways, and receptors.

- **Section 4: Remedial Goals and Remedial Action Objectives** — Presents the remedial goals for the site and the remedial action objectives (RAOs) that were developed for each of the MGP-impacted media.

- **Section 5: Development and Analysis of Alternatives** — Details each of the remedial alternatives that were considered for implementation to address the MGP impacted media. Also reviews each of the alternatives relative to the nine criteria.

- **Section 6**: **Recommended Remedy** — Outlines the selected remedy for the site, describing the recommended remedial alternative for each media.

- **Section 7**: **References**— Presents references cited in the RAA Report.

The text of this RAA Report is supported by tables, figures, and appendices.

2.0 Site Description and History

2.1 SITE DESCRIPTION

The site is located in the Village of Catskill, Greene County, New York (see Figure 1-1). The site is approximately 3.7 acres in size and is located along Water Street in the Village of Catskill. The site is comprised of three separate areas upon which two gas manufacturing facilities operated during two different periods in time (see Figure 5-1). All three of the areas (Areas A, B, and C) and the adjacent Union Mills property are not owned by Central Hudson. The first area, which is the site of the first gas plant (Area A), is adjacent to and south of an old foundry building. The first gas plant building appears to have been demolished and the site is currently vacant. Area A is currently fenced along the eastern (Water Street) and southern (Union Mills property) boundaries. The Union Mills property is currently undergoing commercial/residential renovations. The second area (Area B) is the former location of a gas holder and is currently occupied by an art studio. According to historical maps, the studio is situated directly over the former holder location. Some portions of the former gas holder extend further to the east and south, outside the “footprint” of the art studio building. The third and northernmost area (Area C) is the former location of the second gas plant and is currently a paved parking lot. The parking area is contained by a perimeter fence located in the southern half of the property and a retaining wall located in the northern half of the property.

2.2 SITE HISTORY

The former Catskill MGP began operation in 1858 (Areas A and B) utilizing the coal carbonization process to manufacture gas from coal. By 1890, under the ownership and operation of Catskill Illuminating and Power Company the coal gas plant was producing 3 million cubic feet (cu ft)/year. The first plant was very small and, by 1900, due to increased consumer demand, new equipment was installed to increase the plant’s capacity. At the turn of the century, the Catskill MGP was producing 6 million cu ft/year. In 1905, the Catskill Illuminating and Power Company was purchased by the Upper Hudson Electric and Railroad Company (EA, 1987).

By 1920, production rates reached 11 million cu ft/year, but it was not enough to meet the increased demands of the Catskill district. In 1923, the Upper Hudson Electric and Railroad Company moved the gas plant to the site of the electric light and power station (Area C) nearly adjacent to its first plant, and the process of manufacturing gas was changed from coal carbonization to carbureted water gas. In doing so, the capacity of the gas plant was doubled. In 1925, the Upper Hudson Electric and Railroad Company proposed to demolish the first gas plant and establish an office and storeroom area in part of the first plant while removing the coal shed and processing apparatus. These changes, however, could not be confirmed. In June 1925, the first Catskill gas plant was sold to the adjoining Catskill Foundry and Machine Company (EA, 1987).

In 1926, the Upper Hudson Electric and Railroad Company merged with several other small utility companies to form Central Hudson Gas & Electric Company, which later became the Central Hudson Gas & Electric Corporation (Central Hudson). By 1930, the gas plant was producing 24 million cu ft/year. In 1932, Central Hudson converted the carbureted water gas plant to a butane air gas operation. The plant operated in this manner until 1958, at which time a natural gas transmission line was introduced to the area. As a result, the production of butane air gas was discontinued, the plant was disassembled, and the property and equipment were sold (EA, 1987).

Based on Sanborn Maps (1884, 1889, 1895, 1903, 1912, 1923, 1931, 1945, and 1961) and a Central Hudson map (undated; EA, 1987) the coal carbonization plant (Areas A and B) contained the following major structures: gas holder, gas plant building (with retort room, coal shed, and lime house), three oil cisterns, and two gasometers (holders). The carbureted water gas plant (Area C) contained: gas holder, purifier boxes, tar well, coal shed, and gas plant building containing retorts and a boiler. The locations of the historical MGP structures and present-day features are shown on Figure 5-1.

3.0 Summary of RI and Exposure Assessment

ARCADIS (and various subcontractors) performed the remedial investigation (RI) work at the site on behalf of Central Hudson and prepared the RI Report that was approved by the NYSDEC. The information in Section 3.0 was derived from the 2008 (revised 2010) RI Report prepared by ARCADIS.

3.1 GEOLOGY

The following section outlines the regional and site-specific geology and site-specific hydrogeology of the site. For further details of these topics, please refer to the Phase I findings as discussed within the RI Report.

3.1.1 Regional Geologic Setting

A United States Geological Survey (USGS) report indicated that the unconsolidated sediment at the site is likely a deltaic deposit composed mostly of sand and gravel deposited over an older lacustrine clay (Berdan, 1954). In addition, a Greene County Soil Conservation Service report (1974) indicated the upper five feet of unconsolidated sediment is a silt loam in the immediate vicinity of the site. The Ordovician age Normanskill shale is reported to exist below the unconsolidated material of unknown thickness (Greene County, 1974). Evidence of the shale is apparent in outcrops located within one mile from the site on either side of Catskill Creek.

3.1.2 Site Geologic Setting

Topographic relief at the Catskill site is slight (approximate 2 percent rise) in Area C, and moderate (approximate 5 to 10 percent rise) in Areas A and B, with the land surface sloping westward toward Catskill Creek. The land surface elevation at the site is approximately 8 to 25 feet (NAVD 88). The elevation of the Catskill Creek surface water near the site is approximately 0 feet (NAVD 88). Catskill Creek is approximately 6 to 12 feet deep immediately adjacent to the site.

Site investigations have identified four principal stratigraphic units beneath and adjacent to the site. These units, listed below, show a sequence of events, from the land surface down, (youngest to oldest) specific to the site's geologic and industrial history.

- Fill - Fill and the remnants of several man-made structures, originating from the site's industrial history.
- Fluvial Deposits - Fine sand likely deposited within Catskill Creek and associated floodplains as the stream meandered from side to side.

- Lacustrine/Floodplain Deposits - Silts and clays deposited in glacial lakes or floodplain deposits.
- Glacial Deposits - Sand and gravel and till possibly deposited during the last glacial recession.

The generalized description of these units is provided below:

Unit	Thickness (feet)	Stratigraphic Description
Fill	2 to 20	Sand with varying amounts of clay, silt and gravel, cinders, slag, brick and wood. Present across and adjacent to the site.
Fine Sand	4 to 20	Predominately fine sand with little to trace amounts of silt, fine gravel, organics and shell fragments. At times the fine sands may be layered. Present continuously across Areas A and C.
Silt and Clay	4 to 12	Silts and clays. Present to the east in Area B and along the eastern portion of Area A.
Sand and Gravel/Till	2 to 12.5	Fine sand and unsorted gravel with trace amounts of silt and wood; and is sometimes described as till-like and/or is interbedded with till-like soils. Generally present in Area C and the foundry property, and sporadically present in Areas A and B and the Union Mills property.

Geologic cross sections across the site were prepared based on data generated from previous investigations at the site. These cross sections are contained within the NYSDEC-approved RI Report. The cross sections show the vertical distribution of the stratigraphic units in the site area.

3.2 HYDROGEOLOGY

Hydrostratigraphic units comprise one or more geologic units of similar hydrogeologic properties (e.g., hydraulic conductivity) that may be grouped together to aid in the interpretation of groundwater flow beneath the site. The hydrostratigraphic units at the site are discussed below.

At the site, two primary hydrostratigraphic units were observed during the previous investigation: the fill unit and the fine sand and gravel unit. An additional hydrostratigraphic unit comprised of the silt and clay was observed in the eastern portion of the site.

3.2.1.1Fill

The fill unit forms the uppermost hydrostratigraphic unit across the site, and is bound by the water table above, and by the fine sand unit (or the silt and clay unit to the east) below. The fill is generally described as fine to medium sands, with varying amounts of silt, clay and/or gravel and lesser amounts of organics, cinders, wood, brick, slag and/or glass. This unit derives its water from direct recharge of infiltration from precipitation events, horizontal flow through the fill unit from up-gradient sources and tidal fluctuations of Catskill Creek near the western portion of the site.

Specific-capacity tests were performed at monitoring wells that were screened entirely in the fill unit and partially in the fill unit and in the fine sand unit located beneath the fill. The tests yielded a range in horizontal hydraulic conductivity values (K_h) of 5.37 to 77.3 feet per day. The more elevated hydraulic conductivity value (K_h) is likely attributed to a transmissive sand and gravel fill zone surrounding the upper portion of the sand pack. The apparent reworking or mixing of fill with the underlying finer grained sands may account for the relatively lower hydraulic conductivity value. This data suggests that the hydraulic conductivity of the fill varies across the site and is dependent on the matrix, density and amount of native soils mixed with the fill materials.

3.2.1.2 Fine Sand and Gravel

The fine sand, along with the lower fine sand and gravel, comprises the bottom hydrostratigraphic unit. This unit is significant because the majority of the potential MGP-impacts were observed in the upper fine sand unit. Thus, the majority of the soil borings and monitoring wells, which were advanced and installed to investigate the physical characteristics and the extent of impacts are located in this unit.

The upper fine sand unit can generally be described as brown fine sand with little to trace amounts of silt, fine gravel and organics. The underlying sand and gravel can generally be described as brown-gray fine sand and unsorted gravel with trace amounts of silt

This hydrostratigraphic unit is encountered across all of Areas A and C at a thickness of approximately 5 to 20 feet. The top of this unit likely formed the original land surface prior to development of the area. Its surface is currently covered by fill and asphalt, and is relatively flat in Area C, and is primarily covered with gravel at the surface and is gently to moderately sloped toward Catskill Creek in Area A. The upper portion of this unit may have been re-worked in some areas as the site was developed because the lower portion of the fill appears to contain varying amounts of fine sand and organics mixed with anthropogenic materials.

Specific-capacity tests performed on monitoring wells installed in this unit yielded horizontal hydraulic conductivity values of 6.1 to 8.0 feet per day. The similar hydraulic conductivity values suggests that the upper fine sand and the lower fine sand and gravel act as the same hydrostratigraphic unit and are discussed as such.

3.2.1.3 Silt and Clay

The silt and clay, which was encountered forms another hydrostratigraphic unit primarily located along the eastern portion of Area A and continuing into Area B. The unit can be generally described as brown silty clay containing various amounts of fine to medium gravel, fine sand, rock fragments, and organics. One monitoring well was almost entirely screened in the silt and clay unit. A specific-capacity test performed at this monitoring well yielded a horizontal hydraulic conductivity value of 0.015 feet per day.

3.2.1.4 Bedrock

During the previous investigations, bedrock was encountered beneath each of the three Areas A, B, and C. As noted on the soil boring logs appended to the RI Report, refusal was encountered at depths ranging from 12.5 ft bgs (Elevation -12.5 ft MSL at SB-105 in Area A) to 38.9 ft bgs (Elevation -29 ft MSL at SB-8 in Area C). The bedrock beneath the site is reported to be the Ordovician age Normanskill shale of unknown thickness (Greene County, 1974).

3.2.1.5 Groundwater Flow

Based on the depth to water measurements collected during the RI, the water table was encountered beneath the site ranging from 8.29 to 13.52 ft bgs. The water table map generated from this data illustrated a groundwater flow to the west with discharge to Catskill Creek.

3.3 ANALYTICAL RESULTS – SOIL

Soil samples collected from the site included both surface soil samples (from the top 2 inches) and subsurface samples from soil borings (which ranged in depth from 4 to 39 feet bgs). Soil samples were collected and analyzed from Areas A, B, and C and the adjacent Union Mills property. The paragraphs below discuss both the visual MGP impacts that were observed during past investigations followed by a discussion of the analytical results. As an initial screening during the RI phase, the soil results were compared to the NYS restricted commercial soil clean up objectives (SCOs) for Areas A, B and C. However, since the approval of the RI Report NYSDEC and Central Hudson had discussions and have agreed to evaluate Areas B and C as restricted commercial and Area A and the Union Mills property as restricted residential.

3.3.1 Visual Impacts in Subsurface Soil

Soil collected from subsurface investigation locations was visually characterized and the presence of potential impacts (non-aqueous phase liquids (NAPL), sheen, and/or staining) was noted. The distribution of the observed impacts is shown on Figure 14 of the RI Report. These impacts were observed at 19 of the 47 soil borings advanced during the 2007 and 2008 investigations. Impacts were not observed at the six soil borings installed during the 2009 investigation. Fourteen of these 19 locations only contained trace amounts of NAPL blebs, staining, and/or sheen; the remaining five locations contained higher amounts of NAPLs in the subsurface.

NAPL and/or sheen were observed only in Area A in the vicinity of the former original gas plant building and the two former gasometers. An exception was an observation of sheen (15.7 to 16.3 feet bgs) at boring location SB-111 in Area B. Additional details regarding the observations in this area are provided below. Only trace sheen was observed in Area B and slight odors were observed in Area C, both of which were in the vicinity of the former gas holders.

Potential purifier waste was identified at the site in two soil borings in the form of woody material and green colored cinders. Block shaped wood chips were observed from 8.6 to 10.5 feet bgs at soil boring location SB-11 in Area C. Cinders containing a greenish coloration were observed in fill material from 4.0 to 9.3 feet bgs in boring location SB-15 (Area A).

3.3.1.1Former Original Gas Plant Building/ Oil Cisterns/Gasometers – Area A

Twenty-six soil borings were installed in Area A. Relatively greater NAPL amounts were observed at five soil borings (SB-2, MW-1, SB-100, SB-106, and SB-107) drilled near and west of the former original gas plant building, the oil cisterns and the two gasometers in Area A. The NAPL impacts encountered at these five locations are summarized in the table below.

Boring ID	Impacted Interval (feet bgs)	Impacted Interval (elevation feet)	Vicinity
SB-2	Some NAPL (16.0 to17.3) Trace Blebs (21.0)	Some NAPL (-3.5 to -4.8) Trace Blebs (-8.5)	Adjacent to south side of original gas plant building.
MW-1	Some NAPL (13.0 to13.5) Trace Blebs (14.0 to14.4)	Some NAPL (-3 to -3.5) Trace Blebs (-4 to -4.4)	West of original gas plant building.
SB-100	Viscous NAPL (13.7 +) NAPL Blebs (13.4 to17.0) NAPL Blebs (24.5 to24.7)	Viscous NAPL (-3.94) NAPL Blebs (-3.7 to -7.2) NAPL Blebs (-14.7 to -14.9)	West of original gas plant building, adjacent to Catskill Creek.
SB-106	Viscous NAPL (5.7 to5.9) Trace NAPL (10.6 to17.1)	Viscous NAPL (9.7 to 9.5) Trace NAPL (4.8 to -1.7)	In the vicinity of the former oil cisterns and gas plant building.
SB-107	Viscous NAPL (5.9 to9.2) Little NAPL (9.2 to10.2) Trace NAPL (12.6 to16.2)	Viscous NAPL (5.9 to 5.9) Little NAPL (6.9 to 5.9) Trace NAPL (3.5 to -0.2)	In the vicinity of the former oil cisterns and gas plant building.

NAPL blebs were also observed at eight other boring locations in the vicinity of the gasometers and west of the original gas plant building (SB-1, SB-4, SB-5, SB-13, SB-14, SB-16, SB-101, and SB-113). The shallowest NAPL, observed at boring location SB-16, was a trace bleb at 5 feet bgs. The northern extent of NAPL in overburden is bound by soil borings SB-3, SB-102, SB-103, SB-122 and SB-123 where no visual impacts were observed. The eastern extent of NAPL appears to be bound by soil borings MW-2, SB-104, SB-109, SB-206, and SB-207 where no visual impacts were observed. Based on the shallower elevation of the bedrock surface to the east, it is not expected that NAPL observed in the central portion of Area A would exist beyond the site property to the east. The migration of NAPL would be expected west toward Catskill Creek.

The observations of NAPL at soil boring locations MW-1 and SB-14 during the 2007 investigation led to the installation of several soil borings (SB-100, SB-101 and SB-123) along Catskill Creek during the 2008 supplemental investigation. NAPL impacts were observed at locations SB-100 and SB-101 along the southern and central portions of the western boundary in Area A, respectively. No visual impacts were observed in the northernmost soil boring (SB-123) along the western boundary of Area A.

Because NAPL was observed in soil borings SB-4, SB-5, SB-13 and in MW-1 located along the southern portion of Area A during the 2007 investigation, and due to the presence of NAPL at location SB-100 advanced during the 2008 investigation in the southwest corner of Area A, the work scope was expanded off-site onto the adjacent Union Mills property to define the limits of NAPL to the south.

3.3.1.2Union Mills Property -South of Area A

Based on the data generated from Area A, a total of eight borings were advanced on the Union Mills property (south of Area A). Seven of these soil borings were drilled between the Union Mills building and Catskill Creek to evaluate the southern extent of NAPL. NAPL blebs were observed at two boring locations (SB-114 and SB-119) along Catskill Creek. At SB-114 and SB-119, the interval that the NAPL was observed at each location corresponds to approximately the same depth below ground surface (16.3 to17.4 feet and 16.8 to 17.5 feet bgs, respectively), with sheens extending down to 20.4 feet bgs at location SB-114. Two other soil boring locations (SB-115 and SB-116) adjacent to the southern edge of Area A also contained sheen. The extent of NAPL in the subsurface appears to be bound to the south by soil borings SB-120 and SB-121, between the Union Mills building and Catskill Creek because the lack of observed NAPL in either of the soil borings. One additional boring (SB-109) was installed along the eastern side of the Union Mills building. No impacts were observed at this location.

3.3.1.3Foundry Property – North of Area A

A total of three soil borings were advanced on the property located north of Area A, west and adjacent to Catskill Creek (SB-204 and SB-205) and south of the former foundry building (SB-3). No impacts were noted at these soil boring locations.

3.3.1.4Former Gas Holder – Area B

Due to property access restrictions, no soil borings were advanced in Area B during the 2007 investigation. During the 2008 investigation, a total of four soil borings were advanced in Area B. One of the four borings proposed was to be installed west of the former holder, but due to the proximity of the existing building to Water Street and the presence of buried utilities, it was not feasible to install. Of the three remaining borings installed, only location SB-111 contained trace sheen and MGP-like odor from 15.7 to 16.3 feet bgs. A fourth boring (SB-117) was then added south of SB-111 as a “step out” due to the observations of sheens at SB-111. No other impacts were observed in Area B. Due to restricted access in Area B, soil boring locations were limited to the southern portion/edge of the area.

3.3.1.5Former Gas Holder – Area C

A total of 14 soil borings were installed in Area C during the 2007 and 2009 investigations. At soil borings SB-6 and SB-7, faint odors were noted from 12.0 to 12.5 feet bgs, and 12.0 to 13.5 feet bgs, respectively. No elevated PID readings were detected at either location. A potential buried structure (former gas holder) at 4.4 ft bgs was encountered during the advancement of soil boring SB-7. After augering through the concrete structure, a water filled (likely perched) void from 5.5 to 10.9 feet bgs was encountered. An underwater camera was used to inspect the void; no noticeable impacts were observed and only vegetation was observed in the bottom of the void. A second floor was encountered from 10.9 to 11.5 feet bgs. In addition, two soil borings (SB-208 and SB-209) were installed in the vicinity of the purifier boxes and tar well to verify that MGP-related impacts are not present in this area. No impacts were noted in either of these two soil borings.

3.3.2 Subsurface Soil Analytical Results

The discussion below focuses on BTEX, polycyclic aromatic hydrocarbons (PAHs), and cyanide as indicators of potential MGP impacts. Other volatile organic compounds (VOCs) detected included 2-butanone, acetone, bromomethane, carbon disulfide, chloromethane, iodomethane, and styrene. Other semi-volatile organic compounds (SVOCs) detected included 2,4-dimethylphenol, 4-methylphenol, and bis(2-ethylhexyl)phthalate. All Target Analyte List (TAL) metals were detected. However, only xylenes, select PAHs, and cyanide exceeded commercial SCOs, and only BTEX, 2-butanone, acetone, PAHs, lead, mercury, zinc, and cyanide exceeded unrestricted use SCOs.

3.3.2.1BTEX

Sixteen subsurface soil samples were collected and analyzed for VOCs during the 2007 investigation, twenty-four soil samples were collected during the 2008 investigation, and eight soil samples were collected during the 2009 investigation. Thirty-two of the forty-eight samples collected during the three investigations contained detectable concentrations of BTEX compounds. Concentrations of total BTEX ranged from 0.0018 mg/kg (MW-2 [6-8 feet bgs]) to 840 mg/kg (SB-114[16.3-17.4 feet bgs]). The highest concentrations of total BTEX were generally noted in soil samples collected from the visually impacted material (discussed above) at SB-2, SB-5, SB-14, SB-16, SB-100, SB-101, SB-105, and SB-114. No soil samples were collected from MW-1, SB-106, and SB-107 for chemical analyses. Only one soil sample contained concentrations of xylenes above the commercial SCO: SB-14(11-12 feet bgs) at 530 mg/kg. Another soil sample contained concentrations of benzene above the commercial SCO: SB-114(16.3-17.4 feet bgs) at 66 mg/kg. No samples contained concentrations of toluene or ethylbenzene (or other VOCs) above commercial SCOs.

3.3.2.2PAHs

Sixteen subsurface soil samples were collected and analyzed for SVOCs during the 2007 investigation, twenty-four samples were collected during the 2008 investigation, and eight samples were collected during the 2009 investigation. All but nine of the 48 samples contained detectable concentrations of PAH compounds. Concentrations of total PAHs ranged from 0.023 mg/kg (SB-121[15-17 feet bgs]) to 22,000 mg/kg (SB-105[12-12.5 feet bgs]). Similar to the concentration trend observed for BTEX, the highest concentrations of total PAHs were in samples collected from the visually impacted material (discussed above) at SB-2, SB-4, SB-5, SB-14, SB-16, SB-101, SB-105, and SB-114. Samples obtained from depth intervals below visually impacted soils (SB-14, SB-100, SB-115, and SB-116), contained concentrations of total PAHs similar to total PAH levels in the background surface soil samples (71J and 39J mg/kg). Samples collected from visually non-impacted intervals at MW-2, MW-7, SB-3, SB-6, SB-7, SB-9, SB-12, SB-102, SB-103, SB-109, SB-110, SB-112, SB-117, SB-120, SB-121, SB-122, SB-123, and SB204 through SB-209 contained concentrations of total PAHs less than 29 mg/kg, which are less than the total PAH levels in the background surface soil samples (71J and 39J mg/kg).

Seventeen samples collected during the three investigations contained concentrations of one or more PAHs above the commercial SCOs. Thirteen of these samples correspond to the areas where visually impacted material was observed. The remaining four samples were collected from SB-14 (20-22 feet bgs), SB-15(16.5-18 feet bgs), SB-116 (12-13 feet bgs) and SB-120(16-20.5 feet bgs). These four samples contained concentrations of benzo(a)pyrene at levels slightly above the commercial SCO. Higher concentrations of benzo(a)pyrene were detected in the background surface soil samples than in the soil samples collected from SB-14, SB-15, SB-116, and SB-120.

3.3.2.3Cyanide

A total of nine subsurface soil samples were collected and analyzed for total cyanide during the three investigations (2007, 2008, and 2009). Six of the nine soil samples contained detectable concentrations of total cyanide. Concentrations of total cyanide ranged from 0.180B mg/kg (SB-117[16-16.5 feet bgs]) to 220 mg/kg (SB-14[11-12 feet bgs]). The soil sample collected from SB-14 (11-12 feet bgs) was the only soil sample containing a concentration greater than the commercial SCO for total cyanide.

3.3.3 Visual Impacts in Surface Soil

Surface soil samples were collected from Areas A (4 samples), B (2 samples), and C (2 samples) and at off-site (2 samples) locations during the previous investigations. The samples were visually characterized, and the presence of potential impacts (NAPL, sheen, odors, and/or, staining) was recorded. No visual or olfactory impacts were observed at any of the ten surface sampling locations.

3.3.3.1Surface Soil Analytical Results

The discussion below focuses on BTEX, PAHs, and cyanide as indicators of potential MGP impacts. Other VOCs detected included 2-butanone, acetone, bromomethane, and carbon disulfide. Other SVOCs detected included bis (2-ethylhexyl)phthalate, di-n-butylphthalate, and pentachlorophenol. All TAL metals were detected. However, only select PAHs exceeded commercial SCOs, and only acetone, select PAHs, lead, and zinc exceeded unrestricted use SCOs.

3.3.3.2BTEX

Ten surface soil samples were collected and analyzed for VOCs during the 2007 and 2008 investigations. Five of the ten samples contained detectable concentrations of BTEX compounds. Concentrations of total BTEX ranged from 0.0027J mg/kg (SS-3 [duplicate]/SS-100) to 0.021 mg/kg (SS-7). No surface soil samples contained concentrations of their individual constituents of total BTEX above the commercial or unrestricted use SCOs.

3.3.3.3PAHs

Ten surface soil samples were collected and analyzed for SVOCs during the 2007 and 2008 investigations. All of the samples contained detectable concentrations of PAH compounds. Concentrations of total PAHs ranged from 3.8J mg/kg (SS-100) to 520 mg/kg (SS-8). Nine surface soil samples contained concentrations of one or more PAHs above their respective commercial SCOs and all ten samples contained concentrations of one or more PAHs above their respective unrestricted use SCOs, including the two background samples (SS-3 and SS-4). Sample SS-100 located in Area B contained all PAH concentrations below commercial SCOs. Total PAH levels in the surface soil samples collected on-site (3.8J to 110J mg/kg) were similar to total PAH levels in the background samples (71J and 39J mg/kg) except for the sample from SS-8 (520 mg/kg). PAHs are ubiquitous in urban soils originating from anthropogenic and non-anthropogenic origins such as power generation, industrial processes, burning, vehicle combustion, road materials, and coal among other origins. Total PAHs in urban soils can range to well over 100 mg/kg (O'Brien & Gere, 2000). ARCADIS also conducted a forensic chemical analysis on PAH's redetected in SS-2 and SS-6 on behalf of Central Hudson. The analysis concluded that the PAH's are not related to the coal tar material observed on Area A, and the concentrations were in the range of the background samples (SS-3 and SS-4). The forensic chemical analysis is included as Appendix A.

3.3.3.4Cyanide

Three surface soil samples (SS-2, SS-4, and SS-100) were collected and analyzed for TAL inorganics. Cyanide was not detected in the surface soil samples above commercial or unrestricted use SCOs.

3.4 ANALYTICAL RESULTS – GROUNDWATER

The groundwater quality beneath the site has been impacted from historical MGP operations based on analytical results of groundwater samples that have been collected. No monitoring wells are located in Area B, so the data represents the results from monitoring wells located in Areas A (2 wells) and C (5 wells). Groundwater samples were collected from monitoring wells MW-1 through MW-7 during the October 2007 groundwater sampling event. This evaluation focuses on the nature and extent of BTEX, PAHs, and total cyanide, as indicators of potential MGP impacts. The analytical results were compared with NYSDEC TOGS 1.1.1 (June 1998) Class GA groundwater Standards and Guidance Values (referred to hereafter as "Class GA standards or guidance values").

In addition to BTEX, PAHs, and total cyanide being detected in the groundwater, only one other SVOC was detected in groundwater above a NYSDEC guidance value. The groundwater sample collected from MW-1 located within Area A contained 74 J micrograms per liter (µg/L) of 2, 4-dimethylphenol, which is greater than the guidance value of 50 µg/L. Monitoring wells MW-2, MW-3, MW-4, MW-5, MW-6, and MW-7 also contained iron and manganese above Class GA standards. In addition, monitoring wells MW-5 and MW-6 also contained barium above Class GA standards. Groundwater samples were not filtered prior to collection; therefore, it is possible that the elevated inorganics may be associated with groundwater sample turbidity in some groundwater samples.

3.4.1 BTEX

BTEX was detected in groundwater sampled from monitoring wells MW-1, and MW-2 in Area A, and MW-7 in Area C. Benzene, toluene, ethylbenzene, and xylene were detected in the groundwater sample collected from MW-1, all of which exceeded Class GA standards for these compounds. These four compounds (BTEX) were also detected in MW-2, but only benzene at a concentration of 3.7 µg/L exceeded its Class GA standard of 1µg/L. Toluene was estimated at 0.28 J µg/L in groundwater at monitoring well location MW-7 but was below the Class GA standard of 5 µg/L. The presence of elevated BTEX in groundwater at location MW-1 is related to the presence of NAPL at this location.

3.4.2 PAHs

PAHs were detected in groundwater samples collected from MW-1 and MW-2 in Area A and MW-7 in Area C. At MW-2, only a trace amount of acenaphthene (0.44 J µg/L) was detected in the groundwater sample collected. At MW-7, only a trace amount of naphthalene (1.1 J µg/L) was detected in the groundwater sample collected. Neither of the PAHs detected at MW-2 and MW-7 exceeded their respective Class GA standard. Groundwater collected from MW-1 contained a total PAH concentration of 1,100 J µg/L. Naphthalene (750 µg/L) comprised most of the total PAH concentration in this groundwater sample. Naphthalene, along with fluorene and acenaphthene exceeded the Class GA guidance values for groundwater at MW-1. No other PAHs were detected in the groundwater sample collected from MW-1 at levels exceeding their respective Class GA standards or guidance values. The presence of elevated PAHs in groundwater at MW-1 is related to the presence of NAPL at this location.

3.4.3 Cyanide

Total cyanide was detected in all seven of the monitoring wells at concentrations ranging from 6.50 B µg/L (MW-6) to 259 µg/L (MW-1). Monitoring well MW-1 was the only monitoring well containing groundwater with total cyanide concentrations above its Class GA standard of 200 µg/L. Groundwater from MW-1 contained 259 µg/L of total cyanide. The presence of total cyanide in groundwater at MW-1 is associated with the total cyanide detected in the subsurface soils at adjacent soil boring SB-14.

3.5 ANALYTICAL RESULTS – SOIL VAPOR

The 2007 and 2010 soil vapor results were evaluated and compared to the NYSDOH Guidance, where applicable, and by evaluating the potential origins of the VOCs detected. The NYSDOH Guidance uses two matrices as a tool to establish action levels based on a comparison of subslab vs. indoor air concentrations of seven chlorinated volatile organic compounds (CVOCs). The seven CVOCs are: trichloroethene (TCE), vinyl chloride, carbon tetrachloride, tetrachloroethene (PCE), 1,1,1-TCA, 1,1-DCE and cis-1,2-DCE. Currently, NYSDOH has no promulgated standards or guidance values for subslab or soil vapor VOCs other than the seven identified above.

3.5.1 2007 Soil Vapor Evaluation Results

Ten soil vapor samples were collected in Areas A and C and were analyzed for VOCs by modified United States Environmental Protection Agency (USEPA) Method TO-15. The data generated were initially evaluated to determine the potential origins of the VOCs detected. To perform this forensic evaluation, total ion chromatograms (i.e., gas chromatograph (GC) fingerprints) were examined.

Three different types of constituent groups (A, B, and C) appear to contribute to the compositions of the soil vapor (SV) samples at the site. Type A constituents include low levels of equal amounts of total aromatic and total alkane compounds. The presence of n-alkanes and relatively higher concentrations of the lower-molecular weight aromatics in Type-A suggests that the hydrocarbons are petroleum product related. Type B constituents contain a dominance of the alkane compounds compared to aromatic compounds which suggests that the type of material is a petroleum product, although not a common petroleum product such as gasoline since the relative amount of the alkane compounds is approximately 100 times higher the aromatic compounds. Type B constituents are not from coal tar products, which would consist of almost exclusively aromatic compounds. Type C constituents contain an aromatic and alkane composition that suggests a petroleum origin, probably gasoline.

Samples SV-1, SV-2, SV-3, and SV-5 in Area C, and SV-9 (and probably SV-8) in Area A contain Type A constituents of probable petroleum origin. Samples SV-6 and SV-10 in the northern portion of Area A also contain Type A constituents, mixed with Type B constituents. Sample SV-4 located on the southern end of Area C contains Type B constituents that also appear to have a petroleum origin. Sample SV-7 located in the southernmost part of Area A contains Type C constituents that also appear to have a petroleum origin, probably gasoline. In each of the SV samples there is an occasional detection of trace levels of a couple chlorinated compounds with a few more chlorinated compounds at trace level concentrations in sample SV-6. Overall, the soil vapor results indicate the VOCs are derived from petroleum origins not coal tar origins.

The soil vapor results were not compared to screening values because New York State does not have standards, criteria, or guidance values for concentrations of VOCs in subsurface vapors.

3.5.2 2010 Soil Vapor Evaluation Results

In 2010, additional soil vapor samples were collected. Three subslab soil vapor samples, one indoor air sample, and two ambient air samples were collected from the art studio and the Union Mills building. The results are discussed below.

3.5.2.1Art Studio Results

Two subslab samples were collected from the art studio, and one ambient air sample was collected outside the art studio. The two subslab samples were non-detect for five of the seven CVOCs in the NYSDOH guidance. Carbon tetrachloride was detected in both subslab samples at estimated concentrations of 0.31 µg/m^3 (SV-11) and 0.34 µg/m^3 (SV-12). Tetrachloroethene was detected at estimated concentrations of 0.29 µg/m^3 and 0.27 µg/m^3 in SV-11 and SV-12, respectively. According to the NYSDOH Guidance, neither monitoring nor mitigation would be required with subslab concentrations as reported above. Carbon tetrachloride was detected at an estimated concentration of 0.42 µg/m^3 in the ambient (outdoor) air sample associated with the art studio, suggesting an external source.

Ambient air samples contained low levels of benzene (2.4 µg/m^3) and toluene (2.5 µg/m^3) and subslab samples contained relatively low amounts of the same chlorinated compounds and solvents which included the Freon-type compounds (e.g., trichlorofluoromethane compounds), methylene chloride and ethanol. The Freon-type compounds are used as refrigerants. The subslab samples at SV-11 and SV-12 contained ketone compounds (e.g. acetone, 2-butanone, 2-hexanone and others) and carbon disulfide. Ketones are not commonly associated with gasoline or other petroleum products and are used as solvents in processes involving resins, in manufacturing plastics and textiles, and in household products, paint remover and cleaning agents. For the hydrocarbon compounds which included the paraffin, isoparaffin, naphthene, and alkyl aromatic compounds, the subslab sample at SV-12 contained the highest concentrations. The subslab sample at SV-11 contained almost an order of magnitude lower concentrations of these compounds than SV-12. The compounds are likely originating principally from a petroleum source, probably weathered gasoline as evident by the hydrocarbon composition. The presence of the isoparaffin compounds (e.g., 2,3-

dimethylheptane, 2,3-dimethylpentane), low-molecular weight paraffin compounds (e.g., butane, pentane, hexane, heptanes), and naphthene compounds (e.g., cyclohexane, butylcyclohexane) indicate a petroleum source as these types of compounds are not associated with coal tar products. Alkyl aromatic compounds detected in these samples are found in both petroleum and coal tar products. Usual indicators of coal tar contributions, such as the presence of thiophenes and indene, and relatively high concentrations of the 2-ring PAH naphthalene, were not evident in the soil vapor or air samples. Coal tar products do not appear to be a contributor to the hydrocarbons in the subslab and air samples.

3.5.2.2Union Mills Building Results

A single subslab and paired indoor air sample and one ambient air sample was collected at the Union Mills building. Ambient air samples contained low levels of benzene (2.0 µg/m^3), toluene (3.4 µg/m^3), ethylbenzene (0.38 µg/m^3) (total xylenes (1.26µg/m^3). BTEX was detected in the indoor air sample at concentrations similar to the outdoor air sample indicating a likely outdoor source. Tetrachloroethene and 1,1,1-TCA were detected in the subslab sample (SV-13 – subslab) at estimated concentrations of 0.35 µg/m^3 and 0.38 µg/m^3, respectively. These compounds were not detected in indoor air or ambient air samples. Carbon tetrachloride was not detected in the subslab sample, but was detected in the indoor air and ambient samples at estimated concentrations of 0.40 µg/m^3 and 0.42 µg/m^3, respectively. These readings suggest an external source and would not trigger monitoring or mitigation according to NYSDOH Guidance.

Most of the same VOCs detected at the art studio as noted above were detected in subslab and indoor air samples at the Millworks building, but at concentrations of one to two orders of magnitude lower. As discussed for the art studio, the presence of thiophenes and indene, and relatively high concentrations of the 2-ring PAH naphthalene, were not evident in the soil vapor or air samples. Coal tar products do not appear to be a contributor to the hydrocarbons in the subslab and air samples.

To evaluate potential nearby sources of VOCs within the RI, the prior consultant reviewed an environmental database report provided by EDR, Inc. Several potential sources of petroleum hydrocarbons were identified along Main Street, up-gradient and side-gradient of the site, and along Catskill Creek.

3.6 ANALYTICAL RESULTS – SEDIMENT

No evidence of MGP-related impacts was observed along the bank adjacent to the site during the 2007 reconnaissance, 2007 sediment probing or 2007 sediment sampling activities. Only a hardened waste-like material was observed along the bank adjacent the northwest corner of Area A (and not near the NAPL-impacted soils in the southern portion of Area A), likely associated with the former foundry operations.

During the 2009 investigation, NAPL impacts were observed within Catskill Creek adjacent to Areas A and C. Potential impacts were observed at 7 of the 27 sediment borings advanced during the 2009 investigation.

Indications of NAPL and/or sheen were mainly observed adjacent to Area A (downgradient from impacted soil borings SB-101, SB-100, and SB-114). The table below summarizes the NAPL impacts encountered within the sediments of Catskill Creek.

Boring ID	Impacted Interval (feet bss)	Impacted Interval (elevation feet)	Vicinity
SED-17	Trace Sheen (0-2) Trace NAPL Blebs (2-2.5) Trace NAPL Blebs (4-5)	Sheen (-13.8 to -15.8) NAPL Blebs (-15.8 to -16.3) NAPL Blebs (-17.8 to -18.8)	Within Catskill Creek adjacent to Area A.
SED-18	Trace NAPL Blebs/Staining (8.5-9)	Trace NAPL Blebs/Staining (-18.6 to -19.1)	Within Catskill Creek adjacent to Area A.
SED-28	Trace NAPL Blebs (at 6.7) Little-Trace Blebs (8-9.4)	Trace NAPL Blebs (-19.7) NAPL Blebs (-20.4 to -21.8)	Within Catskill Creek adjacent to Area A.
SED-202	Trace NAPL Blebs (0-0.2) Trace NAPL Blebs (2-2.8)	Trace NAPL Blebs (-11.7 to -11.9) Trace NAPL Blebs (-13.7 to -14.4)	Within Catskill Creek adjacent to Area A building.
SED-203	Trace Sheen (2-3.1)	Sheen (-10 to -11)	Within Catskill Creek adjacent to Area A building.
SED-13	Fingertip-sized viscous tar blob (@6.0)	Fingertip-sized viscous tar blob (-22.6)	Within Catskill Creek adjacent to Area C.
SED-12	Trace Sheen (2-4.5)	Trace Sheen (-18 to -20.5)	Within Catskill Creek adjacent to Area C.

The extent of NAPL-impacted sediments adjacent to Area A is bounded (from north to south) by SED-201, SED-16, SED-31, SED-32, SED-26A, SED-29, SED-27 and SED-19. The extent of NAPL-impacted sediments adjacent to Area C is bounded (from north to south) by SED-11, SED-21, SED-23, and SED-24.

3.6.1 Sediment Sampling Results

As an initial screening, the sediment analytical results were compared to guidance values provided in the NYSDEC Technical Guidance for Screening Contaminated Sediments (1999). The guidance values used include total organic carbon (TOC) adjusted criteria for non-polar organics, lowest effect levels (LELs) and severe effects levels (SELs) for metals, and effects-range low (ER-L) and effects-range medium (ER-M) for total PAHs (collectively referred to as sediment guidance values). The discussion below focuses on BTEX, PAHs, and cyanide as indicators of potential MGP impacts.

3.6.1.1BTEX

Forty-two sediment samples were collected and analyzed for VOCs. Nineteen of the forty-two samples contained detectable concentrations of BTEX compounds. Concentrations of total BTEX ranged from 0.00015J mg/kg (SED-16) to 110 mg/kg (SED-202). Three samples (SED-18, SED-28 and SED-202) contained concentrations of select BTEX compounds above sediment guidance values.

3.6.1.2PAH

Forty-two sediment samples were collected and analyzed for SVOCs. All but three samples contained PAHs. For the 2007 investigation 13 of the 16 samples contained PAH compounds above the TOC adjusted criteria for non-polar organics, including the background sample at SED-07. For the 2009 investigation, 13 of 26 samples contained PAH compounds above non-TOC adjusted criteria for non-polar organics (Note: TOC was not analyzed during the 2009 investigation so the screening was conservatively conducted on non-adjusted PAH concentrations). For both investigations, total PAH levels in eight sediment samples exceeded the ER-L, and total PAH levels in 12 sediment samples exceeded the ER-L and the ER-M. The highest total PAH concentrations were associated with sediments at SED-12 that contained sheening and a petroleum-like odor adjacent to Area C as well as near the village of Catskill storm water discharge from Outfall #7 and NAPL-impacted sediments at SED-17, SED-18, SED-28, and SED-202 adjacent to Area A. In addition, samples near the NAPL-impacted sediments, SED-25 and SED-201 also contained relatively higher total PAH concentrations. North, west, and south of the NAPL-impacted sediment areas, PAH concentrations decrease to levels at or near the ER-L (SED-30, SED-7, SED-11, SED-21, SED-8, SED-4, SED-27, and SED-10).

3.6.1.3 Inorganics

Ten sediment samples were collected and analyzed for TAL inorganics. Cyanide was only detected at low levels in three sediment samples. No sediment guidance values are available for total cyanide.

3.7 EXPOSURE ASSESSMENT

Potential human exposure pathways were evaluated during the RI for the following media: surface soil, subsurface soil and bedrock, groundwater, soil vapor/ambient air, and surface water/sediment. Potential ecological pathways were also evaluated for only surface water and sediment. Ecological receptors for soil exposure pathways were not evaluated given the presence of impervious surfaces over the majority of the site and the general unsuitability of commercial areas for wildlife habitat. The former Catskill MGP site is located in a commercial area in the Village of Catskill. The Union Mills building recently was undergoing commercial/residential development and a commercial development was in progress on the former foundry property including Area A.

3.7.1 Surface Soil

Although PAHs were detected in surface soils with some constituents exceeding their individual commercial SCOs, the total PAH concentrations were within typical urban soil ranges (OBG, 2000). Further, the majority (estimated at 70 percent) of the site is covered by impervious surfaces (e.g. pavement, current and former building foundations, etc.). Overall, potential human exposures to constituents in surface soils at the site are not currently likely for parking lot users, trespassers as well as site workers. The potential for future exposure would increase as the condition of the parking area deteriorates. If potential exposures occurred, these pathways could include dermal contact, incidental ingestion, and/or inhalation of dusts and organic vapors from impacted soils. Any potential exposures could be mitigated by the use of standard health and safety practices.

3.7.2 Subsurface Soils

Impacted overburden containing NAPLs and relatively elevated concentrations of BTEX and PAHs were observed within the southern portion of Area A and beneath the Union Mills property at depths deeper than 5 feet. In addition, potential purifier wastes were observed at soil borings SB-11 in Area C (8.6 to 10.5 feet bgs), in the form of block shaped wood chips, and SB-15 in Area A (4.0 to 9.3 feet bgs), in the form of greenish colored cinders. Complexed cyanide species have been shown to be stable, thus not a toxicological concern for humans (NGA, 2004). Current exposures to the impacted overburden for current utility workers and trespassers are not expected due to the depth of the contamination and the lack of utilities in the impacted areas. Exposure to subsurface impacted overburden may occur if future work involves the excavation of overburden deeper than five feet. Potential subsurface worker exposures could include dermal contact, incidental ingestion, and/or inhalation of dusts and organic vapors from impacted soils. Any potential exposures could be mitigated by the use of standard health and safety practices.

3.7.3 Groundwater

BTEX and PAHs were detected at only monitoring well MW-1. A low level (3.7 µg/L) of benzene was detected at MW-2. No VOCs or SVOCs were detected in the other five monitoring wells, MW-3 through MW-7.

There are no reported active potable water supply wells in the overburden near the site. However within three miles of the site, bedrock wells in the sandstone and shale have been developed for domestic and farm use as well as for non-municipal community water supply (EA, 1987). The Village of Catskill obtains its water supply from a surface water source near the headwaters of Potic Creek, located approximately nine miles from the site (Lower Hudson Coalition of Conservation Districts).

Because the overburden groundwater is relatively shallow (approximately 10 feet), exposure to groundwater in subsurface excavations could occur. Potential subsurface worker exposures could include dermal contact, incidental ingestion, and inhalation of organic vapors from impacted groundwater. Any potential exposures could be mitigated by the use of standard health and safety practices.

Because the overburden groundwater discharges to Catskill Creek adjacent to the site, the surface water could be impacted by groundwater discharges containing site-related impacts. However, any impacts to surface water are likely attenuated via processes in the creek. Further, no impacts to the creek's surface water were detected.

3.7.4 Soil Vapor/Ambient Air

Based on the current conditions, exposure to chemical constituents in soil vapor related to the former MGP is unlikely because the soil vapor results indicate the constituents present are related to petroleum products rather than coal tar NAPLs. In addition, based on current conditions, exposure to chemical constituents in ambient air is unlikely given the depth of subsurface contamination. As discussed above, potential exposure to disturbed subsurface soils could result in inhalation exposures.

3.7.5 Sediment/Surface Water

Adjacent to the site, Catskill Creek is designated as Class C waters. According to NYCRR Part 701.8, Class C waters shall be suitable for fish propagation and survival. The water quality shall be suitable for primary and secondary contact recreation, although other factors may limit the use for these purposes. Catskill Creek is affected by tidal movements of the Hudson River.

Creek sediments near the site consist of unsorted sands and gravels with varying amounts of cobbles and boulders and anthropogenic materials closer to shore underlain by bedrock. NAPL and/or sheen were observed in two areas – a small area adjacent to Area C and an area contiguous with Area A. Impacts were generally deeper than 2 feet below the sediment surface (bss). Relatively elevated BTEX and PAH concentrations are associated with these impacts. Current exposures to the impacted sediments for creek users are not expected due to the depth of the contamination and the water depths in the impacted areas. Exposure to subsurface sediments may occur if future work involves the dredging of sediments. Potential subsurface worker exposures could include dermal contact, incidental ingestion, and/or inhalation of dusts and organic vapors from impacted sediments. Any potential exposures could be mitigated by the use of standard health and safety practices.

Sheens have not been observed in the creek nor have BTEX or PAHs been detected in the surface water samples obtained in the creek adjacent to the site. As such, potential human exposures are not likely.

The primary exposure pathway for fish and wildlife is potential exposure to sediment and surface water. Eight sediment samples contained PAHs above the ER-L and 12 samples contained PAHs above the ER-M adjacent to and downstream of the site. Potential exposure to constituents in sediment may occur via direct contact by aquatic organisms (including fish and macroinvertebrates) and semi-aquatic wildlife. Aquatic organisms can obtain PAHs from the water column and from PAH-impacted food and to a lesser degree from sediment transfers. In fish, PAHs concentrate in the liver, gut, and gall bladder, not in the fish tissue (Brooks, 1997). The major route of PAH elimination is through excretion into bile (Meador, 1995) as well as through feces and urine (Kennedy and Law, 1990). In crustaceans, PAHs concentrate in the hepatopancreas, green gland, stomach, gills, testes, and eyestalk (Brooks, 1997). When PAHs are obtained from water, food, or sediments, the PAHs are rapidly metabolized and excreted by most fish and crustaceans, although biotransformation and excretion rates can vary among species (Brooks, 1997; Meador, 1995; Varanasi et. al, 1989). Because Catskill Creek is connected to the Hudson River approximately one mile from the site and aquatic organisms are mobile, the relatively small area of elevated PAHs concentrations in the sediments adjacent to the site is even less likely to result in PAH exposures to aquatic organisms.

4.0 Remedial Goals and Remedial Action Objectives

4.1 REMEDIAL GOALS

Remedial Action Objectives (RAOs) were established based on the results of the Remedial Investigation as documented in the RI Report revised in May 2010, discussions with NYSDEC, and the following factors:

- The future use of Area A is a restaurant with a creek side raw bar that extends to the edge of Catskill Creek;
- The surface soils within Area A contain impacts from past MGP operations, which contain PAHs that exceed the NY State Restricted-Residential Soil Clean-up Objectives (SCOs);
- The subsurface soils within Area A and the adjacent Union Mills property contain impacts from past MGP operations, which contain BTEX, PAHs, and/or total cyanide that exceeded the NY State Restricted-Residential SCOs;
- The groundwater beneath Area A contains impacts from past MGP operations that contain BTEX, PAHs, and/or total cyanide greater than the Class GA groundwater standard or guidance values;
- The existing and proposed future use of Area C is to remain as a municipal parking lot for Greene County employees;
- Surface soil results within Area C exceeded the NY State Restricted-Commercial SCOs. A forensic analysis was conducted and concluded that the detected PAH's were not MGP related. No soil boring impacts within Area C were detected above the NY State Restricted-Commercial SCOs;
- The groundwater beneath Area C did not contain organic impacts indicative of past MGP operations greater than the Class GA groundwater standard or guidance values;
- The sediment in Catskill Creek adjacent to Areas A and C exhibits impacts from past MGP operations that contain BTEX, and PAHs greater than the Technical Guidance for Screening Contaminated Sediments (1999);
- The existing use of Area B is an art studio, and is not currently or anticipated to be used for residential purposes;
- No soil concentrations above the NY State Restricted-Commercial SCOs were detected in Area B;
- The primary potential exposure pathways are dermal contact, incidental ingestion, and/or inhalation of dusts and organic vapors from impacted soils within Areas A and C;
- The primary potential exposure pathways to workers are dermal contact, incidental ingestion, and/or inhalation of organic vapors from impacted groundwater within Area A;

- The primary potential exposure pathways from impacted sediments to workers and/or the recreational user are dermal contact, incidental ingestion, and/or inhalation of dusts and organic vapors from impacted sediments; and
- The overall goal of the remedial action is to protect public health and the environment.

4.2 REMEDIAL ACTION OBJECTIVES

Based on the above factors, the following RAOs were developed for the site:

- Remove/address known MGP source area contaminants located on-site within Area A and beneath the adjacent Union Mills property that exceeds the NY State Restricted-Residential SCOs through the selection of a preferred remedial alternative;
- Address and prevent direct exposure of impacted soil that exceeds the NY State Restricted-Commercial SCO within Area C;
- Address known MGP impacted groundwater that exceeds the Class GA groundwater standard or guidance values within Area A through the selection of a preferred remedial alternative; and
- Address and prevent direct exposure of known MGP impacted sediment beneath Catskill Creek and adjacent to the site that exceeds the Technical Guidance for Screening Contaminated Sediments (1999) through the selection of a preferred remedial alternative.

5.0 Development and Analysis of Alternatives

The site had been divided into three areas of concern during the Remedial Investigation phase, Area A, Area B, and Area C. The following sections discuss the potential remedial actions that may be applied to these areas and the pros and cons of each action, broken down by the affected media. All areas are owned by a third party, as described in Section 2.0.

As mentioned in Section 4.0 above, there are no exceedances above the NY State Restricted-Commercial SCO for Area B and therefore, no Remedial Action is proposed or discussed for this area.

The existing surface cover within Area A is primarily gravel with sparse vegetative cover and a few observed concrete pads. Within Area C, the surface cover is primarily an asphalt parking lot.

5.1 SOIL

The results of the soil sampling indicate impacted soils above the cleanup standards within Areas A and C. As stated above in Section 4, Figure 5-1 represents the extent of impacted soils and identifies the areas of concern. Based on the results of the Remedial Investigation, the following remedies for remediation, presented below, identify different options available for remediation of the soils.

5.1.1 No Action

If No Action is taken to remediate the site soils, a potential contact hazard will remain on the site for Areas A and C. Area C, which is currently a paved parking lot, prevents direct contact with the subsurface soils due to the pavement. There would be no costs associated with this action. There will be no remediation driven waste generated through this action.

The disadvantage of this remediation option is a potential for on-going liability for future exposure, especially in Area A, which is proposed to be redeveloped.

The advantage of this option is Area B has an existing physical barrier in place to minimize the exposure pathways and is not proposed to be redeveloped for a different use in the foreseeable future.

5.1.2 Excavation

Excavation has been evaluated for the impacted on-site soils within Area A and beneath the Union Mills property to the south. Excavation would involve the removal of soils to a depth up to approximately 16 feet over an area of approximately 7,534 square feet in Area A and to a depth of approximately 18 feet over an area of approximately 3,326 square feet beneath the Union Mills property, as shown on Figure 5-2. The impacted material would be transported to a properly permitted landfill or thermal treatment facility. The site will be backfilled with certified clean fill to existing grade.

Potential complications associated with this remediation option include the following:

- Structural concerns with the Union Mills building during the excavation;
- Limited space for the actual excavation and associated activities;
- Potential to generate excess material for treatment and disposal as part of the excavation;
- Potential dewatering and dewatering treatment during the excavation;
- Potential for odor and VOC emissions from contaminated material; and
- Excavations near Catskill Creek will require use of structural support.

Advantages of this remediation option include the following:

- Minimal follow-up maintenance;
- Excavation of the impacted (source and NAPL) material will aid in groundwater natural attenuation;
- Short-term remediation schedule; and
- Post-excavation soil samples confirm soil remediation is complete.

Approximately 6,697 tons (4,465 cubic yards, CY) of soil will be excavated from Area A and 3,326 tons (2,217 CY) beneath the Union Mills property under this action. The opinion for probable costs for excavation and thermal treatment of the impacted materials is $2,211,209 and is presented in Table 5.1. The costs include equipment, labor, dewatering, transportation, disposal, hauling of clean backfill to the site, and also a secant wall along the north and west sides of the Union Mills building and a secant wall for the area along the bulkhead located along the bank of Catskill Creek. An oxygen reducing compound (ORC) will be mixed in with the backfill material to aid in groundwater treatment. The costs for the ORC are included in the Section 5.3.2.

Front hauling clean thermally treated backfill to the site is also an option. Front hauling will reduce the direct green house gases by reducing the number of trucks traveling to and from the site. Front hauling will also reduce the number of labor hours required for the transportation and disposal. Reusing the clean thermally treated backfill reduces waste and conserves natural resources such as gravel. Front hauling may not be the most desirable option given the site constraints and also the inconsistency of the structural properties of the backfill. It was assumed that overall volume of soil by is reduced by approximately 5% during thermal treatment. Clean backfill will be used to augment the volume of thermally treated soil. Costs for the option of front hauling thermally treated backfill are also presented in Table 5.1.

Landfilling the excavated material is also an option for disposal. Landfilling of material that does not meet the requirements for thermally treated is desirable to Central Hudson due to cost reductions. Landfilling the material may not be an environmentally desirable option since it does not conserve natural resource space. Costs for landfilling are presented in Table 5.1.

5.1.3 In-situ Stabilization/Solidification (ISS)

In-situ Soil Stabilization/Solidification (ISS) has been evaluated for the site as a remedial alternative for Area A and the impacts beneath the Union Mills property. Implementation of this alternative would involve the mixing of the on-site soils with a solidification agent to immobilize the MGP-related impacts and prevent further off-site migration. It is assumed that ISS will produce an excess of approximately 25% of the total material mixed into the site soils. The excess material will be disposed of at a properly permitted facility. A two foot clean soil cap will be placed on the site after the completion of the ISS.

The potential complications of this remediation option include the following:

- Structural concerns with the Union Mills building during the mixing process;
- Limited post-construction use of the site in order to maintain the integrity of the stabilized area;
- Limited work area on-site for mixing operations;
- The addition of the stabilization media will increase the existing soil volume resulting in the generation of material for off-site disposal;
- The generation of dust and VOCs during the mixing process may require air collection and filtration; and
- Underground structures and debris may make mixing very difficult.

Advantages of this remediation option include the following:

- Reducing mobility of contaminants through chemical and physical means; and

- Isolation of the source material resulting in groundwater natural attenuation.

The opinion for probable cost for in-situ treatment of Area A and the adjacent Union Mills property is $4,382,428 and is presented in Table 5.2. The opinion for probable cost includes soil mixing and secant wall near the existing Union Mills building, and site restoration. In-situ treatment would reduce the remediation-generated waste and subsequent treatment or landfilling.

5.2 SEDIMENT

Impacted sediments have been identified within Catskill Creek adjacent to the site. For the purposes of this evaluation, creek sediments are assumed to extend from the top of the bank of Catskill Creek.

5.2.1 No Action

Sediment impacts adjacent to Areas A and C have been recorded along the bottom of the stream channel where the water depth ranges from 6 to 12 feet, depending on the tide. Localized sediment impacts at two sampling locations (SED-012 and SED-013) were observed adjacent to Area C at depth. There are no costs associated with no action for sediments adjacent to Areas A and C. There will be no remediation driven waste or contact with contaminated media through this action.

5.2.2 Dredging

Dredging the sediments would likely require removal of the sediments to the top of the bedrock surface and/or the extent of impacts (average of 8 ft) for the majority of the shoreline adjacent to Area A and continuing south approximately 50 feet along the Union Mills property. The limits of dredging are shown on Figure 5-3.

The potential complications of this remediation option include the following:

- Undulating bedrock will make dredging the soils difficult and may mobilize additional material into the creek;

- Limited site space for dewatering and managing the dredged sediments; and

- Dredging may result in a removal of un-impacted materials.

The advantage of this remediation option includes the immediate removal of the pathway.

The opinion of probable cost for dredging is $2,428,979 and is presented in Table 5.3. This includes equipment, labor, transportation, disposal, a turbidity curtain, engineering design, and project and construction management. Equipment could use ultra low sulfur fuel and idling of trucks/equipment over a specified time will be prohibited.

5.2.3 Containment

Capping the Catskill Creek in the vicinity of Area A with an impervious linear (clay polymer composite) will remove the direct pathway for contact; however, the volume and flow rate of the creek may make maintenance and installation of the cap difficult. The limits of capping are shown on Figure 5-4, which extend slightly beyond the area of impacts as noted in Figure 5-3.

The potential complications of this remediation option include the following:

- Surface water depth will make capping difficult;
- Creek bottom consist of cobbles; and
- Creek bottom is likely scoured on a regular basis during tidal cycles, which will make installation of a permanent cap and future maintenance difficult and costly.

Advantages of this remediation option include the following:

- Removal of contact pathway for the protection of human health; and
- Removal of the sediment eliminates the uptake of impacted material by the aquatic organisms and eliminates entry into the food chain.

The opinion of probably cost for sediment containment is $403,204 and is presented in Table 5.4. This includes equipment, labor, and transportation of capping material, a turbidity curtain, engineering design, project and construction management. Capping will reduce the risk of exposure to contaminants to on-site workers. Capping will reduce the volume of remediation-generated waste.

5.3 GROUNDWATER

Organic groundwater impacts exceeding the Class GA groundwater standards or guidance values have only been observed within the monitoring wells installed in Area A. Inorganic exceedances were observed in the groundwater collected from monitoring wells within Area C, but these results are assumed to have been compromised due to some turbidity noted in the field logs during groundwater sampling activities.

5.3.1 No Action

There are no private drinking water wells located within the direct vicinity of the impacted areas and therefore it is likely that no further action associated with the groundwater would not pose a significant risk to human health or the environment. Groundwater exceedances of organic components likely attributed to the MGP operations were only detected within Area A. There are no costs associated with this action. There will be no remediation driven waste or contact with contaminated media through this action.

5.3.2 Permeable Reactive Barrier (Funnel and Gate)

A permeable reactive barrier (PRB) could be constructed to treat groundwater flowing from east to west on site. A cut-off slurry wall (funnel) would be constructed with a permeable reactive layer (gate). The slurry wall would be constructed at least 10 feet into the bedrock to prevent groundwater from flowing under the wall. The groundwater would flow through the gate, a permeable barrier, which would contain a steel cassette of activated carbon that would facilitate the degradation of the groundwater contaminants. The PRB is shown on Figure 5.5.

The potential complications of this remediation option include the following:

- Passive treatment reactive capacity, requiring replacement of the reactive medium;
- Passive treatment permeability may decrease due to precipitation of metal salts;
- Depth and width of barrier;
- Biological activity or chemical precipitation may limit the permeability of the passive treatment wall; and
- Replacement of the wall due to decreased reactive capacity would involve extensive excavation.

The advantages of this remediation are:

- Minimal impact on the surrounding environment; and
- Limited maintenance.

The opinion of probable cost for this action is $1,544,344 and is presented in Table 5.5. The costs include equipment, labor, engineering design, and project and construction management.

The PRB will reduce remediation generated wastewater, maintain natural groundwater patterns, and prevent cross-contamination of media.

5.3.3 Monitored/Enhanced Natural Attenuation

The use of Monitored or Enhanced Natural Attenuation (MNA) would require a bench-scale test followed by pilot testing to determine the suitability for the treatment based on the amount of organic material present in the site soils, the impact of the groundwater component, and the impact of unknown subsurface obstructions on the treatability of the area. Mixing an ORC during the backfilling of Area A and the Union Mills property will promote biological activity, which will increase the degradation of the potential contaminants in the groundwater. Three monitoring wells would be installed in Area A and the groundwater would be sampled on a quarterly basis with reports prepared quarterly for two years to monitor the groundwater quality relative to the Class GA groundwater standards or guidance values. The groundwater samples that are collected would be analyzed for VOC and SVOC parameters.

The opinion of probable cost for the MNA is $85,301 and is presented in Table 5.6. The costs include placing/mixing ORC in the backfill soils, monitoring well installation, groundwater sampling and analyses, reporting, and project management. MNA reduces remediation generated waste, the potential for cross–media transfer of contaminants, and also reduces the risk of exposure of on-site workers to contaminants. MNA also has less environmental intrusion.

6.0 Recommended Remedy

Based on the treatment technologies evaluated in Section 5 above, a combination of different options will be applied to the different areas of concern. The following sections describe the remedial approach and the basis for the remedy selection.

6.1 DESCRIPTION OF REMEDY

This section will outline the proposed selected remedy for each of the areas of concern at the site. The following paragraphs address the selected alternative(s) for the media beneath Area A including the adjacent Union Mills property, the sediments in Catskill Creek, and the media beneath Area C.

6.1.1 Area A and the Union Mills Property

Sampling results from Area A (described in Section 3.0) and the adjacent Union Mills property yielded the widest horizontal area of impacts of the three areas of concern. Due to the extent of the impacts, the proposed remedial action for this area is excavation. The following sub-sections describe how excavation will address the different media of concern.

Soil

Excavating the soil will remove the impacted material and the area will be restored with certified clean backfill material. Post-excavation soil sampling will be performed to confirm that the impacted materials above the cleanup standards have been removed.

Figure 5-2 presents the proposed limits and depths of the excavation in Area A (16 ft bgs) and on the Union Mills property (18 ft bgs). Due to the proximity of the excavation to the existing buildings that are to remain on the site, prior to beginning any intrusive activities a pre-construction survey of the existing buildings will be performed to identify any structural areas of concern. The results of this survey will be compared to the proximity of the excavation and appropriate support measures will be implemented as determined by a NYS licensed engineer.

The key components of this selected alternative include the following elements:

- Structural evaluation of adjacent buildings;
- Dewatering and groundwater treatment during excavation;
- Excavation support in areas adjacent to Catskill Creek and the Union Mills Building;

- Excavation of an area approximately 7,534 square feet to an average depth of 16 feet; and
- Excavation of an area approximately 3,326 square feet to an average depth of 18 feet.

Anticipated costs associated with this selected alternative are broken down as follows:

- Structural support;
- Excavation of approximately 6,697 tons of material in Area A;
- Excavation of approximately 3,326 tons of material on the Union Mills property;
- Off-site disposal of above;
- Groundwater dewatering and treatment; and
- Site restoration.

The opinion of probably cost for the excavation of Area A and beneath the Union Mills property is $2,211,209. The breakdown of the opinion for probable cost is located in Table 5.1.

Sediment

The planned remedial action for the sediment in the vicinity of Area A is dredging to an average depth of 8 ft. The key components of this selected alternative include the following elements:

- Installation of a turbidity barrier to control suspended sediment during dredging activities;
- Removal of sediments to a depth of 8 feet for the majority of the shoreline adjacent to Area A and continuing south approximately 50 feet along the Union Mills property; and
- Dewatering and disposal of sediments at a properly permitted facility.

Anticipated costs associated with this selected alternative are broken down as follows:

- Turbidity barrier; and
- Dredging and disposal of sediments.

The opinion for probably cost associated with dredging is $2,070,041. The breakdown of the opinion of probably cost is located in Table 5.3.

Groundwater

While the proposed remedy for Groundwater is No Action, the excavation and removal of the source material is expected to restore the groundwater quality to Class GA standards or guidance values. Following the completion of the excavation activities, the soil backfill material will include the addition of a bioaugmentation reagent (oxygen releasing compound (ORC)) to address any remaining MGP residuals and to promote biological activity for acceleration of the process of groundwater restoration. In addition, eight quarters of groundwater sampling and analyses (VOCs and SVOCs) are proposed to confirm that the groundwater conditions have improved and have met Class GA groundwater standards or guidance values. The opinion for probable cost for sampling and reporting is $85,301 and is presented in Table 5.6.

6.1.2 Area C

Soil

There is no planned remedial action for the soils in Area C. An ARCADIS forensic chemist performed an analysis of the surface soil data for Area C and has concluded that the composition of PAHs from those samples is distinctly different that the coal-tar PAHs observed at Area A. The data is provided in Appendix A. The existing use of this area is a parking lot that is currently paved. The parking lot prevents direct contact with surface soils.

Sediment

There is no planned remedial action for the sediment adjacent to Area C. Localized sediment impacts at two sampling locations (SED-012 and SED-013) were observed adjacent to Area C at depth. Given the depth of water in the creek in that area, it is unlikely there would be a significant risk associated with direct human contact with the bottom sediments.

Groundwater

There is no planned restoration for the groundwater component for this area given there was no organic exceedance above the Class GA groundwater standards or guidance values for this area.

6.2 DEED RESTRICTIONS

Following completion of the proposed remedy, Deed Restrictions will be placed on each parcel. The purpose of the Deed Restriction will be to control the future use of the property. Area A and the Union Mills property will be designated as “Restricted Residential” use and Areas B and C will be designated as “Commercial.” Furthermore, a Site Management Plan (SMP) will be developed and will outline the institutional or engineering controls used to manage exposure to contamination remaining at the site (if any).

6.3 BASIS FOR REMEDY SELECTION

The basis for the above remedy selection is based on the site RAOs identified in Section 4 above. Based on these objectives, the cleanup standard for Area A is Restricted-Residential and for Areas B and C is Restricted-Commercial. Each selected remedial action, identified above, was chosen based on remediation efficiency, action maintenance activities, and cost.

7.0 References

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Tables

Catskill Former Manufactured Gas Plant

Remedial Action Alternatives: Opinion of Probable Costs
Table 5.1 - Soil Remedial Alternative 2: Area A & Millworks Building Area Excavation

	Description	Qty	Unit Measure	Unit Cost	Extended Cost
1.0	Excavation, Transporation, & Disposal				
1.1	Excavate impacted soil (1)	6,682	CY	$25.00	$167,048
1.2	Loadout, transport and disposal of impacted soil at ESMI	10,023	Ton	$64.50	$646,476
				Item SubTotal:	$813,524
2.0	Structure Support				
2.1	Secant wall for Millworks Building (2)	2,250	Sq Ft	$75.00	$168,750
2.2	Secant Wall for Bulkhead Area (3)	4,500	Sq Ft	$75.00	$337,500
				Item SubTotal:	$506,250
3.0	Dewatering & Treating Water in Exavacation				
3.1	Well Installation	1	LS	$8,000.00	$8,000.00
3.2	Frac Tank Rental	180	day	$50.00	$9,000.00
3.3	Treating Water in Exavacation	100,000	Gallons	$0.10	$10,000
				Item SubTotal:	$18,000
4.0	Site Restoration				
4.1	Transportation of Clean Stone from ESMI for backfill	10,023	Ton	$10.00	$100,229
				Item SubTotal:	$100,229
4.2	Place and compact certified clean backfill	10,023	Ton	$10.00	$100,229
				Item SubTotal:	$100,229
				Subtotal Excavation:	$1,538,232.26
5.0	**Design and Construction Management Costs**				
5.1	Remedial Design	10.0%	Percent		$153,823
5.2	Project Management	7.5%	Percent		$115,367
5.3	Construction Oversight	7.5%	Percent		$115,367
				Item SubTotal:	$384,558
				Subtotal Remediation:	$1,922,790
6.0	Contingency	15%	Percent		$288,419
	Total Soil Remediation Alternative #2				**$2,211,209**
	Option 1: (4)				
1.2a	Loadout, transport and disposal of impacted soil to landfill	10,023	Ton	$70.00	$701,602
				Item SubTotal:	$701,602
4.1a	Front Haul Thermally Treated Material from ESMI for backfill (5)	9,522	Ton	$8.00	$76,174
				Item SubTotal:	$76,174
	Transportation of Clean Stone from ESMI for backfill (5)	501	Ton	$10.00	$5,011
				Item SubTotal:	$5,011

Notes:
1. Soil density of 1.5 used to convert cubic yards (CY) to tons.
2. Millworks Building structural support based on a 75 ft long by 30 ft deep wall.
3. Bulkhead structural support based on a 150 ft long by 30 ft deep wall.

4. Option 1 presents costs for landfilling excavation material (instead of thermal treatment) or using thermally treated material as backfill instead of clean fill.
5. It was assumed that volume of material is reduced by approximately 5% during thermal treatment. Clean backfill must be used to augment the thermally treated backfill.

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Catskill Former Manufactured Gas Plant

Remedial Action Alternatives: Opinion of Probable Costs
Table 5.2 - Soil Remedial Alternative 3: Area A- In-Situ Stabilization

Description	Qty	Unit Measure	Unit Cost	Extended Cost
Mobilization & demobilization	1	LS	$250,000.00	$250,000
			Item SubTotal:	$250,000
In-Situ Treatment & Stabilization	7,240	CY	$250.00	$1,810,000
			Item SubTotal:	$1,810,000
Structure Support				
Secant Wall for Millworks Building (1)	2,250	Sq Ft	$75.00	$168,750
Secant Wall for Bulkhead Area (2)	4,500	Sq Ft	$75.00	$337,500
			Item SubTotal:	$506,250
Disposal of Excess Material from ISS (3)	2715	Ton	$70.00	$190,050
			Item SubTotal:	$190,050
Clean Soil Cap (4)	3,326	Ton	$10.00	$33,260
			Item SubTotal:	$33,260
			Subtotal In-Situ Treatment:	$2,822,820
Design and Construction Management Costs				
Remedial Design	20.0%	Percent		$564,564
Project Management	7.5%	Percent		$211,712
Construction Oversight	7.5%	Percent		$211,712
			Item SubTotal:	$987,987
			Subtotal Remediation:	$3,810,807
Contingency	15%	Percent		$571,621
Total Soil Remediation Alternative #3				**$4,382,428**

Notes:
1. Millworks Building structural support based on a 75 ft long by 30 ft deep wall.
2. Bulkhead structural support based on a 150 ft long by 30 ft deep wall.
3. Excess material is estimated to be 25% of total mixed material. Excess material will be transported to a certified landfill for disposal.
4. Assume soil cap is two (2) feet thick.

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Remedial Action Alternatives: Opinion of Probable Costs
Table 5.3 - Sediment Remedial Alternative 2: Area A Dredging & Disposal

Description	Qty	Unit Measure	Unit Cost	Extended Cost
Mobilization & demobilization	1	LS	$250,000	$250,000
			Item SubTotal:	$250,000
Turbidity Barrier (1)	320	Linear Foot	$62	$19,840
Dredging (2)	2,312	CY	$560	$1,294,720
			Item SubTotal:	$1,314,560
			Subtotal Dredging & Disposal:	$1,564,560
Design and Construction Management Costs				
Remedial Design	20.0%	Percent		$312,912
Project Management	7.5%	Percent		$117,342
Construction Oversight	7.5%	Percent		$117,342
			Item SubTotal:	$547,596
			Subtotal Remediation:	$2,112,156
Contingency	15%	Percent		$316,823
Total Sediment Remediation Alternative #2				**$2,428,979**

Notes:
1. Turbidity barrier costs provided by ACF Environmental.
2. Dredging includes, excavation, dewatering, and treatment, and disposal.

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Remedial Action Alternatives: Opinion of Probable Costs
Table 5.4 - Sediment Remedial Alternative 3: Area A Sediment Capping

Description	Qty	Unit Measure	Unit Cost	Extended Cost
Mobilization & demobilization	1	LS	$150,000	$150,000
			Item SubTotal:	$150,000
Turbidity Barrier (1)	320	LF	$62	$19,840
Installation of AquaBlok® Sediment Cap (2)	12,560	Sq Ft	$4.50	$56,520
			Item SubTotal:	$76,360
			Subtotal Sediment Capping:	$226,360
Design and Construction Management Costs				
Remedial Design	25.0%	Percent		$56,590
Project Management	7.5%	Percent		$16,977
Construction Oversight	10.0%	Percent		$22,636
			Item SubTotal:	$96,203
			Subtotal Remediation:	$322,563
Contingency	25%	Percent		$80,641
Total Sediment Remediation Alternative #3				**$403,204**

Notes:
1. Turbidity barrier costs provided by ACF Environmental.
2. AquaBlok ® costs provided by AquaBlok®

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Catskill Former Manufactured Gas Plant

Remedial Action Alternatives: Opinion of Probable Costs
Table 5.5 - Groundwater Remedial Alternative 2: Permeable Reactive Barrier

Description	Qty	Unit Measure	Unit Cost	Extended Cost
Mobilization & demobilization	1	LS	$150,000	$150,000
			Item SubTotal:	$150,000
Slurry Wall (1)	5,700	Sq Ft	$100.00	$570,000
Activated Carbon	20,000	lbs	$1.40	$28,000
Cassette for Activated Carbon	1	LS	$75,000.00	$75,000
			Item SubTotal:	$673,000
Well Installation	1	LS	$8,000.00	$8,000
Groundwater Sampling/Reporting	8	Quarterly	$4,500.00	$36,000
			Item SubTotal:	$44,000
			Subtotal Groundwater Treatment:	$867,000
Design and Construction Management Costs				
Remedial Design	25.0%	Percent		$216,750
Project Management	7.5%	Percent		$65,025
Construction Oversight	10.0%	Percent		$86,700
			Item SubTotal:	$368,475
			Subtotal Remediation:	$1,235,475
Contingency	25%	Percent		$308,869
Total Groundwater Remediation Alternative #2				**$1,544,344**

Notes:
1. Slurry wall estimate is based on a 190 ft long by 30 ft deep wall.

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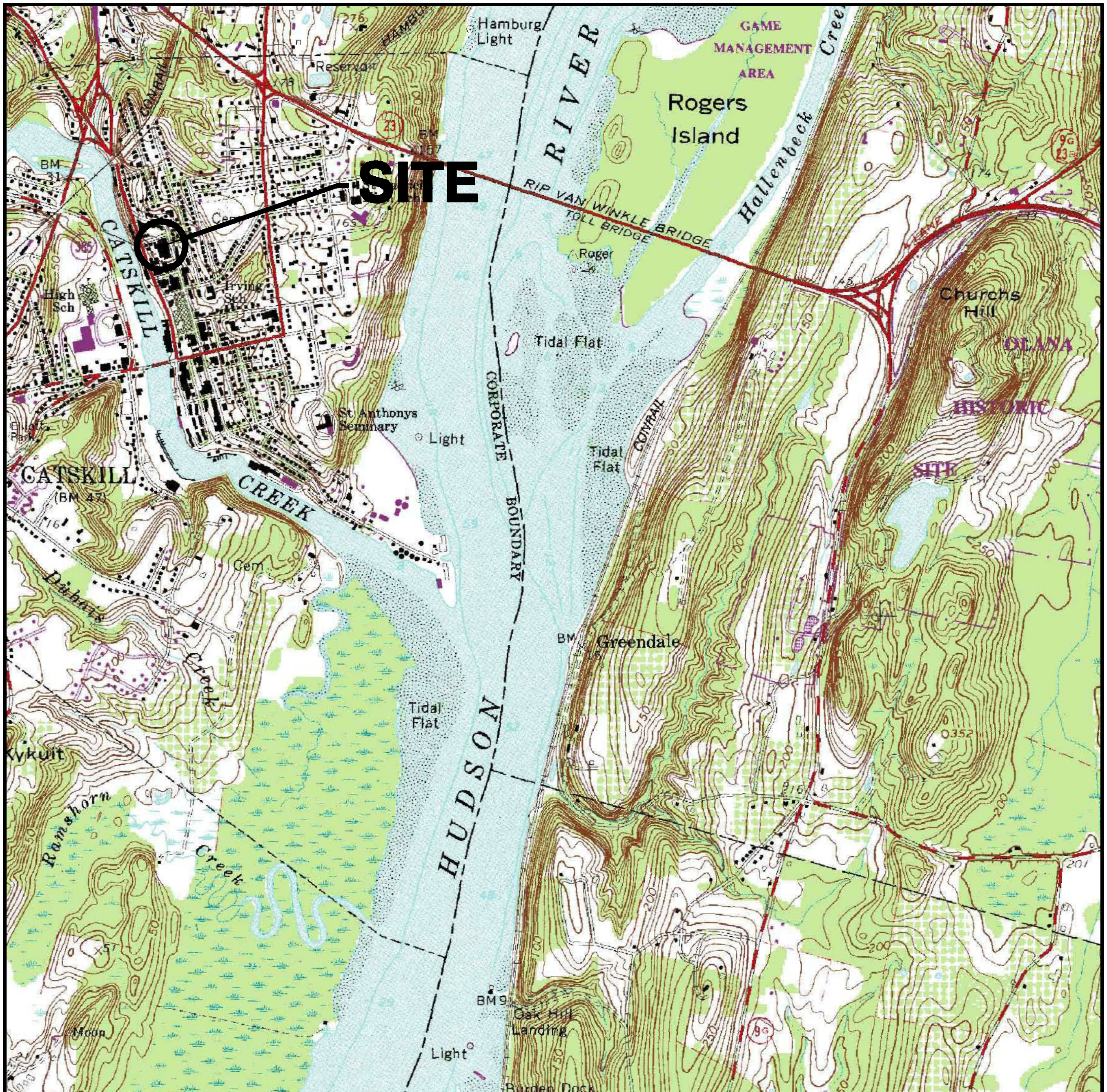
Remedial Action Alternatives: Opinion of Probable Costs
Table 5.6 - Groundwater Remedial Alternative 3: Monitoring & Enhanced/Natural Attenuation

Description	Qty	Unit Measure	Unit Cost	Extended Cost
Oxygen Reducing Compound	1	LS	$25,000.00	$25,000.00
			Item SubTotal:	$25,000
Well Installation	1	LS	$8,000.00	$8,000.00
			Item SubTotal:	$8,000
Quarterly Groundwater Sampling/Reporting	8	Quarter	$4,500.00	$36,000.00
			Item SubTotal:	$36,000
			Subtotal Monitoring & Enhanced/Natural Attenuation :	$69,000
Project Management				
Project Management	7.5%	Percent		$5,175
			Item SubTotal:	$5,175
			Subtotal Remediation:	$74,175
Contingency	15%	Percent		$11,126
Total Groundwater Remediation Alternative #3				**$85,301**

Figures



MAP SOURCE:

USGS TOPOGRAPHIC QUADRANGLE
HUDSON SOUTH, NEW YORK

2000 0 2000

Scale in feet

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ORIGINAL SHEET - ANSI A

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CENTRAL HUDSON GAS & ELECTRIC CORP.
FORMER CATSKILL MGP SITE
CATSKILL, NEW YORK

Figure No.

1

Title

SITE LOCATION MAP

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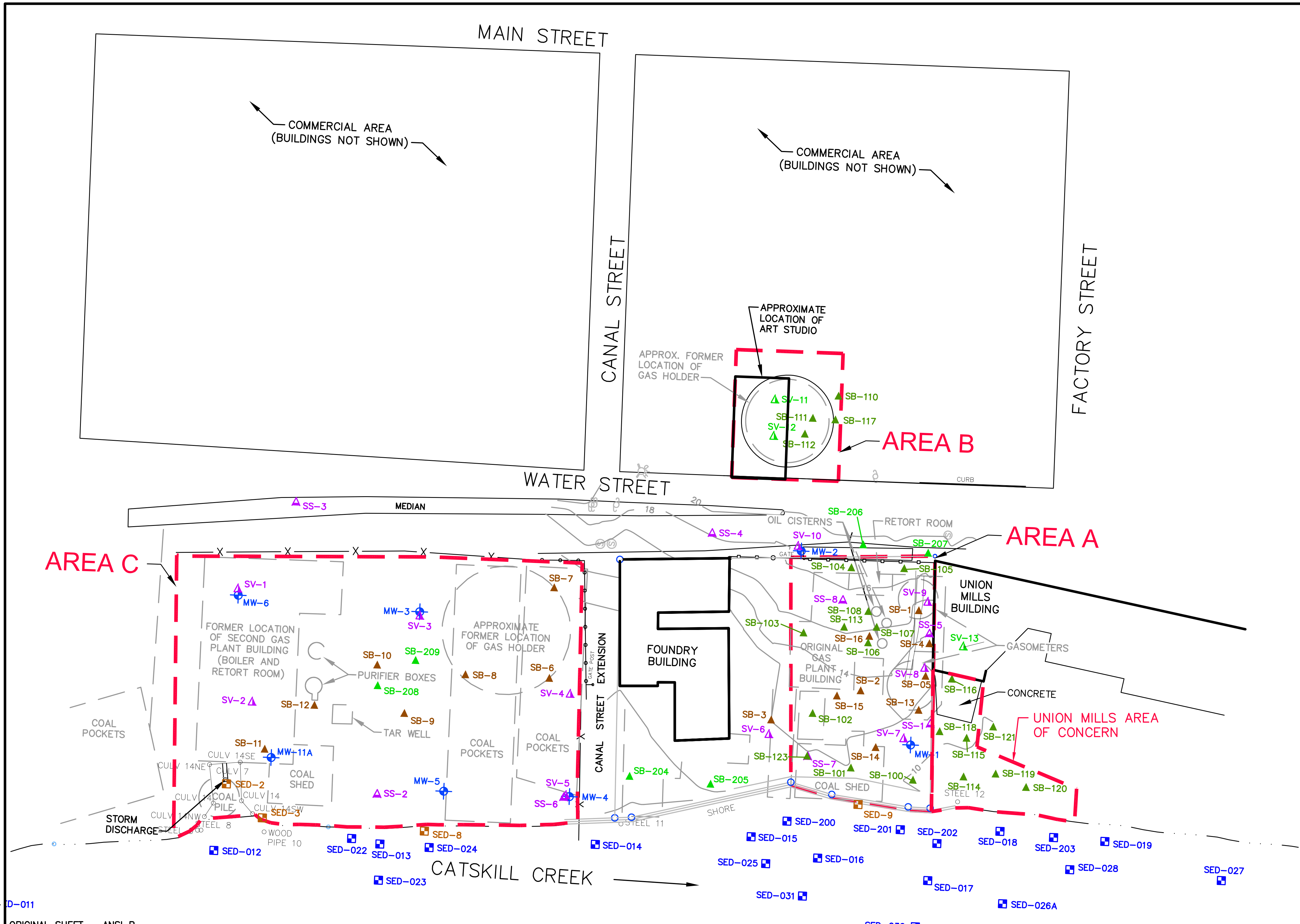

LEGEND:

- HISTORICAL LOCATION
- SB-1 — 2007 SOIL BORING LOCATION
- SB-100 — 2008 SOIL BORING LOCATION
- SB-204 — 2009 SOIL BORING LOCATION
- SS-02 — SURFACE SOIL LOCATION
- MW-7 — MONITORING WELL
- SV-01 — SOIL VAPOR LOCATION (2007)
- SV-1 — SUB-SLAB SOIL VAPOR LOCATION (2010)
- SED-014 — SEDIMENT SAMPLE LOCATION (2009)
- SED-8 — SEDIMENT SAMPLE LOCATION (2007)
- APPROXIMATE SHORELINE
- FENCE
- AREAS OF CONCERN

NOTES:

1. ALL SITE FEATURES ARE APPROXIMATE.
2. EXISTING SOIL BORING, SURFACE SOIL, AND MONITORING WELL LOCATIONS FROM ARCADIS BBL SURVEY PERFORMED 10/04/07, SOIL VAPOR LOCATIONS FROM BBL SURVEY PERFORMED 10/25/07. BASED ON NORTH AMERICAN DATUM OF 1983, NEW YORK EAST ZONE, AND NORTH AMERICAN VERTICAL DATUM OF 1988.
3. NOT ALL HISTORICAL FEATURES SHOWN.
4. THE BOUNDARIES OF AREA A, B, AND C ARE SHOWN AS DEFINED IN THE BROWNFIELD CLEAN-UP AGREEMENT A4-0553-0606.
5. BASEMAP TAKEN FROM DRAWINGS PROVIDED IN THE ARCADIS MAY 2010 REMEDIAL INVESTIGATION REPORT FOR THE CATSKILL FORMER MANUFACTURED GAS PLANT.

GRAPHIC SCALE: 0 — 50' — 100'

ORIGINAL SHEET – ANSI B

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Figure No.
5-1

Title
AREAS OF CONCERN

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LEGEND:

- HISTORICAL LOCATION
- SB-1 — 2007 SOIL BORING LOCATION
- SB-100 — 2008 SOIL BORING LOCATION
- SB-204 — 2009 SOIL BORING LOCATION
- SS-02 — SURFACE SOIL LOCATION
- APPROXIMATE SHORELINE
- FENCE
- AREAS OF CONCERN
- SECANT WALL
- AREA OF EXCAVATION

NOTES:

1. ALL SITE FEATURES ARE APPROXIMATE.
2. EXISTING SOIL BORING, SURFACE SOIL, AND MONITORING WELL LOCATIONS FROM ARCADIS BBL SURVEY PERFORMED 10/04/07, SOIL VAPOR LOCATIONS FROM BBL SURVEY PERFORMED 10/25/07. BASED ON NORTH AMERICAN DATUM OF 1983, NEW YORK EAST ZONE, AND NORTH AMERICAN VERTICAL DATUM OF 1988.
3. NOT ALL HISTORICAL FEATURES SHOWN.
4. THE BOUNDARIES OF AREA A, B, AND C ARE SHOWN AS DEFINED IN THE BROWNFIELD CLEAN-UP AGREEMENT A4-0553-0606.
5. BASEMAP TAKEN FROM DRAWINGS PROVIDED IN THE ARCADIS MAY 2010 REMEDIAL INVESTIGATION REPORT FOR THE CATSKILL FORMER MANUFACTURED GAS PLANT.

0 50' 100'
GRAPHIC SCALE

ORIGINAL SHEET - ANSI B

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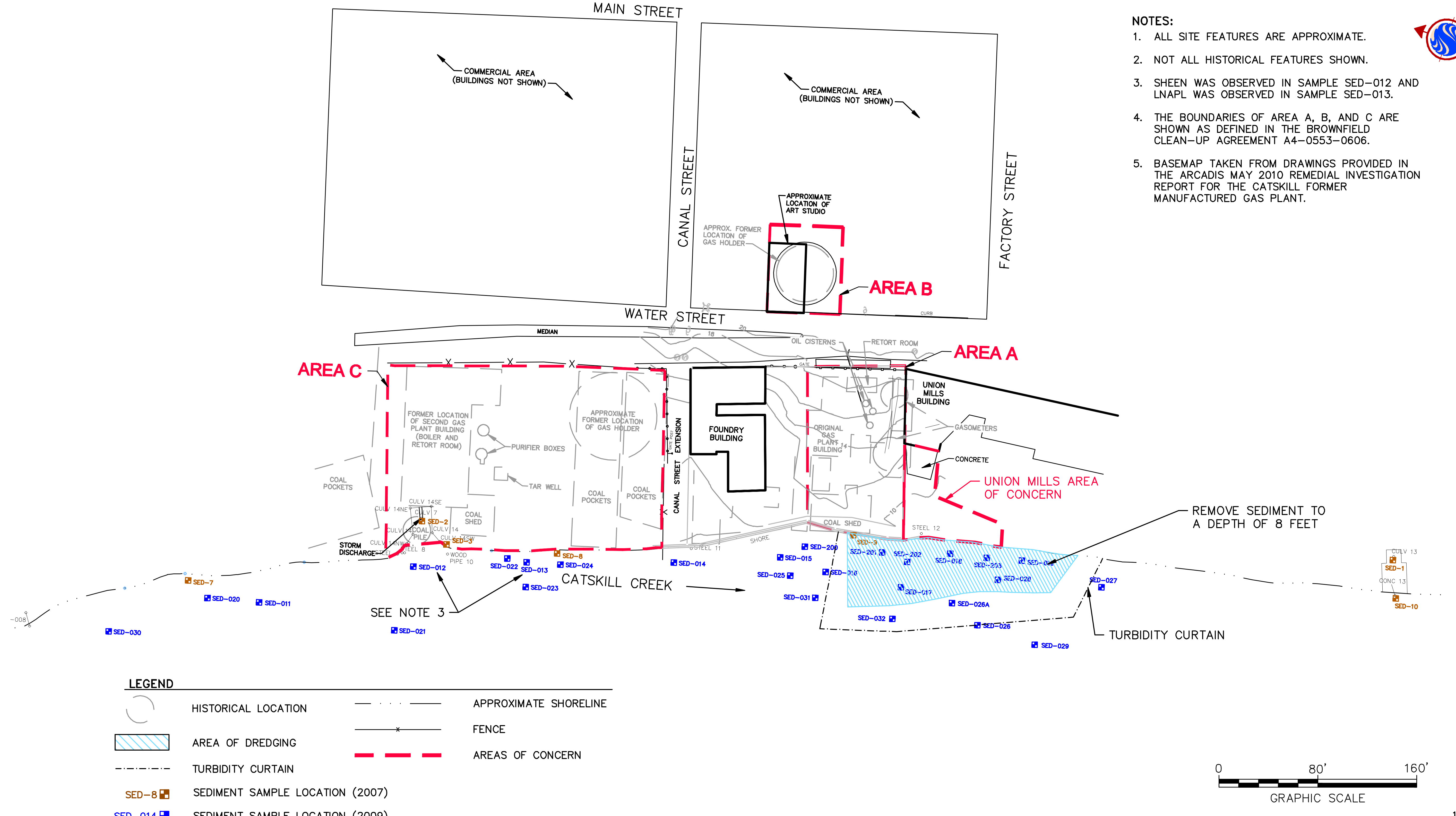
Figure No.
5-2

Title
LIMITS OF EXCAVATION



NOTES:

1. ALL SITE FEATURES ARE APPROXIMATE.
2. NOT ALL HISTORICAL FEATURES SHOWN.
3. SHEEN WAS OBSERVED IN SAMPLE SED-012 AND LNAPL WAS OBSERVED IN SAMPLE SED-013.
4. THE BOUNDARIES OF AREA A, B, AND C ARE SHOWN AS DEFINED IN THE BROWNFIELD CLEAN-UP AGREEMENT A4-0553-0606.
5. BASEMAP TAKEN FROM DRAWINGS PROVIDED IN THE ARCADIS MAY 2010 REMEDIAL INVESTIGATION REPORT FOR THE CATSKILL FORMER MANUFACTURED GAS PLANT.

V:\1916\ACTIVE\2010\191610392 CENTRAL HUDSON - CATSKILL MGP SITE\DRAWINGS\10392C-104.DWG
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ORIGINAL SHEET - ANSI B

12/2010
191610392

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Plymouth Meeting, Pennsylvania
19462
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Client/Project
CENTRAL HUDSON GAS & ELECTRIC CORP.
FORMER CATSKILL MGP SITE
CATSKILL, NEW YORK

Figure No.
5-3

Title
LIMITS OF SEDIMENT DREDGING

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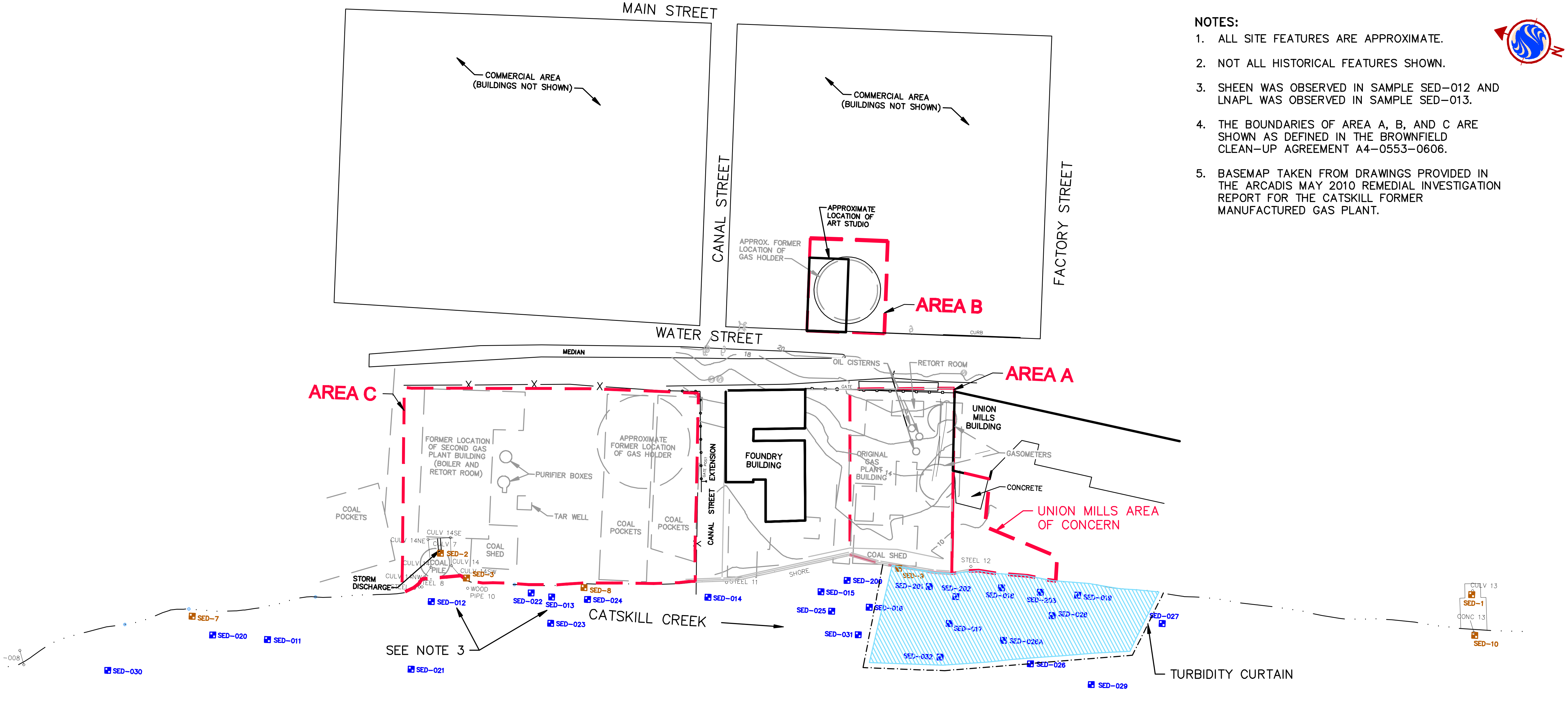

NOTES:

1. ALL SITE FEATURES ARE APPROXIMATE.
2. NOT ALL HISTORICAL FEATURES SHOWN.
3. SHEEN WAS OBSERVED IN SAMPLE SED-012 AND LNAPL WAS OBSERVED IN SAMPLE SED-013.
4. THE BOUNDARIES OF AREA A, B, AND C ARE SHOWN AS DEFINED IN THE BROWNFIELD CLEAN-UP AGREEMENT A4-0553-0606.
5. BASEMAP TAKEN FROM DRAWINGS PROVIDED IN THE ARCADIS MAY 2010 REMEDIAL INVESTIGATION REPORT FOR THE CATSKILL FORMER MANUFACTURED GAS PLANT.

LEGEND

- HISTORICAL LOCATION
- AREA OF DREDGING
- TURBIDITY CURTAIN
- SED-8 SEDIMENT SAMPLE LOCATION (2007)
- SED-014 SEDIMENT SAMPLE LOCATION (2009)
- APPROXIMATE SHORELINE
- FENCE
- AREAS OF CONCERN

0 80' 160'
GRAPHIC SCALE

ORIGINAL SHEET - ANSI B

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Figure No.
5-4

Title
LIMITS OF CAPPING

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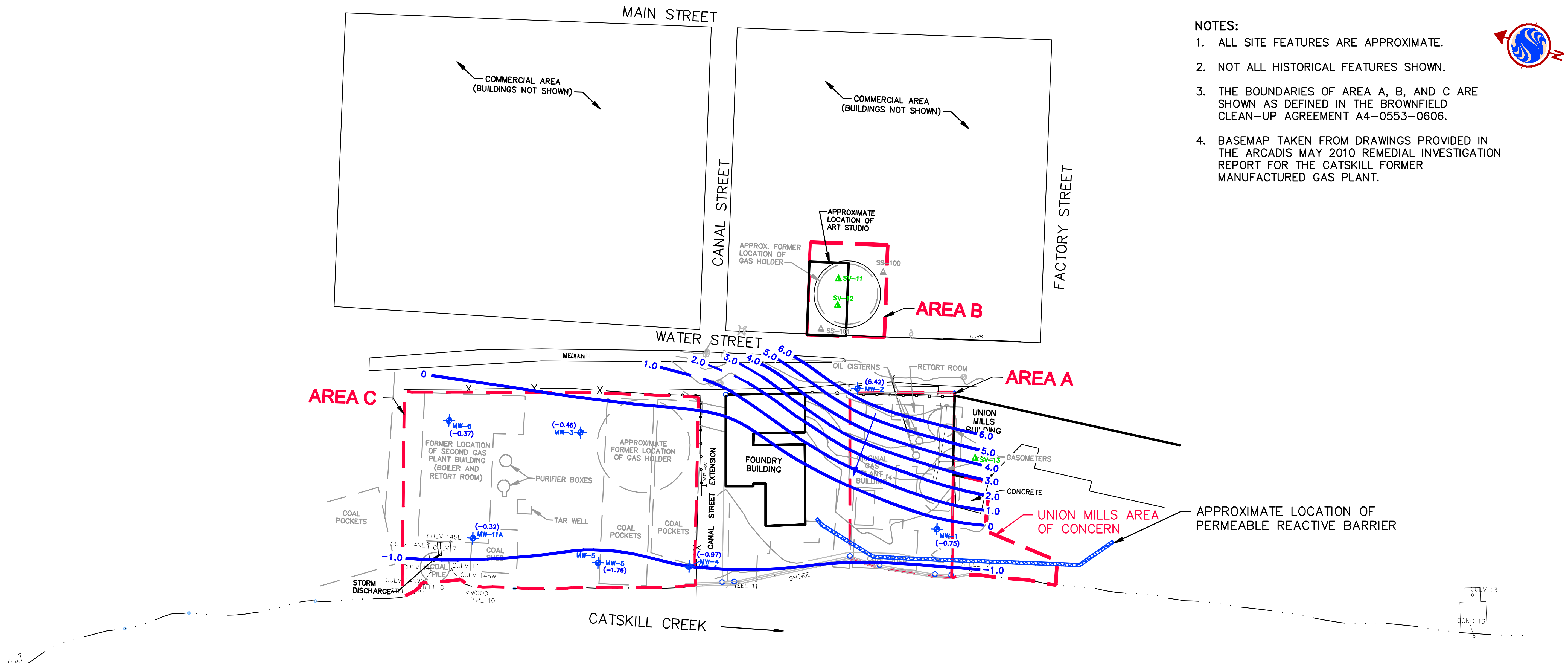

LEGEND

- HISTORICAL LOCATION
- (-1.76) GROUNDWATER ELEVATION
- -1.0 GROUNDWATER CONTOUR - DEC 13, 2007
- MW-7 MONITORING WELL
- APPROXIMATE SHORELINE
- FENCE
- AREAS OF CONCERN
- GROUNDWATER FLOW DIRECTION
- PERMEABLE REACTIVE BARRIER

NOTES:
1. ALL SITE FEATURES ARE APPROXIMATE.
2. NOT ALL HISTORICAL FEATURES SHOWN.
3. THE BOUNDARIES OF AREA A, B, AND C ARE SHOWN AS DEFINED IN THE BROWNFIELD CLEAN-UP AGREEMENT A4-0553-0606.
4. BASEMAP TAKEN FROM DRAWINGS PROVIDED IN THE ARCADIS MAY 2010 REMEDIAL INVESTIGATION REPORT FOR THE CATSKILL FORMER MANUFACTURED GAS PLANT.

GRAPHIC SCALE 0 80' 160'

ORIGINAL SHEET - ANSI B

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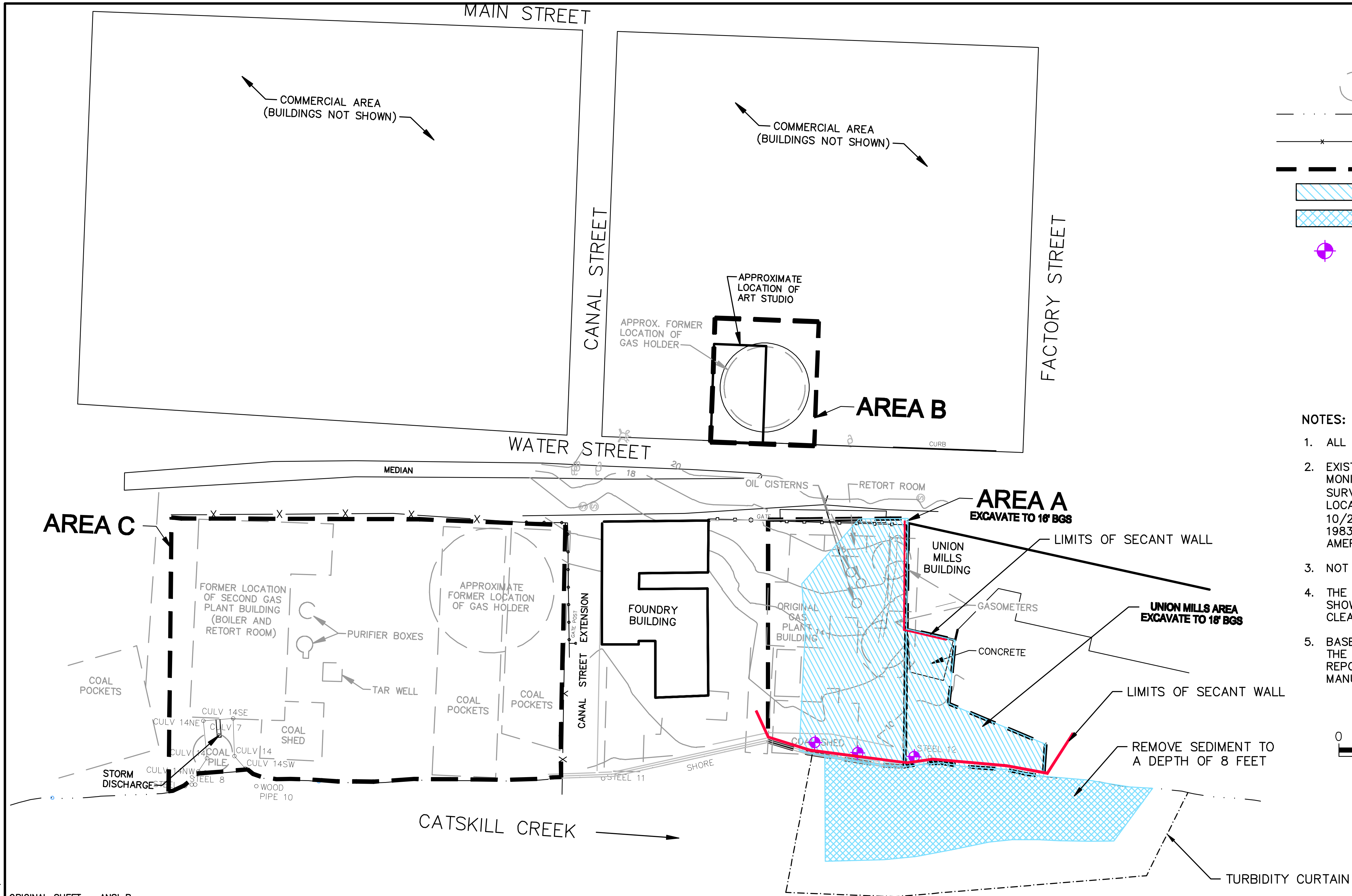
Figure No.
5-5

Title
APPROXIMATE LOCATION OF PERMEABLE REACTIVE BARRIER



NOTES:

1. ALL SITE FEATURES ARE APPROXIMATE.
2. EXISTING SOIL BORING, SURFACE SOIL, AND MONITORING WELL LOCATIONS FROM ARCADIS BBL SURVEY PERFORMED 10/04/07, SOIL VAPOR LOCATIONS FROM BBL SURVEY PERFORMED 10/25/07. BASED ON NORTH AMERICAN DATUM OF 1983, NEW YORK EAST ZONE, AND NORTH AMERICAN VERTICAL DATUM OF 1988.
3. NOT ALL HISTORICAL FEATURES SHOWN.
4. THE BOUNDARIES OF AREA A, B, AND C ARE SHOWN AS DEFINED IN THE BROWNFIELD CLEAN-UP AGREEMENT A4-0553-0606.
5. BASEMAP TAKEN FROM DRAWINGS PROVIDED IN THE ARCADIS MAY 2010 REMEDIAL INVESTIGATION REPORT FOR THE CATSKILL FORMER MANUFACTURED GAS PLANT.

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Figure No.
5-6

Title
SELECTED REMEDIAL ALTERNATIVES

Appendix A

Forensic Evaluation of Area C Surface Soil Samples

Priority pollutant, 2- to 6-ring PAH (PPPAH) data and the gas chromatograms (GCs) from the Method 8270 (PAH) analysis of soil samples SS-2 and SS-6 collected in Area C and soil samples of representative potential coal tar sources of PAHs in Area A of the CHGE Former Catskill MGP Site in Catskill, NY were used to evaluate the potential source of PAHs in samples SS-2 and SS-6. Six soil samples containing varying concentrations of PAHs where coal tar materials were observed from different areas of Area A (SB-100, SB-101, SB-113, and SB-114) were selected to represent potential sources of PAHs to surface soils at SS-2 and SS-6 in Area C. No coal tar was observed in Area C and total PPPAHs from soil samples obtained in Area C were less than 10 ppm; therefore, no samples from Area C are applicable for a forensic PAH evaluation to SS-2 and SS-6. PAH diagnostic ratios were calculated for each sample (Table 1) and selected ratios displayed in double ratio plots (Figures 1 and 2). Figure 1 shows the range of total PPPAH concentrations of Area A samples compared to that of the SS-2 and SS-6 samples. Figure 2 provides preliminary information on the PAH compositional characteristics in Area A locations and SS-2 and SS-6 samples in Area C which are used to help differentiate potential sources of PAHs in environmental samples (Costa and Sauer, 2005; Yunker et al., 2002).

PAH composition diagnostic ratios in Figure 2 indicate that there appears to be a distinct difference in PAH compositions of the SS-2 and SS-6 samples compared to the potential source samples in Area A. The Area A samples have similar PAH composition characteristics suggesting the presence of coal tar products produced by the coal carbonization (CC) process (EPRI, 2000; Fl/Py ratio greater than 1 for CC coal tars). The higher PAH concentration samples (total PPPAH > 1000 mg/kg) indicate also a coal tar material in the Area A samples.

The SS-2 and SS-6 PAH compositions are not indicative of the coal tar type present in Area A since none of the SS-2 and SS-6 ratios (Figure 2) fall within the range of the coal tar material of Area A. The potential source(s) of PAHs in these samples were further evaluated based on both the apparent PAH concentrations and compositions. The PAH concentrations of SS-2 and SS-6 (TPPPAH: 36 and 52 mg/kg, respectively) are in the range of a variety of urban environment sources. Total PAHs in background urban soils can range to over 100 ppm (O'Brien & Gere, 2000). When compared to site-specific background total PPPAH concentrations at SS-3 and SS-4 (total PPPAH: 71 and 39 mg/kg, respectively), the total PPPAH concentrations at SS-2 and SS-6 fall with the background range (total PPPPAH: 36 and 52 mg/kg, respectively). Compositionally, the gas chromatogram patterns of both SS-2 and SS-6 in the attached file shows a large 'hump' (UCM-unresolved complex mixture) in the GC indicative of the presence of heavy type petroleum fuel oil or product.

In summary, the PAHs in SS-2 and SS-6 are not related to the coal tar materials observed at Area A. In addition, the total PPPAH concentrations in samples SS-2 and SS-6 lie within the total PPPAH concentration range of the background samples SS-3 and SS-4. The PAHs in SS-2 and SS-6 appear to be from a variety of urban environmental sources including petroleum-related PAHs.

References

Costa, H.J. and T.C. Sauer. 2005. Forensic approaches and considerations in identifying PAH background. *Environmental Forensics* 6: 9-16.

EPRI (Electric Power Research Institute). 2000. *Chemical Source Attribution at Former MGP Sites.* EPRI, Palo Alto, CA, NYSEG, Binghamton, NY, and RG&E, Rochester, NY. Report No. 1000728.

O'Brien & Gere Engineers, Inc., 2000*. Polycyclic Aromatic Hydrocarbons in Urban Soils – Literature Review.*

Yunker, M.B., Macdonald, R.W., Vingarzin, R., Mitchell, R.H., Goyette, D., and Sylvestre, S. 2002. PAH in the Fraser River basin: a critical appraisal of PAH ratios as indicators of PAH source and composition. *Organic Geochemistry* 33:489-515.

Table 1.
Analytical Data and PAH Diagnostic Ratios For 2008 Area A and 2007 Area C Samples
CHGE Former Catskill MGP Site, Catskill NY

Sample ID		SB-100(16-20)		SB-100(20-24)		SB-101 (19-20)		SB-101(20-20.5)		SB-113(16-18)		SB-114(16.3-17.4)		SS-2 (0-2')		SS-6 (0-2')	
Lab ID		773542		773543		773544		773545		NY128494		773720					
Collection Date		10/29/2008		10/29/2008		10/29/2008		10/29/2008		10/30/2008		10/30/2008		10/07		10/07	
	Units	Results	Qual	Results	Qual	Results	Qual	Results	Qual	Results	Qual	Results	Qual	Results	Qual	Results	Qual
Benzene	ug/Kg	3800		100		1500	J	410	J	180	J	66000					
Toluene	ug/Kg	19000		120		13000		1200		100	J	170000					
Ethylbenzene	ug/Kg	13000		200		38000		3800		950		140000					
Xylene (total)	ug/Kg	48000		500		140000		13000		5700		460000					
Styrene	ug/Kg	1300		9.7		2400	U	710	U	520	U	6300	U				
4-Methylphenol	ug/Kg	48	J	370	U	51000	U	180	J	360	U	40000	U				
2,4-Dimethylphenol	ug/Kg	100	J	370	U	51000	U	2000	U	360	U	4200	J				
Naphthalene	ug/Kg	98000	D	2800		3500000	D	120000	D	18000	D	2400000	D	200		350	
Acenaphthylene	ug/Kg	14000	DJ	280	J	92000		8100		680		280000		350		510	
Acenaphthene	ug/Kg	8900	DJ	1400		650000	D	38000	D	630		130000		73		280	
Fluorene	ug/Kg	19000	D	1200		600000	D	44000	D	1000		320000		90		680	
Phenanthrene	ug/Kg	52000	D	2900	D	1800000	D	130000	D	2700		960000	D	1,800		3,400	
Anthracene	ug/Kg	18000	D	1100		730000	D	45000	D	940		420000	D	590		1,200	
Fluoranthene	ug/Kg	32000	D	1800		1100000	D	99000	D	1680		570000	D	5,200		4,300	
Pyrene	ug/Kg	19000	D	1200		650000	D	58000	D	850		310000		5,600		7,800	
Benzo(a)anthracene	ug/Kg	11000	DJ	680		390000		44000	D	630		220000		3,300		6,100	
Chrysene	ug/Kg	10000	DJ	640		350000		37000	D	560		210000		3,100		10,000	
Benzo(b)fluoranthene	ug/Kg	6000	DJ	360	J	290000		32000	D	540		100000		4,700		4,000	
Benzo(k)fluoranthene	ug/Kg	7900	DJ	520		340000		34000	D	480		140000		3,900		4,100	
Benzo(a)pyrene	ug/Kg	8000	DJ	490		290000		38000	D	450		160000		3,900		5,700	
Indeno(1,2,3-cd)pyrene	ug/Kg	1600		220	J	58000		9900		110	J	57000		1,300		780	
Dibenz(a,h)anthracene	ug/Kg	770		95	J	29000	J	4900		49	J	26000	J	370		410	
Benzo(g,h,i)perylene	ug/Kg	1300		180	J	45000	J	8000		88	J	45000		1,300		2,200	
TPPPAH		307,470		15,865		10,914,000		749,900		29,387		6,348,000		35,773		51,810	
TPPPAH mg/kg		307		16		10,914		750		29		6,348		36		52	
2-Methylnaphthalene	ug/Kg	30000	D	2400		730000	D	29000	D	3600	D	640000	D	72	J	150	
Dibenzofuran	ug/Kg	17000	D	1200		550000	D	34000	D	1000		290000		81		550	
TPAH		354,777		19,481		12,204,914		813,650		34,016		7,284,348		35,962		52,562	
Fl/Py		1.68		1.50		1.69		1.71		1.98		1.84		0.93		0.55	
BAA/C		1.10		1.06		1.11		1.19		1.13		1.05		1.06		0.61	
BAA/BAP		1.38		1.39		1.34		1.16		1.40		1.38		0.85		1.07	
B(b+k)FL/C		1.40		1.33		1.66		1.89		1.77		1.24		2.77		0.97	
2-&3-ring PAHs/TPPPAH		0.68		0.61		0.68		0.51		0.81		0.71		0.09		0.12	

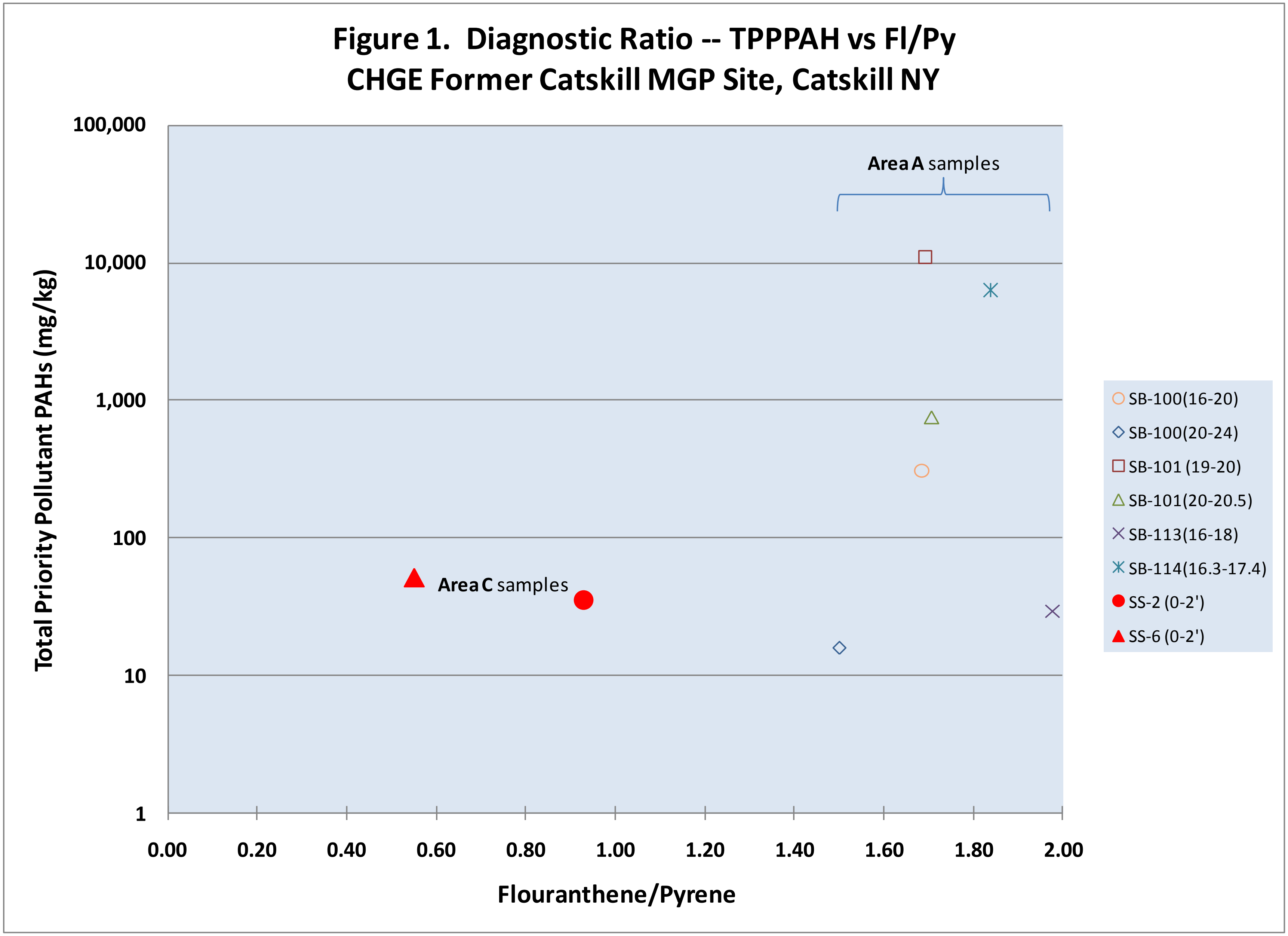


Figure 1. Diagnostic Ratio -- TPPPAH vs Fl/Py
CHGE Former Catskill MGP Site, Catskill NY
Total Priority Pollutant PAHs (mg/kg)
100,000
10,000
1,000
100
10
1
0.00
0.20
0.40
0.60
0.80
1.00
1.20
1.40
1.60
1.80
2.00
Flouranthene/Pyrene
Area A samples
Area C samples
SB-100(16-20)
SB-100(20-24)
SB-101 (19-20)
SB-101(20-20.5)
SB-113(16-18)
SB-114(16.3-17.4)
SS-2 (0-2')
SS-6 (0-2')

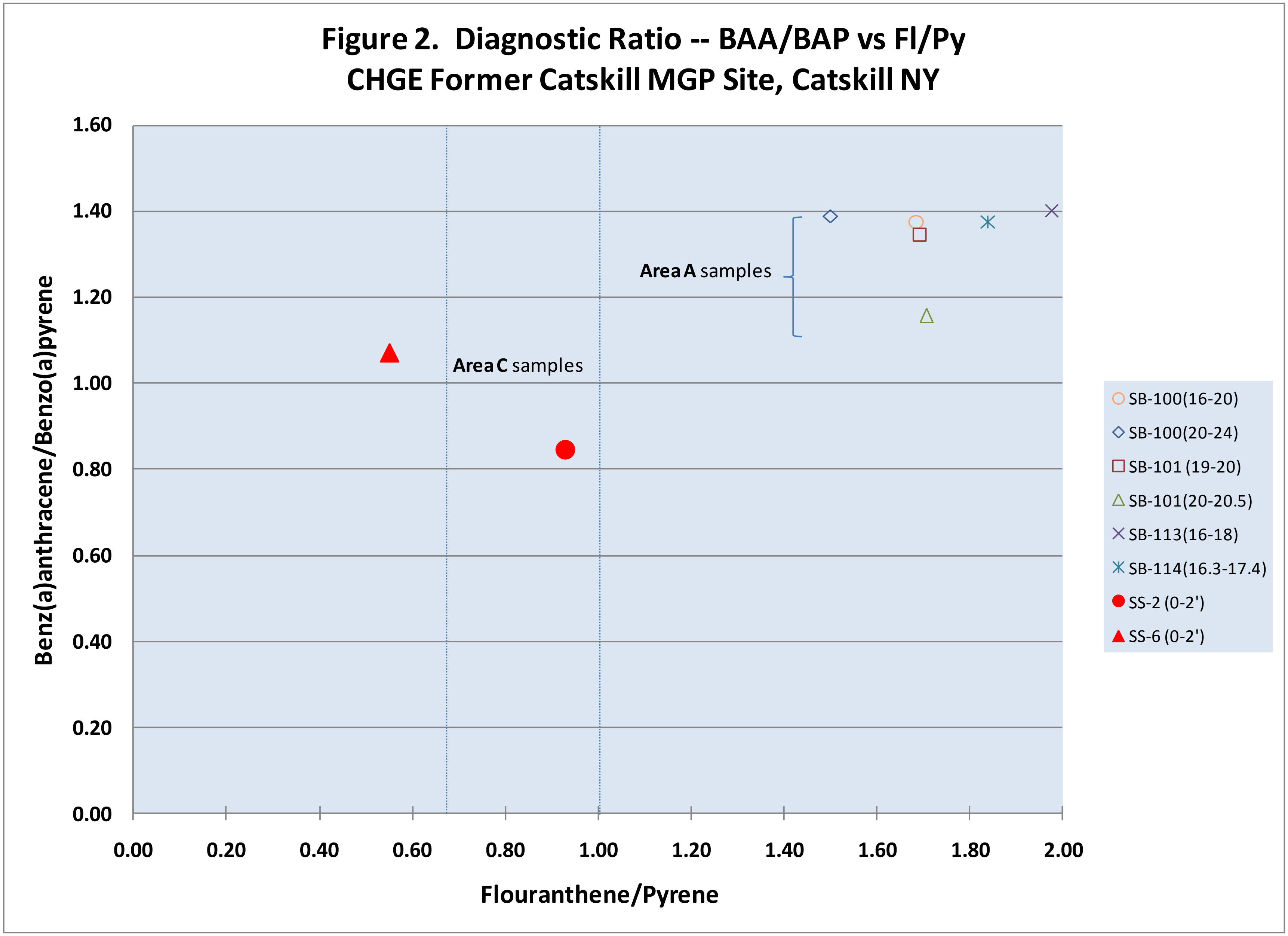


Figure 2. Diagnostic Ratio -- BAA/BAP vs Fl/Py
CHGE Former Catskill MGP Site, Catskill NY
Benz(a)anthracene/Benzo(a)pyrene
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
Area A samples
Area C samples
0.00
0.20
0.40
0.60
0.80
1.00
1.20
1.40
1.60
1.80
2.00
Flouranthene/Pyrene
SB-100(16-20)
SB-100(20-24)
SB-101 (19-20)
SB-101(20-20.5)
SB-113(16-18)
SB-114(16.3-17.4)
SS-2 (0-2')
SS-6 (0-2')

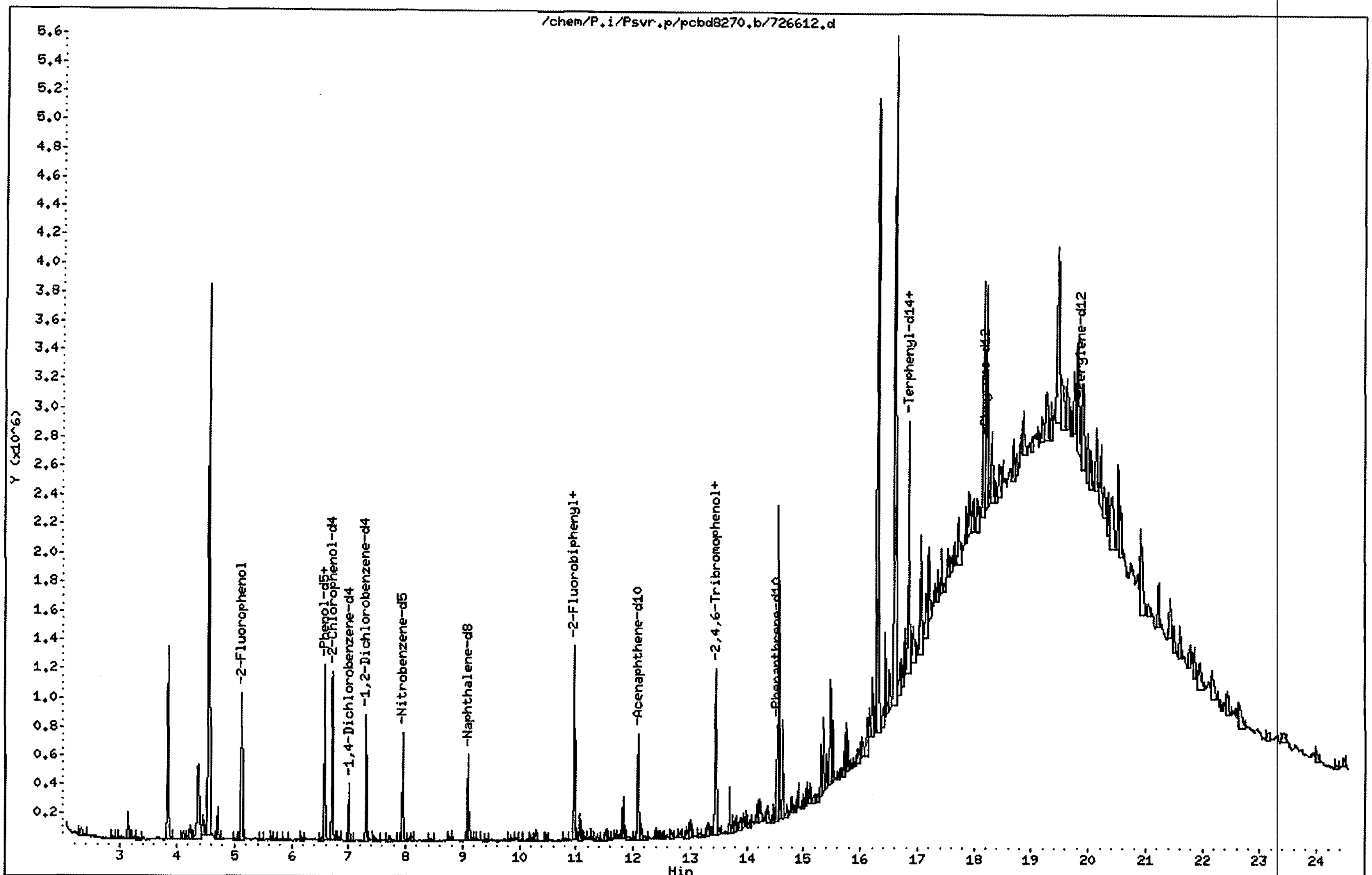
SS-2

Page 1

Data File: /chem/P.i/Psvr.p/pcbd8270.b/726612.d
Date : 20-OCT-2007 21:40
Client ID: SS-2 (0-2)
Sample Info: SS-2 (0-2) ;[ ]10/03/07 @1420(SOIL)
Volume Injected (uL): 2.0
Column phase: RTX-5

Instrument: P.i

Operator: prp
Column diameter: 0.25



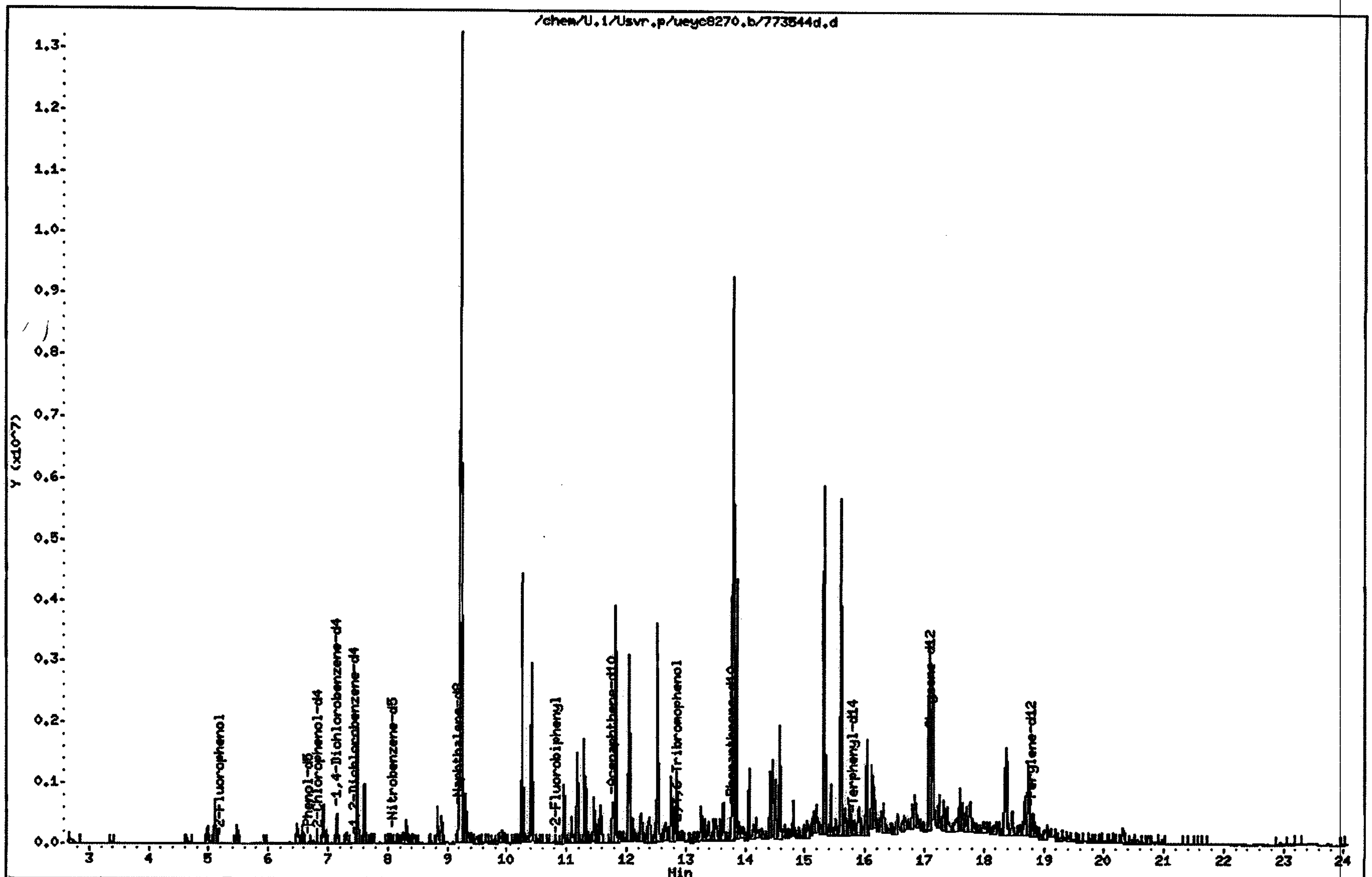
482

Data File: /chem/U.i/Usvr.p/ueyc8270.b/773544d.d
Date : 17-DEC-2008 13:41
Client ID: SB1011920
Sample Info: SB-101(19-20) :[ ]10/29/08 @1400(SOIL)
Volume Injected (uL): 2.0
Column phase: Rxi-5ms

Instrument: U.i

Operator: mtw
Column diameter: 0.25

REPRENTS AREA A Samples



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Date : 30-OCT-2007 10:57

Client ID: SS-6_0-2

Instrument: P.i

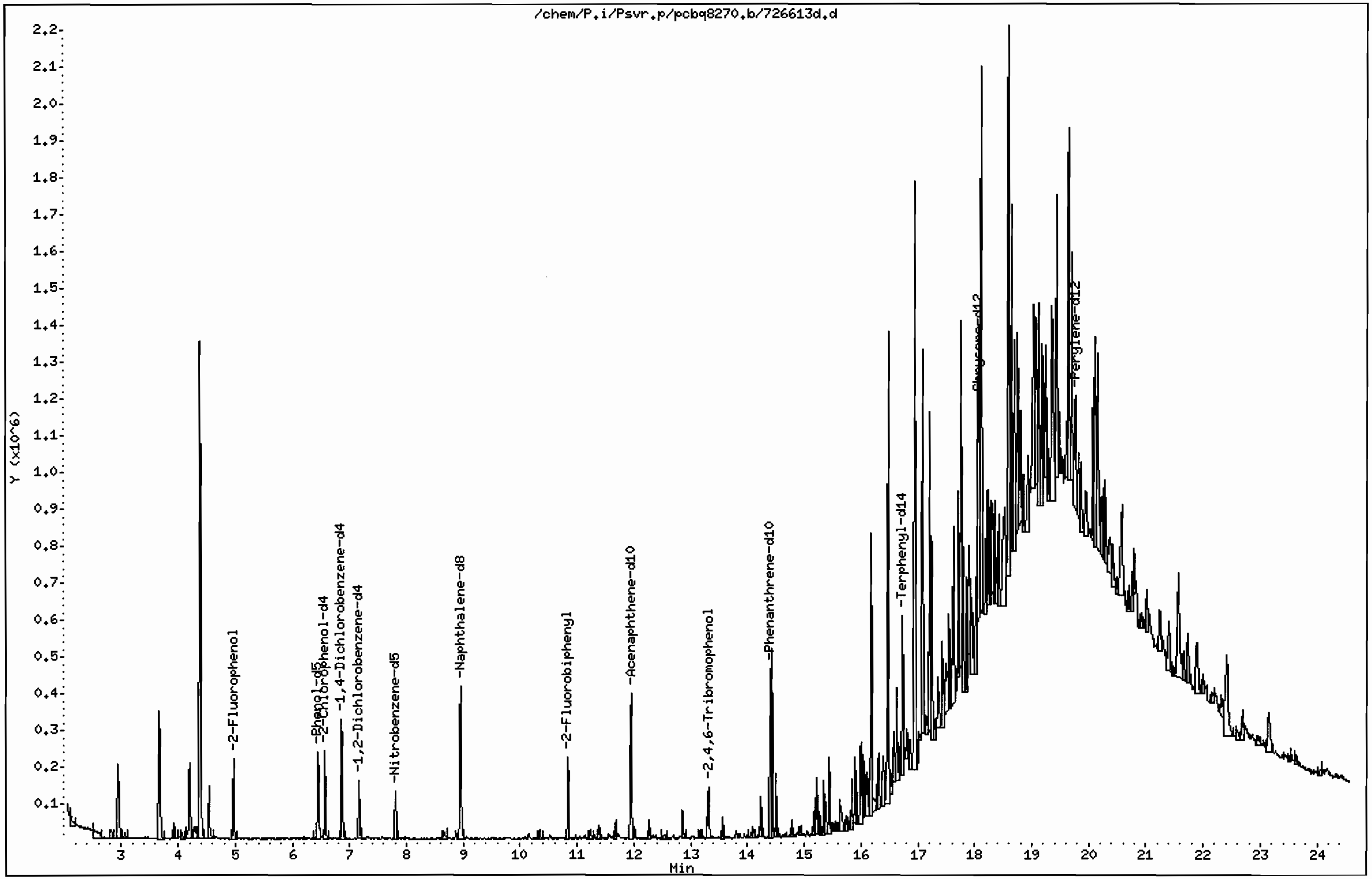
Sample Info: SS-6 (0-2) :[ ]10/03/07 @1400(SOIL)

Volume Injected (uL): 2.0

Operator: djb

Column phase: RTX-5

Column diameter: 0.25



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