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# Groundwater Remedial Investigation Report

## Final

**PPG Garfield Avenue Group**
**Hudson County Chromium Sites**
**Jersey City, New Jersey**

GW-077

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# List of Acronyms

| | |
|---|---|
| ACO | Administrative Consent Order |
| A-DGA | amended dense-graded aggregate |
| ADT | Aquifer Drilling and Testing |
| Ag | silver |
| Al | aluminum |
| AOC | Area of Concern |
| As | arsenic |
| Ba | barium |
| Be | beryllium |
| bgs | below ground surface |
| Ca | calcium |
| CCPW | chromate chemical production waste |
| Cd | cadmium |
| CEA | Classification Exception Area |
| Co | cobalt |
| COCs | contaminants of concern |
| COPR | Chromite Ore Processing Residue |
| Cr | total chromium |
| $Cr^{+3}$ | trivalent chromium |
| $Cr^{+6}$ | hexavalent chromium |
| CrSCC | Chromium Soil Cleanup Criteria |
| CSM | conceptual site model |
| Cu | copper |
| DO | dissolved oxygen |
| DGA | dense-graded aggregate |
| DNAPL | dense non-aqueous phase liquid |
| EDD | electronic data deliverable |
| El. | elevation |
| Fe | iron |
| FS | Forrest Street |
| FSP | Forrest Street Properties |
| FSPM | Field Sampling Procedures Manual |
| FSP-QAPP | Field Sampling Plan-Quality Assurance Program Plan |
| ft | feet |
| GA Group | Garfield Avenue Group |
| GGM | green-gray mud |
| GPS | global positioning system |
| GWQS | groundwater quality standard(s) |
| HASP | Health and Safety Plan |
| HCC | Hudson County Chromate |
| Hg | mercury |
| HPT | Hydraulic Profiling Tool |
| ICP-AES | inductively coupled plasma atomic emission spectroscopy |
| IDW | investigation-derived wastes |
| IRM | Interim Remedial Measure |

| | |
|---|---|
| ISAB | *in situ* anaerobic bioprecipitation |
| JCO | Judicial Consent Order |
| JCRA | Jersey City Redevelopment Agency |
| K | potassium |
| lbs | pounds |
| LCS | laboratory control sample |
| LDC | Laboratory Data Consultants, Inc. |
| Mg | magnesium |
| µg/L | micrograms per liter |
| mg/kg | milligrams per kilogram |
| mg/L | milligrams per liter |
| MFHN | Metropolitan Family Health Network |
| MGP | manufactured gas plant |
| Mn | manganese |
| MS/MSD | Matrix Spike/Matrix Spike Duplicate |
| N.J.A.C. | New Jersey Administrative Code |
| Na | sodium |
| NAD83 | North American Datum of 1983 |
| NAVD88 | North American Vertical Datum of 1988 |
| NFA | No Further Action |
| Ni | nickel |
| NJ | New Jersey |
| NJDEP | New Jersey Department of Environmental Protection |
| NJGS | New Jersey Geologic Survey |
| NTU | nephelometric turbidity units |
| OGS | open grade stone |
| ORP | oxidation-reduction potential |
| Pb | lead |
| PBR | Permit-By-Rule |
| PDI | preliminary design investigation |
| PFAS | Per- and polyfluoroalkyl substances |
| PFNA | perfluorononanoic acid |
| PPE | personal protective equipment |
| PSEG | Public Service Electric & Gas Company |
| PVC | polyvinyl chloride |
| QA | quality assurance |
| QC | quality control |
| RA | Remedial Action |
| RAP | Remedial Action Permit |
| RAWP | Remedial Action Report |
| RAP | Remedial Action Work Plan |
| RI | remedial investigation |
| RIR | Remedial Investigation Report |
| RIWP | Remedial Investigation Work Plan |
| ROW | right-of-way |
| RPD | relative percent difference |
| Sb | antimony |
| SDG | sample delivery group |

| | |
|---|---|
| Se | selenium |
| Site 133E | Site 133 East |
| Site 133W | Site 133 West |
| SOP | standard operating procedure |
| Sr | strontium |
| SVOCs | Semi-volatile organic compounds |
| TAL | Target Analyte List |
| TEP | Technical Execution Plan |
| Tl | thallium |
| TRSR | Technical Requirements for Site Remediation |
| USCS | Unified Soil Classification System |
| USEPA | United States Environmental Protection Agency |
| USGS | United States Geological Survey |
| V | vanadium |
| VAP | vertical aquifer profiling |
| VOCs | volatile organic compounds |
| WRA | Well Restriction Area |
| wt. | weight |
| Zn | zinc |

# List of Definitions

**Chromate Chemical Production Waste (CCPW):** A by-product generated from the production of sodium bichromate, including chromite ore processing residue, green-gray mud, and fill mixed with chromite ore processing residue or green-gray mud.

**Chromite Ore Processing Residue (COPR):** A specific type of CCPW generally characterized as a reddish brown, coarse to fine, gravel with varying amounts of sand and silt particles. The gravel portion of the matrix is typically defined as nodules from the chromate manufacturing process that range in size from ⅛- to ¾-inch in diameter. However, nodules have been infrequently detected at diameters of over an inch. Different sized nodules may be found cemented together to form larger clusters. The matrix of these clusters may consist of cement-like silt. These nodules can be disintegrated easily with a hammer. Occasionally when detected in the saturated zone, COPR nodules may appear as a fine-grained material that has been weathered. The permeability of this material is variable. The inner matrix of COPR nodules typically contains higher concentrations of hexavalent chromium than the surface of the nodules but lower concentrations than green-gray mud.

**Chromium:** An element found in nature that is commonly used in manufacturing activities. Chromium may be present in soil or water as trivalent chromium and hexavalent chromium. Trivalent chromium is an essential nutrient at trace concentrations. Hexavalent chromium can be present in many forms, some of which are carcinogenic at high concentrations. Total chromium, as measured in soil or groundwater, is the sum of trivalent and hexavalent chromium.

**Green-Gray Mud (GGM):** Generally lime green dense silt, with minor amounts of fine sand and clay. When found in the saturated zone, the grain size of this material may have been affected further due to weathering processes. This can give the material a wet, clayey silt or silty clay appearance with little or no physical or structural integrity. This material has a low permeability. The pH of this material is generally 11 to 12 standard units.

# Executive Summary

AECOM has prepared this Final Remedial Investigation Report (RIR) on behalf of PPG to present the results, findings, and recommendations associated with the groundwater Remedial Investigation (RI) for the Garfield Avenue Group (GA Group) part of the Hudson County Chromate (HCC) Sites in Jersey City, Hudson County, New Jersey. This revision incorporates additional data collected since the submission of the October 2018 Draft RIR to meet the RI delineation objectives.

This groundwater RI was conducted primarily to delineate the horizontal and vertical extent of chromate chemical production waste (CCPW)-related impacts (hexavalent chromium, antimony, nickel, thallium, vanadium, and total chromium [Cr]) to groundwater within the GA Group Project Area. The RI also addresses the extent of groundwater impacts related to non-CCPW Target Analyte List (TAL) metals, volatile organic compounds (VOCs), and semi-volatile organic compounds (SVOCs) that are on or emanating from Site 114 due to PPG's brief ownership (i.e., ten years, from 1954 to 1964) of the Site 114 property.

The City of Jersey City receives its potable water from the Rockaway River, a tributary of the Passaic River, with water treatment at the Jersey City Water Treatment plant in Boonton, New Jersey prior to distribution to the municipality. Groundwater in this part of Jersey City is classified as Class II-A (potable ground water with conventional treatment at current water quality); however, the groundwater is slightly brackish and is not used for potable, industrial, commercial, or private use. Groundwater in the Project Area is found within four hydrostratigrapic units. These include the shallow zone (fill material), intermediate zone (estuarian "meadow mat" deposits underlain by fluvial sand, silt, and clay with lenses of gravel), the deep zone (sand and gravel with lenses of clay or silt underlain by basal glacial till), and bedrock (Lockatong Formation, Stockton Formation, and a diabase sill along the western boundary of the Project Area). The regional groundwater flow direction in the overburden is generally toward the southeast.

The source of chromium impacts to groundwater in the Project Area is chromium-impacted soil associated with historical use of Site 114 for chromite ore processing operations. Between 2010 and 2020, PPG completed excavation of chromium-impacted soil from the GA Group Sites and roadways. Excavations on adjacent properties are ongoing. As of September 30, 2020, a total of 861,729 tons of hazardous waste material, and 195,338 tons of non-hazardous waste material have been removed from these areas.

The Public Service Electric & Gas Company (PSEG) is responsible for investigating and remediating impacts related to the operation of the former manufactured gas plant (MGP) located within the Project Area due to their ownership and operation of the Halladay Street Gas Works formerly located on Site 114. Soil remediation was performed by PSEG on the former MGP location within Site 114 and a groundwater RIR for MGP constituents was submitted to NJDEP in May 2014. A Classification Exception Area (CEA) for MGP-related contamination was proposed by PSEG and established by NJDEP in June 2014.

A CEA for CCPW impacts in the intermediate and deep water-bearing zones was proposed by PPG and established by NJDEP in June 2018 for the GA Group Sites. The 2018 CEA applies to groundwater contamination related to historical operations at Site 114. An update to this CEA is included with this RIR to include the shallow, intermediate, and deep water-bearing zones, as well as a portion of the bedrock water-bearing zone. This RIR also includes a CEA/Well Restriction Area application for historic fill-related impacts to groundwater on Site 114.

Numerous groundwater investigation activities have been conducted in the Project Area since 2003. While the data from these investigations was used in the evaluation of groundwater impacts and the conclusions derived from the evaluation of these groundwater impacts, this RIR primarily focuses on the groundwater investigation work conducted from 2015 to the present.

A conceptual Site Model (CSM) was prepared for the Project Area and updated during the groundwater RI to provide the most current understanding of Project Area geology, hydrogeology, source areas, and nature and extent of CCPW-related impacts to groundwater. The CSM is a 'living' document that will be updated as necessary upon completion of subsequent investigation activities.

The RI determined that CCPW constituents have leached from historical source areas, infiltrated into the subsurface, and migrated downward through the unsaturated zone. Once within the saturated zone, migration occurs primarily along the prevailing direction of groundwater flow, either horizontally or vertically, depending on hydraulic conditions via either advection or diffusion based on soil type. Impacted groundwater spread laterally as low permeability zones were encountered and/or diffused into and through the lower permeability soil horizon. Back-diffusion of Cr from the lower-permeability soils into surrounding higher-permeability soils is expected to occur over time. The presence of natural (meadow mat) and anthropogenic (MGP residuals) organic matter within soils also impacts the mobility of Cr in groundwater via reduction and precipitation.

Based on the data collected to date, the following conclusions pertaining to the distribution of CCPW-related impacts to groundwater were reached for the Project Area:

- Horizontal delineation has been achieved for the shallow, intermediate, and deep water-bearing zones.
- Horizontal delineation within bedrock has been achieved on the eastern and northern portions of Site 114. Additional delineation is required in the southwestern portion of Site 114.
- Vertical delineation within the overburden has been achieved in several parts of the Project Area; however, additional vertical delineation is required in bedrock in the southwestern portion of Site 114.

Based on the data collected to date, the following conclusions pertaining to non-CCPW metals, VOCs, and SVOCs that are on or emanating from Site 114 are identified for the Project Area:

- The constituents emanating from Site 114 have been identified and the horizontal and vertical extents of these constituents have been delineated.

# 1.0 Introduction

AECOM has prepared this Final Remedial Investigation Report (RIR) on behalf of PPG to present the results, findings, and recommendations associated with the groundwater Remedial Investigation (RI) for the Garfield Avenue Group (GA Group) part of the Hudson County Chromate (HCC) Sites in Jersey City, Hudson County, New Jersey. The GA Group Sites include Sites 114, 132, 133, 135, 137, and 143, the Roadways (Carteret Avenue, Forrest Street, Garfield Avenue, Caven Point Avenue, Pacific Avenue, Halladay Street North, and Halladay Street South), and the Off-Site Properties (Al Smith Moving, Halsted Corporation, Fishbein, Forrest Street Properties, and Ten West Apparel). This RIR also presents the results, findings, and recommendations associated with the groundwater RI for HCC Site 186 and Site 199. Hereinafter, these sites, collectively, are referred to as “the Project Area” (**Figure 1-1** and **Figure 1-2**). The initial Draft Groundwater RIR was submitted to the New Jersey Department of Environmental Protection (NJDEP) on October 1, 2018 (AECOM, 2018b). This revision incorporates additional data collected since the submission of the October 2018 Draft RIR to meet the RI delineation objectives.

This groundwater RIR:

- Presents data collected as part of groundwater RI field activities conducted from 2017 to February 2021;
- Presents an updated Conceptual Site Model (CSM) that incorporates the current understanding of the geology, hydrogeology, source areas, and the horizontal and vertical extents of CCPW-related groundwater impacts in the Project Area including an evaluation of the fate and transport of chromium in groundwater;
- Presents historical groundwater data and other pertinent information collected across the Project Area to support the updated CSM;
- Provides an evaluation of non-CCPW metals, VOCs, and SVOCs that may or may not be emanating from Site 114; and
- Provides conclusions and recommendations based on the findings of groundwater RI activities completed to date.

## 1.1 Remedial Investigation Objectives

The primary objective of the groundwater RI for the Project Area was to delineate the horizontal and vertical extent of chromate chemical production waste (CCPW)-related impacts to groundwater within the Project Area. CCPW metals include antimony (Sb), nickel (Ni), thallium (Tl), vanadium (V), and total chromium (Cr). In addition, delineation of the extent of groundwater impacts related to non-CCPW Target Analyte List (TAL) metals (which include: silver [Ag], aluminum [Al], arsenic [As], barium [Ba], beryllium [Be], calcium [Ca], cadmium [Cd], cobalt [Co], copper [Cu], iron [Fe], mercury [Hg], potassium [K], magnesium [Mg], manganese [Mn], sodium [Na], strontium [Sr], lead [Pb], selenium [Se], and zinc [Zn]), volatile organic compounds (VOCs), and semi-volatile organic compounds (SVOCs) that are on or emanating from Site 114 was also within the scope of the groundwater RI due to PPG’s brief ownership of the Site 114 property (i.e., ten years, from 1954 to 1964).

The groundwater RI was implemented using a phased approach and was conducted in parallel with ongoing soil and groundwater remediation activities within the Project Area. The first phase of the RI, implemented in 2017 and 2018, focused primarily on the shallow and intermediate water-bearing zones with limited investigations in the deep water-bearing zone and was conducted in accordance with the July 2017 *Groundwater Remedial Investigation Work Plan - Rev. 1* (herein referred to as the Groundwater RIWP and included in **Appendix A***)* (AECOM, 2017b). Following submission of the October 2018 Draft Groundwater RIR, additional remedial investigation activities were implemented from 2019 to 2021 in accordance with scopes of work approved by NJDEP during various technical meetings, including the installation and sampling of basal till/weathered bedrock, and bedrock monitoring wells on Site 114.

## 1.2 Regulatory History

Investigation and remediation activities at the Project Area are regulated by the NJDEP and are administered by the Superior Court of New Jersey under an Administrative Consent Order (ACO) and a Partial Judicial Consent Order Concerning the PPG Sites (JCO).

PPG and the NJDEP entered into an ACO in 1990, requiring the investigation and remediation of locations where CCPW or CCPW-impacted materials related to former PPG operations may have been present. On June 26, 2009, NJDEP, PPG and the City of Jersey City entered into a JCO with the purpose of assessing and remediating sources of contamination and impacted soil and groundwater at PPG's HCC Sites. In accordance with the JCO, PPG is responsible for remediating CCPW, CCPW-impacted materials, and other contaminants of concern (COCs) that are on or have emanated from Site 114 onto adjacent parcels.

The Public Service Electric & Gas Company (PSEG) is responsible for investigating and remediating impacts related to the operation of the former manufactured gas plant (MGP) located within the Project Area (PSEG, 2007; PSEG, 2009; PSEG, 2014a). Soil remediation has been performed on the former MGP location within Site 114. A groundwater Classification Exception Area (CEA) was put in place by PSEG primarily for MGP constituents within the area impacted by the former MGP operations (PSEG, 2014b).

## 1.3 Remedial Investigation Requirements

This RI was implemented in accordance with the following requirements and guidance documents:

- New Jersey Administrative Code (N.J.A.C.) 7.26E: Technical Requirements for Site Remediation (NJDEP, 2012b);
- Groundwater Technical Guidance: Site Investigation, Remedial Investigation, Remedial Action Performance Monitoring, Site Remediation Program (NJDEP, 2012a);
- Appendix B of the 1990 NJDEP ACO (NJDEP, 1990); and
- June 26, 2009 JCO (Superior Court of New Jersey, 2009).

Groundwater analytical results are compared to the NJDEP Class II-A Groundwater Quality Standards (GWQS) in accordance with N.J.A.C. 7:9C (NJDEP, 2020c), and groundwater impacts are delineated to the appropriate GWQS. Currently there is no GWQS for $Cr^{+6}$; therefore, $Cr^{+6}$ impacts are evaluated in comparison to the GWQS for Cr of 70 micrograms per liter (µg/L).

## 1.4 Contaminants of Concern

Constituents of concern for the Project Area include $Cr^{+6}$ and CCPW metals. The RI also evaluated additional COCs including VOCs, SVOCs, and non-CCPW TAL metals on or emanating from Site 114 due to PPG's brief ownership of the Site 114 property or due to PSEG's former MGP operations.

## 1.5 Classification Exception Area

A CEA serves as an institutional control and provides notification to the public that COC concentrations remain greater than the GWQS. There are three CEAs either already established or proposed for the Project Area.

### 1.5.1 CEA for Project Area Groundwater

A CEA for the intermediate and deep water-bearing zones for Site 114 was established by the NJDEP on June 11, 2018. The 2018 CEA applies to groundwater contamination related to historical operations at Site 114 in the intermediate and deep water-bearing zones. A proposal to update this CEA is included with this RIR. The updated CEA encompasses an area of approximately 35 acres and extends vertically to a depth of approximately 114 feet (ft) below ground surface (bgs). The updated CEA includes the shallow, intermediate, and deep water-bearing zones, as well as a portion of the bedrock water-bearing zone where Cr-related contamination was observed during the recently completed bedrock investigation activities. The vertical extent of the CEA within bedrock will be updated in the future if additional information becomes available indicating that an update to the CEA is necessary. The following COCs are included in the CEA update:

- CCPW-related COCs:
  - Chromium
  - Hexavalent Chromium
  - Antimony
  - Nickel
  - Thallium
  - Vanadium

- Non-CCPW-related COCs:
  - 1,1,2-Trichloroethane
  - 1,1-Dichloroethylene
  - 1,2-Dichloroethane
  - 1,4-dioxane
  - Aluminum
  - Bis(2-ethylhexyl)phthalate
  - Chloride
  - cis-1,2-Dichloroethene
  - Copper
  - Iron
  - Manganese
  - Pentachlorophenol
  - Sodium
  - Styrene (monomer)
  - Sulfate
  - Tetrachloroethene
  - Trichloroethylene
  - Vinyl Chloride

### 1.5.2 CEA for Historic Fill-related COCs

The distribution of historic fill-related compounds in the Project Area groundwater was evaluated in PPG's Technical Memorandum *GW-072, Constituents of Concern Emanating from Site 114 – Groundwater* ("Emanating from Groundwater Technical Memorandum", included in **Appendix A**), as well as in PSEG's 2014 Groundwater RIR (PSEG, 2014a). These documents identified the constituents in groundwater associated with historic fill. NJDEP has concurred with this assessment. Therefore, a CEA and Well Restriction Area (CEA/WRA) application for historic fill-related impacts to groundwater is included with this revised Draft Groundwater RIR. The following historic fill-related COCs are included in the Historic Fill CEA:

- Beryllium
- Cadmium
- Cobalt
- Mercury
- Selenium
- Silver
- Zinc
- 3+4-Methylphenol

### 1.5.3 CEA for MGP-related Impacts

As stated in Section 1.2, PSEG is responsible for remediating impacts related to the operation of the former MGP on Site 114. Several MGP-related COCs remain in groundwater at concentrations greater than their respective GWQS. The COCs related to the former MGP are summarized in the Emanating from Groundwater Technical Memorandum (**Appendix A**).

On June 6, 2014, PSEG submitted an application for the establishment of a CEA for groundwater contamination relating to the operation of the former MGP on Site 114 (Block 21501, Lots 16, 17, 18 and 19) (PSEG, 2014b), which was approved by the NJDEP on July 25, 2014. The CEA encompasses an area of approximately 76 acres and extends vertically to a depth of 100 ft bgs.

## 1.6 NJDEP Forms

Per N.J.A.C. 7:26E-1.6, the following regulatory forms are included with this submission:

1) Cover/Certification Form;

2) Case Inventory Document (CID);

3) Updated Receptor Evaluation;

4) CEA/WRA for Project Area;

5) CEA/WRA for Historic Fill; and

6) Public Notification Form.

# 2.0 Background Information

## 2.1 Remedial Investigation Sites

A summary of the remedial investigation sites is provided in **Table 2-1**. Details of site locations, description, and historical site information are provided in the following sub-sections.

### 2.1.1 Location, Description, and History – Site 114

Site 114 is vacant land located in a commercial and residential area on Garfield Avenue in Jersey City, Hudson County, New Jersey. Site 114 is described in the ACO as Block 2026.A, Lots 1 and 3A and Block 2026.1, Lots 2A, 3B and 4A (current Block 21501, Lots 16, 17, 18, 19, and 20). Site 114 is bordered to the west by Garfield Avenue, to the south by Carteret Avenue, to the east by Halladay Street, and to the north by Forrest Street and an active railroad (Site 199) operated by New Jersey (NJ) Transit (referred to as NJ Transit Light Rail).

The total area encompassed by Site 114 is 16.6 acres. Site 114 is the former location of a chromite ore processing facility and an MGP. The Morris Canal, a man-made surface water body trending northeast/southwest, formerly bisected the GA Group Sites. The MGP facility operated on the portion of Site 114 located east of the former Morris Canal from about 1886 to the mid-1930s. The western half of Site 114 was the location of the former chromite ore processing facility that operated from about 1911 to 1963. The chromite ore processing operation included a large stockpile of CCPW, primarily consisting of chromite ore processing residue (COPR), extending from the eastern portion of Site 114 southward onto Site 137. The locations of the former processing facility and the CCPW storage pile were identified using historical aerial photographs (**Figure 2-1**), which were provided in the March 2011 Remedial Investigation Work Plan (March 2011 RIWP) (AECOM, 2011).

Following demolition of above-grade structures associated with the chromite ore processing facility and the MGP facility, the remaining foundations were buried, raising the ground surface elevation (El.) by several feet. Three warehouse structures were later constructed on the property during the late 1960s. These warehouses were demolished down to the concrete floor slabs between August and December 2002.

The areas adjacent to and across the surrounding streets from Site 114 are characterized as commercial and light industrial. An office furniture manufacturer/warehouse and an auto repair shop are located west of Site 114 across Garfield Avenue. Residential areas are present further to the west. A former auto body shop/used car dealer (Site 143), a former abandoned warehouse now a vacant lot (Site 132), and former light industrial machinery/box manufacturer/warehouses/packing and recycling (Site 137) are present to the south of Site 114. Other properties further to the south/southeast include three vacant lots formerly occupied by warehouses (Site 133, Site 135, and Al Smith Moving and Storage). East of the Site 114 across Halladay Street, a former bag manufacturer/ warehouse (the former Halsted Corporation) and a former auto/truck repair shop were present. Commercial, light industrial, railroad right-of-way (ROW), and material recycling facilities are located further to the east and southeast. The NJ Transit Light Rail ROW (Site 199) is located along the northern Site 114 boundary. A Light Rail Transit Station is present to the west-northwest of Site 114. Warehouse and light industrial buildings are present toward the northeast and across Forrest Street. Berry Lane Park and several commercial, light-industrial, and residential properties are located to the north beyond the

Light Rail ROW, including a former commercial property that is now a vacant lot (Site 186). The residential areas north and west of Site 114 have been identified as part of the Jersey City Redevelopment Agency (JCRA)-approved Morris Canal Redevelopment Plan (City of Jersey City, Division of City Planning, 2020). Final details of this redevelopment have not been established.

Prior to the completed soil remedial action at Site 114, there were approximately 4.0 acres of paved areas (roadways and parking), including Dakota Street, which bisected Site 114 in an east-west direction starting at Garfield Avenue. Dakota Street was not an active public ROW; it is currently enclosed within the fenced area of Site 114. Prior to soil remedial activities, approximately 1.8 acres of Site 114 consisted of landscaped and open areas surrounding the concrete slabs of the warehouses. The landscaped areas consisted primarily of long and narrow vegetated strips along the edges of the concrete slabs. There was a 4.0-acre area on Site 114 that was capped with stone overlying a polyethylene liner, which was constructed by PPG in 1992 as an Interim Remedial Measure (IRM (i.e., IRM #1).

Beginning in 2005, RI activities were conducted at Site 114 by PPG and PSEG relative to CCPW, CCPW-impacted materials, and MGP-impacted materials. PPG and PSEG developed a coordinated remedial approach in areas where both CCPW and MGP material was present. Separate Remedial Action Work Plans (RAWPs) were prepared by PPG and PSEG to address the CCPW and MGP material, respectively. Based on the findings of the RI, the recommended remedial action (RA) for the CCPW-impacted soils at Site 114 included the excavation and removal of visible CCPW and soils with concentrations of $Cr^{+6}$ greater than the Chromium Soil Cleanup Criteria (CrSCC) of 20 milligrams per kilogram (mg/kg). In the MGP-impacted areas, the recommended RA for the MGP-impacted soil at Site 114 was excavation of oily material/tar material to the underlying meadow mat layer, where it was present, along with engineering controls (clean fill soil cap) and institutional controls (deed notices) for soil remaining in place with contaminants at concentrations greater than unrestricted-use standards/criteria.

On behalf of PPG, AECOM submitted the *Remedial Action Report, Site 114 (AOC 114-1A, AOC 114-2, AOC 114-3, AOC 114-4A, AOC 114-4B, and AOC 114-5) Soil, Final*, August 2019 (Site 114 Soil RAR) (AECOM, 2019j) documenting the remedial action for CCPW, CCPW-impacted soil, and other impacted soil at Site 114. NJDEP approval of the Remedial Action Report (RAR) was issued on December 5, 2019 (NJDEP, 2019k). Deed notices were recorded for the affected blocks and lots on December 18 and 19, 2019. NJDEP issued the soil remedial action permits associated with the referenced Areas of Concern (AOCs) on Block 21501 Lots 18, 19, and 20 on February 7, 2020. NJDEP issued a Consent Judgment Compliance letter, concurring that remedial actions for soil for the referenced AOCs were complete, on June 1, 2020 (NJDEP, 2020b).

Groundwater RI activities were conducted at Site 114 from 2003 through 2007, 2011 and 2012, and 2015 to the present. Groundwater is being addressed as one AOC for the GA Group Sites (including Site 114). As described in Section 1.5, groundwater CEAs for select areas have been proposed by PPG and PSEG and established by NJDEP. In addition, in order to expedite treatment of Cr-impacted groundwater, PPG developed and implemented a phased groundwater IRM approach. The groundwater IRM is ongoing.

Site 114 is currently vacant land owned by JCRA and 900 Garfield Ave, % Ryann LLC (900 Garfield Avenue, LLC). At the present, Site 114 remains completely enclosed by a barrier fence for security purposes.

### 2.1.2 Location and Description of Other Garfield Avenue Group Sites

The remaining five sites that comprise the GA Group include Sites 132, 133, 135, 137, and 143. These Sites are proximate to each other and are located on abutting parcels, collectively bordered to the west by Garfield Avenue, to the south by Caven Point Avenue, to the east by Pacific Avenue, and to the north by Carteret Avenue (**Figure 1-2**).

#### 2.1.2.1 Site 132 – Former Town and Country

Site 132 is located in a commercial and residential area on Garfield Avenue in Jersey City, Hudson County, New Jersey. Site 132 is bordered to the west by Garfield Avenue; to the south by vacant land (816 Garfield Avenue [a.k.a. the Former Fishbein Property]), to the east by Site 137, and to the north by Site 143 and Carteret Avenue. Site 114 is located directly north across Carteret Avenue. The total area encompassed by Site 132 is 3.16 acres. A vacant warehouse, constructed circa 1971, was demolished and the grassy and paved areas were removed in July 2013. The building slab was subsequently removed. The warehouse was previously occupied by Town and Country Linen.

The *Final Remedial Action Report, Site 132 (AOC 132-1) Soil*, May 2019 (Site 132 Soil RAR) (AECOM, 2019d) documents the implementation and completion of the remedial action at Site 132. The remedial action included the excavation and removal of visible CCPW and soils with concentrations of $Cr^{+6}$ greater than the CrSCC of 20 mg/kg. The NJDEP issued an Approval, Consent Judgement Compliance Letter for Site 132 (AOC 132-1) on November 1, 2019 (NJDEP, 2019h), which serves as the functional equivalent of a No Further Action (NFA) letter. The NJDEP issued a Remediation Action Report Determination/Approval of the Site 132 Soil RAR on June 27, 2020 (NJDEP, 2020f).

#### 2.1.2.2 Site 133 – Former Ross Wax

Site 133 is located in a commercial and industrial area on Halladay Street in Jersey City, Hudson County, New Jersey. The western parcel of Site 133 (Site 133W) is bordered to the west and to the south by 800 Garfield Avenue (a.k.a. Ten West Apparel), to the east by Halladay Street, and to the north by Site 137. The eastern parcel of Site 133 (Site 133E) is bordered to the west by Halladay Street, to the south by Caven Point Avenue, to the east by commercial property (Al Smith Moving) and Site 135, and to the north by Carteret Avenue. The total area encompassed by Site 133 is 2.41 acres. Several contiguous warehouses were located on Site 133E, covering an area of approximately 1.7 acres. The warehouses were demolished from September through October 2014. Previous site uses included varnish and paint manufacturing.

The Final Remedial Action Report, Site 133E (AOC 133E-1A and AOC 133E-2A) and Site 135 (AOC 135-1) Soil, August 2019 (Site 133E & 135 Soil RAR) (AECOM, 2019k) documents the implementation and completion of the remedial action at Site 133E and Site 135. The remedial action included the excavation and removal of visible CCPW and soils with concentrations of $Cr^{+6}$ greater than the CrSCC of 20 mg/kg, along with engineering controls (clean fill soil cap) and institutional controls (deed notices) for soil remaining in place with contaminants at concentrations greater than unrestricted-use standards/criteria. The NJDEP issued a Remediation Action Report Determination/Approval of the Site 133 East (AOC 133E-1A and AOC 133E-2A) and Site 135 (AOC 135-1) Soil RAR on October 11, 2019 (NJDEP, 2019e). The NJDEP issued an Approval, Consent Judgement Compliance Letter for Site 133 (AOC 133E-1A) on March 24, 2020 (NJDEP, 2020a), which serves as the functional equivalent of an NFA letter.

#### 2.1.2.3 Site 135 – Former Vitarroz/Narula

Site 135 is located in a commercial and industrial area on Pacific Avenue in Jersey City, Hudson County, New Jersey. Site 135 is bordered to the west by Site 133E, to the south by commercial property (Al Smith Moving), to the east by Pacific Avenue, and to the north by Carteret Avenue. The total area encompassed by Site 135 is approximately 1.5 acres. Several contiguous warehouses were formerly located on the property, covering an area of approximately 1.2 of the 1.5 acres. These structures were demolished in January and February of 2016 prior to the initiation of soil remediation at Site 135. Previous site uses included general grocery warehousing, operations by the Clorox Chemical Co., and other manufacturing operations.

The *Final Remedial Action Report, Site 133E (AOC 133E-1A and AOC 133E-2A) and Site 135 (AOC 135-1) Soil*, August 2019 (Site 133E & 135 Soil RAR) (AECOM, 2019k) documents the implementation and completion of the remedial action at Site 133E and Site 135. The remedial action included the excavation and removal of visible CCPW and soils with concentrations of $Cr^{+6}$ greater than the CrSCC of 20 mg/kg, along with engineering controls (clean fill soil cap) and institutional controls (deed notices) for soil remaining in place with contaminants at concentrations greater than unrestricted-use standards/criteria. The NJDEP issued a Remediation Action Report Determination/Approval of the Site 133 East (AOC 133E-1A and AOC 133E-2A) and Site 135 (AOC 135-1) Soil RAR on October 11, 2019 (NJDEP, 2019e). A Remedial Action Permit (RAP) for Site 135 was issued on November 13, 2020.

#### 2.1.2.4 Site 137 – Former Rudolf Bass & Former TSI City Carriers

Site 137 is located in a commercial and industrial area on Carteret Avenue in Jersey City, Hudson County, New Jersey. Site 137 is bordered to the west by Site 132, 816 Garfield Avenue (a.k.a. the Former Fishbein Property), and 800 Garfield Avenue (a.k.a. Ten West Apparel), to the south by Site 133W, to the east by Halladay Street, and to the north by Carteret Avenue. Site 114 is located immediately north of Carteret Avenue. The total area encompassed by Site 137 is approximately 3.24 acres. Two warehouses and paved areas were formerly located on the property. The larger of these two warehouses located at 45 Halladay Street was owned and operated by Rudolf Bass and was utilized for the storage of used industrial machinery for resale and various businesses including but not limited to woodworking and storage. The smaller warehouse located at 25 Halladay Street was occupied by TSI City Carriers.

Prior to the construction of these warehouses, Site 137 was used to stockpile CCPW generated at the former PPG chromite ore processing facility. The CCPW was stockpiled at Site 137 until about 1958, when the property was cleared and leveled. The 45 Halladay Street building was demolished in March 2014 and the building at 25 Halladay Street was demolished from late August through early September 2013.

The *Final Remedial Action Report, Site 137 North (AOC 137-1A and AOC 137-2A) and Site 143 (AOC 143-1) Soil*, July 2019 (Site 137N & 143 Soil RAR) (AECOM, 2019g) documents the implementation and completion of the remedial action at Site 137 North and Site 143. The remedial action included the excavation and removal of visible CCPW and soils with concentrations of $Cr^{+6}$ greater than the CrSCC of 20 mg/kg. The NJDEP issued a Remediation Action Report Determination/Approval of the Site 137 North (AOC 137-1A and AOC 137-2A) and Site 143 (AOC 143-1) Soil RAR on September 30, 2019 (NJDEP, 2019c). The NJDEP issued an Approval, Consent Judgement Compliance Letter for Site 137 North (AOC 137-1A) on June 26, 2020 (NJDEP, 2020d), which serves as the functional equivalent of an NFA letter.

#### 2.1.2.5 Site 143 – Former F. Talarico Auto

Site 143 is located in a commercial and residential area on Garfield Avenue in Jersey City, Hudson County, New Jersey. Site 143 is bordered to the west by Garfield Avenue, to the south and east by Site 132, and to the north by Carteret Avenue. Residential properties are located west of Garfield Avenue. Site 114 is located immediately north of Carteret Avenue. The total area encompassed by Site 143 is approximately 0.72 acres. A building constructed between 1963 and 1966 and paved areas were present on the property. The property operated as Talarico Auto and was used for auto repair and sales. Previous site uses included vacant land, auto salvage, and residential. The building was demolished in July 2013 and the building slab was subsequently removed in preparation for soil remediation.

The *Final Remedial Action Report, Site 137 North (AOC 137-1A and AOC 137-2A) and Site 143 (AOC 143-1) Soil*, July 2019 (Site 137N & 143 Soil RAR) (AECOM, 2019g) documents the implementation and completion of the remedial action at Site 137 North and Site 143. The remedial action included the excavation and removal of visible CCPW and soils with concentrations of $Cr^{+6}$ greater than the CrSCC of 20 mg/kg. The NJDEP issued a Remediation Action Report Determination/Approval of the Site 137 North (AOC 137-1A and AOC 137-2A) and Site 143 (AOC 143-1) Soil RAR on September 30, 2019 (NJDEP, 2019c). The NJDEP issued an Approval, Consent Judgement Compliance Letter for Site 143 North (AOC 143-1A) on June 26, 2020 (NJDEP, 2020e), which serves as the functional equivalent of an NFA letter.

### 2.1.3 Roadways and Off-Site Properties

#### 2.1.3.1 Roadways

The Roadways that abut the GA Group Sites include Carteret Avenue, Caven Point Avenue and Pacific Avenue, Forrest Street, Garfield Avenue, Halladay Street North, and Halladay Street South (**Figure 1-2**).

**<u>Carteret Avenue</u>**

The Carteret Avenue property is located in Carteret Avenue between Garfield Avenue to northwest and Pacific Avenue to southeast in a commercial and residential area in Jersey City, Hudson County, New Jersey. Carteret Avenue is bordered to the south by Site 143, Site 132, Site 137 North, Site 133 East, Site 135, and Halladay Street South (the portion of Halladay Street located between Carteret Avenue and Caven Point Avenue). Carteret Avenue is bordered to the north by Site 114, Halladay Street North (the portion of Halladay Street located between Forrest Street and Carteret Avenue), and the Former Halsted Corporation property. The total area encompassed by Carteret Avenue Roadway is approximately 1.4 acres. Carteret Avenue Roadway is currently vacant land owned by the City of Jersey City. Prior to remedial activities, the property consisted of a two-lane asphalted roadway underlain by underground water, combined sewer, and gas utility lines.

The *Final Remedial Action Work Plan (Soil) – Carteret Avenue, Addendum to the Final Remedial Action Work Plan (Soil) Rev. 4, Garfield Avenue Group Sites, Jersey City, Hudson County, New Jersey* (Carteret RAWP) (AECOM, 2019f) describes the selected RA for $Cr^{+6}$ and CCPW-impacted soil in Carteret Avenue consisting of the following:

- Excavation of a clean corridor for utility workers to remove CCPW-related or historic fill-related impacts, where technically feasible;

- Excavation, where feasible, to remove soil with concentrations of $Cr^{+6}$ greater than the CrSCC to remove source material; and
- Implementation of engineering controls and institutional controls (notice in lieu of deed notice and implementation of the measures in the Utility Work Coordination Manual, Final [AECOM, 2020a]) with a corresponding RAP.

The excavation elements of the RA have been implemented. The *Final Carteret Avenue Remedial Action Report (RAR) Tables and Figures Submittal* (AECOM, 2020m) was approved by NJDEP on January 29, 2021 (Weston, 2021c). PPG submitted the draft RAR for Carteret Avenue on August 12, 2021 to document the implementation and completion of the RA (AECOM, 2021f). .

**Caven Point Avenue and Pacific Avenue Roadways**

Caven Point Avenue and Pacific Avenue Roadways is located in a commercial and residential area in Jersey City, Hudson County, New Jersey. These active urban roadways border the GA Group Sites located to the north, including (from west to east): Ten West Apparel (800 Garfield Avenue), Halladay Street South, Site 133 East, the Al Smith Moving property, and Site 135. The total area encompassed by the Site is approximately 2.4 acres. Caven Point Avenue and Pacific Avenue are active, two-lane, asphalt, municipal roadways underlain by underground water, combined sewer, and gas utility lines roadways, owned by the City of Jersey City.

The *Remedial Investigation Report/Remedial Action Work Plan (Soil) – Caven Point Avenue and Pacific Avenue Roadways (AOC CPA-1A), Final (Revision 1), Addendum to the Final Revision 1 Supplemental Soil Remedial Investigation Report – Soil and the Final Remedial Action Work Plan (Soil) Rev. 4 for Garfield Avenue Group Sites* (AECOM, 2020h) describes the selected RA for $Cr^{+6}$ and CCPW-impacted soil in Caven Point Avenue and Pacific Avenue Roadways consisting of the following:

- The existing asphalt roadway serves as a soil cap;
- Implementation of institutional controls (notice in lieu of deed notice); and
- Issuance of a RAP.

The *Final Caven Point and Pacific Avenue Roadways Remedial Action Report (RAR) Tables and Figures Submittal* (AECOM, 2020k) was approved by NJDEP on December 18, 2020 (Weston, 2020b). PPG is preparing the draft RAR for Caven Point and Pacific Avenue Roadways, pending the results of preliminary design investigation sampling in Phase 3B South (Ten West Apparel [800 Garfield Avenue], Halladay Street South, Site 133 East).

**Forrest Street Roadway**

Forrest Street Roadway is located in a commercial and residential area in Jersey City, Hudson County, New Jersey. Forrest Street Roadway is bordered to the south and west by Site 114. Forrest Street Roadway is bordered to the north by Forrest Street Properties (FSP). Forrest Street is bordered to the northeast by a Halladay Street residential property. The total area encompassed by Forrest Street Roadway is approximately 0.45 acres. Forrest Street Roadway is an active, two-lane asphalt roadway underlain by underground water, combined sewer, and gas utility lines.

The *Final Remedial Action Report, Forrest Street (AOC FS-1A, AOC FS-1B, AOC FS-1C, AOC FS-2A, AOC FS-2B, and AOC FS-2C) Soil*, September 2019 (AECOM, 2019l) documents the implementation and completion of the remedial action at Forrest Street. The remedial action included the excavation and removal of accessible, visible CCPW and soils containing $Cr^{+6}$ to meet the requirements of the Chromium Policy (NJDEP, 2007) in accordance with the Method to Determine Compliance (NJDEP, 2013), as well as soils containing CCPW metals in accordance with the CRSCC or SRS, based on the current use scenario. Engineering controls and institutional controls (Notice in Lieu of Deed Notice) addressed remaining-in-place constituents. Prior to the future residential use of the adjacent FSP, PPG will conduct a remedial excavation within Forrest Street at AOC FS-1B and AOC FS-1C to address CCPW-impacted soil, which is currently inaccessible due to the current commercial use of the adjacent FSP. NJDEP approval of the RAR was issued on November 12, 2020 (NJDEP, 2020h), acknowledging property owner approval of the Notice in Lieu of Deed Notice and the NJDEP's issuance of a RAP.

**Garfield Avenue Roadway**

Garfield Avenue is located in a commercial and residential area in Jersey City, Hudson County, New Jersey. Garfield Avenue Roadway is bordered to the east by Site 114 and to the west by Frenchpark Warehouse Co., Jersey Auto Repair, and vacant land. The Garfield Avenue Roadway extends from Carteret Avenue to the New Jersey Transit Hudson-Bergen Light Rail. The total area encompassed by Garfield Avenue Roadway is approximately 0.9 acres. Garfield Avenue Roadway is a heavily traveled urban roadway that runs approximately north-south. Concrete sidewalks are present on both the east and west sides of the roadway.

The *Remedial Action Work Plan (Soil) – Garfield Avenue Roadway, Final, Addendum to the Final Remedial Action Work Plan (Soil) Rev. 4* (AECOM, 2019a) describes the selected RA including:

- For the current use of Garfield Avenue: engineering controls and institutional controls (notice in lieu of deed notice and implementation of the measures in the Utility Work Coordination Manual, Final [AECOM, 2020a]).
- For the future Canal Crossing Redevelopment (CCRD): limited excavation of shallow CCPW-related impacts and CCPW source material, where technically feasible, engineering controls and institutional controls ((notice in lieu of deed notice and implementation of the measures in the Utility Work Coordination Manual).

PPG is preparing the draft RAR for Garfield Avenue to document completion of soil remediation activities.

**Halladay Street North**

Halladay Street North is located in a commercial and residential area in Jersey City, Hudson County, New Jersey. The Halladay Street North property is located on Halladay Street between Forrest Street to the northeast and Carteret Avenue to the southwest. Halladay Street North is bordered to the northwest by Site 114 and to the southeast by the Former Halsted Corporation Property (Halsted). The total area encompassed by Halladay Street North is approximately 1.2 acres.

The excavation elements of the RA have been implemented, which included excavation and removal of visible CCPW and soils containing $Cr^{+6}$ to meet the requirements of the Chromium Policy (NJDEP, 2007) in accordance with the Method to Determine Compliance (NJDEP, 2013), as well as soils containing CCPW metals in accordance with the CrSCC or SRS. The *Final Halladay Street North Remedial Action Report (RAR) Tables and Figures Submittal* (AECOM, 2021d) was issued on February 15, 2021; NJDEP approval was received on April 1, 2021 (NJDEP, 2021). PPG submitted the draft RAR for Halladay Street North and a portion of the Former Halsted Corporation Property on July 20, 2021 to document completion of soil remediation activities (AECOM, 2021e).

**Halladay Street South**

Halladay Street South is located in a commercial and residential area in Jersey City, Hudson County, New Jersey. Halladay Street South is located on Halladay Street between Carteret Avenue to the north and Caven Point Avenue to the south. The southernmost portion of Halladay Street South, immediately adjacent to Caven Point Avenue, is considered part of Phase 3B South and will be addressed in a separate submission from Halladay Street South. Halladay Street South is bordered to the west by Site 137A, Site 137B, and Site 133 West, and to the east by Site 133 East. Site 114 is located to the northwest across Carteret Avenue from Halladay Street South. The total area encompassed by Halladay Street South is approximately 0.8 acres.

The *Remedial Action Report Halladay Street South (AOC HSS-1A and AOC HSS-2A) Soil, Final* (AECOM, 2019b) documents the implementation and completion of the remedial action at Halladay Street South. The remedial action included excavation and removal of accessible, visible CCPW and soils containing $Cr^{+6}$ to meet the requirements of the Chromium Policy (NJDEP, 2007) in accordance with the Method to Determine Compliance (NJDEP, 2013), as well as soils containing CCPW metals in accordance with the CrSCC or SRS. Engineering controls and institutional controls (Notice in Lieu of Deed Notice) addressed remaining-in-place naphthalene. NJDEP approval of the RAR was issued on November 15, 2019 (NJDEP, 2019j). On June 30, 2020, NJDEP issued an Approval, Consent Judgement Compliance Letter specifically with respect to AOC HSS-1A (CCPW and CCPW-related metals) (NJDEP, 2020g).

### 2.1.3.2 Off-Site Properties

The Off-Site Properties that abut the GA Group Sites include Al Smith Moving, Halsted Corporation, Fishbein, Forrest Street Properties, and Ten West Apparel (**Figure 1-2**).

**Al Smith Moving & Furniture Company, Inc.**

The Al Smith Moving & Furniture Company, Inc. property (ASM) is located at 33 Pacific Avenue in a commercial and residential area in Jersey City, Hudson County, New Jersey. ASM is bordered to the northwest by Site 133 East, to the northeast by Site 135, to the southeast by Pacific Avenue, and to the southwest by Caven Point Avenue. The total area encompassed by ASM is approximately 0.5 acres. ASM is currently vacant land owned by GND PACIFIC HOLDINGS, LLC. Prior to remediation, the property was almost completely occupied by a commercial warehouse building operated by the Al Smith Moving & Furniture Company, Inc. The building was demolished as part of the RA at the Site in 2017.

The *Remedial Action Report Al Smith Moving & Furniture Company, Inc. (AOC ASM-1) Soil, Final* (AECOM, 2019c) documents the implementation and completion of the remedial action at ASM. The remedial action included excavation and removal of accessible, visible CCPW and soils containing $Cr^{+6}$ to meet the requirements of the Chromium Policy (NJDEP, 2007) in accordance with the Method to Determine Compliance (NJDEP, 2013). NJDEP approval of the RAR was issued on May 28, 2019 (NJDEP, 2019a). On October 11, 2019, NJDEP issued an Approval, Consent Judgement Compliance Letter with respect to AOC ASM-1 (CCPW and CCPW-related metals) (NJDEP, 2019f).

**Halsted**

The Former Halsted Corporation Property (Halsted) is located in a commercial and residential area in Jersey City, Hudson County, New Jersey. The total area encompassed by Halsted is approximately 1 acre. The excavation elements of the RA have been implemented, which included excavation and removal of visible CCPW and soils containing $Cr^{+6}$ to meet the requirements of the Chromium Policy (NJDEP, 2007) in accordance with the Method to Determine Compliance (NJDEP, 2013), as well as soils containing CCPW metals in accordance with the CrSCC or SRS. Engineering controls and institutional controls (Notice in Lieu of Deed Notice), once implemented, will address $Cr^{+6}$ remaining in soil at concentrations greater than the CrSCC in inaccessible soils. The *Final Former Halsted Corporation Property (Halsted) Remedial Action Report (RAR) Tables and Figures Submittal* (AECOM, 2020d) was approved by NJDEP on October 16, 2020 (Weston, 2020a). PPG submitted the draft RAR for Halladay Street North and a portion of the Former Halsted Corporation Property on July 20, 2021 to document completion of soil remediation activities (AECOM, 2021e).

**Former Fishbein Property**

The site identified as the Former Fishbein Property (Fishbein) is located at 816 Garfield Avenue in a commercial and residential area in Jersey City, Hudson County, New Jersey. The former Fishbein property is bordered to the north by Site 132; to the south by Ten West Apparel (800 Garfield Avenue); to the east by Site 137, and to the west by Garfield Avenue. The total area encompassed by Fishbein is approximately 0.26 acres. PPG purchased the property on December 9, 2013; at that time, it was a vacant, partially-paved lot, and is currently in that condition. Historically, the property was used as an automobile scrap yard and a parking area. Remediation of Fishbein is being conducted as part of Phase 3B South. Implementation of RA in Phase 3B South is anticipated to be complete in early 2022. Documentation of the RA at Fishbein will be provided in the RAR submittals for Phase 3B South.

**Forrest Street Properties**

The Forrest Street Properties (FSP) is located in a commercial and residential area in Jersey City, Hudson County, New Jersey. FSP is comprised of the properties located at 84, 86-90, 98-100, and 108 Forrest Street. FSP is bordered to the west by Site 114, to the south by Site 114 and Forrest Street, to the east by the Halladay Street residential properties, and to the north by Site 199 and the NJ Transit Light Rail Line. The total area encompassed by FSP is approximately 1.38 acres. FSP contains vacant, industrial, and/or commercial land owned by 90 Forrest Associates, LLC (Block 21501, Lots 11 and 12), and 100 Forrest Associates, LLC (Block 21501, Lots 14 and 15). Block 21501, Lot 15 is currently vacant land used for access to 100 Forrest Street. Prior to remediation, the Block 21501, Lot 15 property was vacant and undeveloped.

The *Remedial Action Report, Forrest Street Properties (AOC FSP-1A, AOC FSP-1B, AOC FSP-2A, and AOC FSP-2B) Soil, Final* (AECOM, 2019l) documents the implementation and completion of the remedial action at the Block 21501, Lot 15 portion of FSP. The remedial action included excavation and removal of accessible, visible CCPW and soils containing $Cr^{+6}$ to meet the requirements of the Chromium Policy (NJDEP, 2007) in accordance with the Method to Determine Compliance (NJDEP, 2013), as well as soils containing CCPW metals in accordance with the CRSCC or SRS, based on the current use scenario. Engineering controls and institutional controls (Deed Notice) address remaining-in-place constituents. NJDEP approval of the RAR for only AOC FSP-1A and AOC FSP-1B was issued on October 29, 2019 (NJDEP, 2019g). On November 15, 2019, NJDEP issued a Conditional Approval with respect to the RAR for FSP (AOC FSP-1A*, AOC FSP-1B, AOC FSP-2A, and AOC*

*FSP-2B)*, conditioned upon confirmation of property owner consent for the restricted-use remedy and recorded Deed Notice. (NJDEP, 2019i).

**Ten West Apparel (800 Garfield Avenue)**

The Ten West Apparel (800 Garfield Avenue) property is in a commercial and residential area in Jersey City, Hudson County, New Jersey. The property is bordered to the north by the former Fishbein property, to the east by Site 137 and Site 133, to the south by Caven Point Avenue, and to the west by Garfield Avenue. The total area encompassed by the property is approximately 2.1 acres. The property is occupied by a single-story concrete block warehouse building. Historical operations included warehousing and trucking. Remediation of 800 Garfield Avenue is being conducted as part of Phase 3B South. Implementation of RA in Phase 3B South is anticipated to be complete in early 2022. Documentation of the RA at 800 Garfield Avenue will be provided in the RAR submittals for Phase 3B South.

### 2.1.4 Other Properties Associated with the Groundwater Remedial Investigation

Additional properties associated with this groundwater RI include Site 186 and Site 199 (**Figure 1-2**).

#### 2.1.4.1 Site 186

Site 186 is located at the corner of Union Street and Garfield Avenue in a light industrial and commercial area of Jersey City. Site 186 is comprised of Block 19802 Lot 2. Site 186 is bound to the north by Union Street, beyond which are other light industrial properties; to the south by grassy area and paved parking lot associated with the Metropolitan Family Health Network (MFHN) facility, beyond which is the NJ Transit Light Rail; to the east by Garfield Avenue, beyond which is light industrial property and HCC Site 207; and to the west by the MFHN, beyond which is residential-use properties. Site 186 is paved with asphalt and has recently been used as a parking lot for used cars. Historically, Site 186 was occupied by commercial businesses including a company that manufactured greenhouses, a machine shop, a retail store (pattern shop), and a dress making company. By 1961, the property was vacant of structures (AECOM, 2014).

The *Final Soil Remedial Action Report, Non-Residential Chromate Chemical Production Waste Site 186* (AECOM, 2014) documents the implementation and completion of the remedial action at Site 186. The remedial action included the excavation and removal of visible CCPW and soils with concentrations of $Cr^{+6}$ greater than the CrSCC of 20 mg/kg. The NJDEP issued a Remediation Action Report Determination/Approval of the Site 186 Soil RAR on April 16, 2014 (NJDEP, 2014). Groundwater quality at Site 186 has been evaluated and the data are presented in this RI report. No further action is required related to groundwater.

#### 2.1.4.2 Site 199

Site 199 is designated by the NJDEP as an orphan sewer site and is located along the NJ Transit Hudson-Bergen Light Rail (HBLR) tracks between Garfield Avenue and Halladay Street in Jersey City, New Jersey. The Site covers approximately 2.4 acres (approximately 1,040 feet long by 100 feet wide) and is mostly owned by the Jersey City Municipal Utilities Authority (JCMUA), with smaller portions owned by the City of Jersey City and the JCRA. NJ Transit maintains a ROW extending approximately 50 feet on both sides of the light rail tracks, for operation of the light rail system. In accordance with the Consent Judgment between the NJDEP et al. and Honeywell International, Inc. et al., dated September 7, 2011, Honeywell and PPG share responsibility for addressing chromium-related impacts at the Site.

On January 7, 2021, Honeywell submitted to the NJDEP the *Remedial Investigation Report/Remedial Action Work Plan/Remedial Action Report Site 199 – Sludge Line 2* (Honeywell, 2021). This document only addressed the impacted fill materials related to and located along the two 6-inch diameter sludge lines that were installed in the 1950s and abandoned in the 1970s. The remedial action included the implementation of engineering controls (existing pavement caps, existing track ballast cap, and existing soil cap) and institutional controls (deed notices) for the sludge line corridor only. PPG has agreed to address CCPW-related groundwater impacts found away from the sludge lines (proximate to Site 114), as well as soil contamination found within the footprint of the Morris Canal on Site 199. Groundwater conditions at Site 199 are characterized in this RI report.

## 2.2 Previous and Ongoing Groundwater Investigations

This section summarizes groundwater investigation activities that were, or are being, implemented separately from the groundwater RI that will be referenced herein to meet RI objectives.

### 2.2.1 Historical Groundwater Investigations (2003-2007)

Historical groundwater sampling activities were conducted in the Project Area between 2003 and 2007. These investigations were conducted as part of other ongoing investigations and were generally evaluated as independent groundwater investigations. These investigations were not comprehensive, but rather were specific to particular areas within the Project Area. Details of these previously conducted investigations are summarized in the following reports that were submitted to the NJDEP:

- Remedial Investigation Report, PPG Site 114 – Garfield Avenue, Jersey City, New Jersey (ENSR, 2006); and
- Remedial Investigation Report – Non-Residential Chromate Chemical Production Waste Sites – Sites 114, 132, 133, 135, 137 and 143, Jersey City, New Jersey (AECOM, 2009).

### 2.2.2 Groundwater Investigations (2011-2012)

During 2011 and 2012, the following groundwater activities were conducted in the Project Area:

- May 2011: Inspection and gauging of accessible wells within the Project Area;
- June 2011: Comprehensive groundwater sampling within the Project Area;
- November 2011: Synoptic groundwater gauging of accessible wells within the Project Area;
- December 2011: Civil survey of accessible monitoring wells;
- November 2011 through February 2012: Groundwater investigation at the Forrest Street and Forrest Street Properties Sites, including well installation, water level measurements, and groundwater sampling; and
- March 2012: Limited groundwater sampling of wells that were inaccessible during the June 2011 comprehensive sampling event.

### 2.2.3 Groundwater Investigations - Former MGP Operations

Several groundwater RI activities relating to the delineation of MGP-related impacts resulting from PSEG's operations of the former MGP facility on Site 114 were completed and are summarized in the following reports previously submitted to the NJDEP:

- Remedial Investigation Report – Former Halladay Street Gas Works, Jersey City, New Jersey (PSEG, 2007);
- Remedial Investigation Progress Report – Groundwater Monitoring Well Gauging and Sampling, Former Halladay Street Gas Works, Jersey City, New Jersey (PSEG, 2009);
- Remedial Investigation Report – Former Halladay Street Gas Works, Jersey City, New Jersey (PSEG, 2014a) (included in **Appendix A**); and
- Notification of Groundwater Classification Exception Area – PSEG Former Halladay Street Gas Works (PSEG, 2014b).

### 2.2.4 Groundwater Investigations (2015-Present)

From 2015 to the present, the following groundwater-related investigations or evaluations were completed or are ongoing in the Project Area:

- Forrest Street (FS) and Forrest Street Properties (FSP) well installation, groundwater gauging, and groundwater sampling (AECOM, 2019e; AECOM, 2020b; AECOM, 2020g);
- Vertical Aquifer Profiling (VAP) and Hydraulic Profiling Tool (HPT) investigations:
    - Site-wide (AECOM, 2016b),
    - Site 199 (2020) (**Appendix L.1**), and
    - FS/FSP (AECOM, 2019e; AECOM, 2020b; AECOM, 2020g);
- Groundwater investigation in the Halsted Site (78 Halladay Street) (AECOM, 2016b);
- Sampling of Project Area-wide historical monitoring wells (December 2015) (Appendix L);
- Pilot studies, IRMs, and groundwater monitoring to support groundwater remedial action, including the following:
    - Bioprecipitation pilot test (ARCADIS, 2017a);
    - In-situ chemical reduction pilot test (AECOM, 2017d);
    - In-situ fracturing pilot test (AECOM, 2019m);
    - Site-wide FerroBlack®-H Permit-by-Rule (PBR) compliance and capillary break groundwater monitoring (ongoing) (AECOM, 2016b; AECOM, 2016c; AECOM, 2017a; AECOM, 2020e; AECOM, 2020i);
- Site 114 Phase I and Phase II IRM (ongoing) (ARCADIS, 2017; AECOM, 2020f);
- Phase III IRM preliminary design investigation (PDI), including VAP and HPT borings, and installation and sampling of three multi-purpose wells (114-MW67C, 114-MW68C, and 114-MW70C); and
- Evaluation of non-CCPW constituents in groundwater that may have emanated from Site 114 onto adjacent properties (AECOM, 2021b).

Results and findings from these investigations and sampling programs were previously communicated to the NJDEP in various data submittals, technical memoranda, and/or regulatory reports as referenced above.

## 2.3 Remedial Activities

The following sections provide a summary of remedial activities for the Project Area.

### 2.3.1 Soil Remedial Action

The source of chromium impacts to groundwater at the Project Area is chromium-impacted soil. Between 2010 and 2020, PPG completed excavation of chromium-impacted soil from HCC Sites 114, 132, 133 East, 135, 137 North, 143, and 186, from adjacent properties (Al Smith Moving & Furniture Company, Forrest Street Properties, and the former Halsted Corporation property), and adjacent roadways (Carteret Avenue, Halladay Street, and Forrest Street), in accordance with the *Final Remedial Action Work Plan (Soil) Rev. 3, Garfield Avenue Group – Sites 114, 132, 133, 135, 137 and 143, Jersey City, New Jersey* (Final Soil RAWP) (AECOM, 2018a). As of September 30, 2020, a total of 861,729 tons of hazardous waste material, and 195,338 tons of non-hazardous waste material have been removed from these areas (AECOM, 2020j). Excavated material was disposed of at licensed, off-site locations in accordance with applicable regulations. Additional excavation and backfilling activities are planned, or are ongoing, at additional areas, including at Site 133 West, Site 137 South, and certain adjacent properties (Ten West Apparel and the former Fishbein property). In adjacent Garfield Avenue, a restricted-use remedy has been agreed upon by the City of Jersey City, PPG, and NJDEP due to the numerous utilities located in this roadway and traffic issues.

Shoring (sheet pile) was installed by PPG around the perimeter of Site 114 and along some internal portions of Site 114 to facilitate implementation of remedial soil excavations. Sheet pile varied in depth depending on the required depth of excavation and proximity to features that needed to be protected. Details regarding the sheet pile installation are provided in the Site 114 Soil RAR (AECOM, 2019j). Additional sheet pile installation was conducted on Site 114 by PSEG during remedial activities associated with the former Halladay Street Gas Works MGP. Sheet pile was also installed in other areas outside of Site 114 (e.g., on Site 143, 132, 137, and 135 along Carteret Avenue), and along Halladay Street South.

A total of approximately 1,371,000 tons of imported fill material has been placed within the Project Area through September 30, 2020. Clean fill (dense graded aggregate [DGA]) for a portion of these sites was amended with FerroBlack®-H, a chemical reductant. FerroBlack®-H is a water-based suspension of ferrous iron and sulfide designed to prevent the clean backfill from being contaminated by chromium-impacted groundwater and to support groundwater remediation. Dosages of FerroBlack®-H applied to the clean fill ranged from 0.7% by weight (wt.) to 2.8% by wt. Placement of FerroBlack®-H-amended backfill has resulted in substantial improvement in groundwater quality within the shallow water-bearing zone across the Project Area, as is evident from the analytical data collected from shallow zone monitoring wells installed within these remediated areas. A capillary break was installed in select portions of the Project Area to prevent the formation of surficial $Cr^{+6}$ blooms (chromium blooms) due to capillary rise, as detailed in Section 3.7.3.

Soil RARs for Sites 114, 132, 133 East, 135, 137 North, 143, Al Smith Moving & Furniture Company, Forrest Street, Forrest Street Properties, and Halladay Street South have been submitted to the project stakeholders and have been approved, or conditionally approved, by the NJDEP.

### 2.3.2 Groundwater Interim Remedial Measures

To expedite the treatment of groundwater associated with the portion of the GA Group Sites that is impacted with Cr and $Cr^{+6}$, a phased groundwater IRM approach was developed and is currently being implemented.

#### 2.3.2.1 Phase I IRM

The Phase I IRM focused primarily on the intermediate water-bearing zone and the upper portion of the deep water-bearing zone, in areas where source removal in the shallow water-bearing zone was completed and where elevated $Cr^{+6}$ is present in the groundwater. The Phase I IRM also included a small Cr-impacted area in the shallow water-bearing zone.

The Phase I IRM was implemented between July 2017 and March 2020. In this Phase, groundwater was extracted from the areas of highest Cr and $Cr^{+6}$ concentrations in the northern portion of Site 114. The extracted groundwater was treated using the on-site water treatment plant. The Phase I IRM also included a small area in the shallow water-bearing zone on Site 114 where a carbon source was injected to treat elevated Cr and $Cr^{+6}$ concentrations.

The objectives of the Phase I IRM were to achieve the following:

- Meaningful reductions of Cr and $Cr^{+6}$ concentrations in groundwater:
  - In the northern portion of Site 114, reduction of $Cr^{+6}$ and Cr in the intermediate and deep water-bearing zones via groundwater extraction to make the area more suitable for *in situ* anaerobic bioprecipitation (ISAB) in a future IRM phase.
  - In the southern portion of Site 114, creation of an anaerobic reactive zone (via injection of amended water) in the intermediate and deep water-bearing zones to support ISAB reduction of both $Cr^{+6}$ and Cr concentration levels.
  - Achieve the same within a localized area of shallow groundwater in the northern portion of Site 114.
- Documentation of post-treatment trends showing continuing attenuation/reduction of Cr concentrations toward the GWQS.
- Capture of site-specific information on the remedial system operation to support optimization of subsequent IRM phases.

A monitoring program, as described in the *Groundwater Interim Remedial Measure: Phase I Design and Permit-by-Rule Authorization Request* (ARCADIS, 2017b), is being implemented and includes baseline sampling, operational monitoring, treatment monitoring, and post-treatment monitoring. Quarterly technical status reports, which provide a summary of activities performed, data collected, and optimization of treatment steps are prepared and submitted to the NJDEP.

As of March 2020, a total of approximately 14 million gallons of groundwater were extracted, and 9.4 million gallons of injection solution (dilute organic carbon and/or potable water) were injected into the target treatment zones. An estimated 32,327 pounds (lbs) of Cr and 29,544 lbs of $Cr^{+6}$ were removed as a result of Phase I IRM operations (ARCADIS, 2020). As of April 1, 2020, operation of the Phase I IRM system ceased and delivery of organic carbon substrate through the recirculation area is considered complete. Performance monitoring data collected through the fourth quarter of 2020 demonstrate that considerable reductions in the concentrations of Cr and $Cr^{+6}$ have been achieved since initiation of Phase I IRM operations in December 2017 (ARCADIS, 2021).

#### 2.3.2.2 Phase II IRM

As outlined in the Phase II PBR (ARCADIS, 2019), the objectives of the Phase II IRM program are as follows:

- Establish anaerobic reactive zones to support ISAB reduction of $Cr^{+6}$ and total Cr within:
  - The northern portion of Site 114 where Phase I groundwater extraction was used to reduce Cr.
  - The southeastern portion of Site 114.
- Document post-treatment trends showing continuing attenuation/reduction of total Cr toward achieving the Class II-A GWQS.
- Capture site-specific information on the system operation to support subsequent IRM phases.

Baseline sampling of the Phase II well network was completed in March 2020 and full-scale operation of the system began in September 2020. The Phase II IRM includes a combination of groundwater extraction and injection using pulsed organic carbon substrate delivery. An estimated 117,000 gallons to 138,000 gallons of reagent (organic carbon substrate and chemical reductant) and 11,000,000 to 15,000,000 gallons of potable water are planned to be injected into the treatment zones over a 12-month period.

#### 2.3.2.3 Phase III IRM

The third phase of the groundwater IRMs is being planned to treat Cr-contaminated groundwater in the shallow, intermediate, and deep water-bearing zones in areas that are not targeted by the Phase I and Phase II IRMs. A groundwater PDI in select areas to the south and east of Carteret Avenue was completed between September and December 2020 to support planning for the Phase III IRM. A total of 19 temporary groundwater screening points were advanced to perform HPT and VAP to collect data on high and low permeability zones and water quality with respect to concentrations of Cr and $Cr^{+6}$ in groundwater in these areas. In addition, three multi-purpose wells were installed on Site 114 to evaluate groundwater quality in the lower portion of the deep water-bearing zone.

# 3.0 Environmental Setting

## 3.1 Physical Setting

The Project Area is located in an urban area in Jersey City, Hudson County, New Jersey between Garfield Avenue, Caven Point Avenue, Pacific Avenue, and the NJ Transit Light Rail. The Project Area consists of former industrial and commercial properties and businesses located within the Canal Crossing Redevelopment Area, which encompasses 111 acres of planned redevelopment space in the southeastern section of Jersey City, NJ (City of Jersey City, 2020).

## 3.2 Historical Industrial and Regional Development

The Project Area is located in a section of Jersey City that experienced significant industrial development in the early 1900s. Based on soil borings, visual observations, analytical data (AECOM, 2012a), and published information from the New Jersey Geologic Survey (NJGS) (NJGS, 2004), much of the land along the present-day Jersey City shoreline was reclaimed from the Upper New York Bay. In the early 1900s, much of the Jersey City area was identified as viable for development to support the booming industry of this region. A review of historical mapping indicates that the majority of filling activities occurred between the late 1800s and 1947 (AECOM, 2012a). Looking for available land, developers filled the marshlands and estuarine areas to supply properties for development. Research indicates that fill included construction spoils, silts and sands, demolition debris, garbage from New York City, incinerator ash, coal ash, ship ballast, industrial waste, and other miscellaneous materials. The meadow mat was covered and/or removed for building foundations or other improvement projects (ENSR, 2006). The surface water features were buried under compacted surface soils and other impervious surface features that channeled local surface water flow to subsurface storm water drainage systems. Many parcels in this area changed ownership several times over the years and each owner used the land for different industrial purposes.

The NJDEP Technical Requirements for Site Remediation (TRSR) (NJDEP, 2017a) acknowledges that some environmental impacts in urban areas are due to the components of historic fill material. Based upon the boring logs and analytical data collected during the RIs conducted in the Project Area, several of the SVOC compounds and metals detected in soil at concentrations exceeding applicable standards are attributable to historic fill material and not PPG or PSEG site operations. As most of the Project Area was underlain by non-native fill material from the ground surface to the meadow mat prior to implementation of any soil remedial actions, it is expected that some of the non-CCPW-and SVOC-related impacts to groundwater are attributable to historic fill. In addition, the metals As, Pb, and Hg may be related to the former MGP operations but are also found in historic fill material placed throughout Site 114. Prior to soil remediation, additional metals related to the ash, cinders, and miscellaneous materials found in the fill were also identified on Site 114 (AECOM, 2018a).

## 3.3 Topography

The United States Geological Survey (USGS) Jersey City, NJ topographic quadrangle map presents the regional topography for the Project Area. Site 114 has little topographic relief, with ground surface ranging from El. 10 to 16 ft relative to the North American Vertical Datum of 1988 (NAVD88). However, just to the west of Garfield Avenue the topography rises approximately 30 to 40 ft in elevation within several hundred yards of the Project Area, and to approximately El. 100 ft NAVD88 within a half-mile west of the Project Area. The topography east of the Project Area is fairly flat, extending to the Hudson River and Upper New York Bay. In general, the former warehouse foundations at Site 114 were elevated 2 to 5 ft above the surrounding ground surface. The topography of the GA Group Sites south of Carteret Avenue range in elevation from about El. 9 to 15 ft NAVD88. The elevation of the Project Area following soil remediation and partial restoration presently ranges from El. 11 to 15 ft NAVD88.

## 3.4 Former Morris Canal

The former Morris Canal is situated along the western property boundary of Sites 133 and 137, bisects Site 114, and extends northeast and southwest beyond the GA Group Sites (**Figure 3-1**). Historical records indicate that the former canal was up to 40 feet wide and 25 feet deep. The canal was decommissioned in the 1920s and was subsequently backfilled by 1951. Fill used to abandon the former canal consisted of a variety of non-native materials, including CCPW.

## 3.5 Geology

A description the regional and Project Area geology is presented below.

### 3.5.1 Regional Surficial Geology

The regional surficial geology is described in the USGS *Surficial Geologic Map of Northern New Jersey* (Stone, et.al, 2002) and the NJGS *Surficial Geology of the Jersey City Quadrangle* (Stanford, 1995). Based on these sources, regional surficial materials overlying bedrock consist of unconsolidated sediments of Recent and Pleistocene age, including alluvial, estuarine, eolian (windblown), and glacial lacustrine deposits, as well as glacial till of late Wisconsin age. A cross-section illustrating the regional surficial geology for the Project Area is presented in **Figure 3-2**.

Each of the native regional surficial units present in the Project Area is described below (Stanford, 1995):

- **Estuarine and salt-marsh deposits**: Black, dark brown, and dark gray organic silt and clay, and salt-marsh peat, with some sand; contains shells; up to 40 ft thick, but generally less than 20 ft thick.
- **Lake bottom deposits**: Gray to reddish brown silt, clay, and fine sand; thinly layered to varved; well-sorted and stratified; up to 150 ft thick.
- **Rahway Till**: Reddish-brown to reddish-yellow silty sand to sandy silt, containing some to many subrounded and subangular pebbles and cobbles and few subrounded boulders; poorly sorted, non-stratified, generally compact below the soil zone; up to 50 ft thick.

The Rahway Till is further described as a glacial sediment deposited directly from glacial ice and consisting of two facies that are distinguished texturally and structurally (Stone, et.al, 2002). The lower facies consists of a compact, dense, massive basal till of lodgement and basal-meltout origin containing few lenses of sorted silt and fine sand. The upper facies consists of a noncompact ablation till of meltout origin, containing sand, gravel, boulders, and minor beds of sorted and stratified sand, silt, and clay. The Rahway Till forms a nearly continuous blanket on the bedrock surface, except on the steep eastern slope of the Palisades Ridge (Stanford, 1995).

Artificial fill, consisting of sand, gravel, silt, clay, and rock, as well as construction spoils, demolition debris, garbage from New York City, incinerator ash, coal ash, ship ballast, industrial waste, and other miscellaneous materials overlie the native unconsolidated materials in areas where fill was used to reclaim the shoreline from the Upper New York Bay or to fill marshlands and estuarine areas.

### 3.5.2 Regional Bedrock Geology

Jersey City is located within the upper portion of the drainage basin for Newark Bay and lies within a glaciated section of the Triassic/Jurassic Basin. The bedrock is principally composed of Upper Triassic to Lower Jurassic age sedimentary rocks, known collectively as the Newark Supergroup (Drake, Jr. et al., 1997), and was formed from sediments deposited into a northeast-southwest trending structural basin known as the Newark Basin. In New Jersey, the sedimentary rocks of the Newark Supergroup are composed of reddish-brown arkosic sandstone, mudstone, siltstone, conglomerate, and dark gray argillite (Volkert, 2016). The Newark Supergroup has been divided into three formations on the basis of lithology, including a lower unit identified as the Stockton Formation, a middle unit identified as the Lockatong Formation, and an upper unit identified as the Passaic Formation. These sedimentary units have been intruded by igneous rock, principally diabase, in the form of sills and dikes, with the intrusions now generally forming ridges such as the Palisades and the Heights in Jersey City. More detailed descriptions of each of these bedrock units are provided in USGS Open File Map OFM-110 (Volkert, 2016).

Regional geologic mapping (Volkert, 2016) indicates that the Project Area is underlain by the Stockton Formation, the Lockatong Formation, and Diabase (**Figure 3-3**). A cross-section illustrating the shape of the regional bedrock surface in the Project Area is presented in **Figure 3-2**. West of the Project Area, bedrock surface rises abruptly creating a topographic high. A bedrock low occurs just east of Garfield Avenue. Further to the East, the bedrock surface rises gently to a large plateau that extends to the shoreline of New York Bay. The bedrock surface slopes downward again east of Ellis Island. In general, the bedrock surface slopes from west to east across the Project Area and is relatively shallow west of Garfield Avenue but fairly deep beneath Site 114.

Regionally, the beds of the Newark Supergroup in the Hackensack River basin generally strike to the northeast and dip at approximately 16 degrees to the west-northwest. A prominent set of vertical joints strikes north 45 degrees east, approximately parallel to the strike of the beds. A secondary set of nearly vertical joints strikes north 75 degrees west, subparallel to the dip of the bedding. Faults, where present, typically strike northeastward and are parallel to, or intersect, the strike of the beds at low angles.

Each of the regional bedrock units present in the Project Area is described below (Volkert, 2016):

- **Diabase**: Dark-greenish-gray to black, fine-grained, massive, hard diabase; composed mainly of calcic plagioclase, clinopyroxene and opaque oxide minerals; contacts are aphanitic and display chilled, sharp margins with enclosing sedimentary rocks.
- **Lockatong Formation**: Cyclically deposited sequences consisting of gray to greenish-gray and reddish-brown siltstone, silty argillite, dark-gray to black shale and mudstone, and white to buff arkosic sandstone; up to 10 ft of unit may be thermally metamorphosed along contact with diabase.
- **Stockton Formation**: Interbedded sequences of gray, grayish-brown, or slightly reddish-brown, medium to fine grained, thin to thick-bedded, poorly sorted to clast imbricated conglomerate, planar to trough cross-bedded, and ripple cross-laminated arkosic sandstone, and reddish-brown clayey fine-grained, sandstone, siltstone and mudstone.

### 3.5.3 Project Area Surficial Geology

The Project Area is located on miscellaneous fill material that was used to reclaim the salt marsh for construction of this portion of Jersey City. Native materials beneath the fill include an organic meadow mat layer and unconsolidated deposits of glacial origin. Unconsolidated native surficial deposits pinch out against the rising bedrock surface west of the Project Area, in the vicinity of Garfield Avenue where outcrops of the Diabase are mapped (Volkert, 2016).

The primary surficial geologic units within the Project Area, from top to bottom, include:

- Fill (**the shallow zone**), consisting of:
    - Non-native fill materials in areas where soil remediation is not needed or has not yet been implemented, and
    - Clean fill (unamended or amended with the FerroBlack®-H reductant) where the previously existing non-native fill materials and subsurface structures were excavated to remove sources of Cr.
- Underlying the fill, a discontinuous layer of estuarine organic-rich deposits (meadow mat);
- Underlying the meadow mat, or directly below the fill where the meadow mat is absent, native soils consisting of sands, silty sands, silts, and clays (**the intermediate zone**) generally separated from the underlying deep zone by a layer of interbedded lower permeability silts, clayey silts, silty sands, and clays (**the transition zone, part of the intermediate zone**); and
- Underlying the intermediate zone, sands with lenses of silt, clay, and gravel underlain by the basal facies of the Rahway Till (**the deep zone, includes the basal till and overlying sands**).

Fill within the Project Area includes miscellaneous debris, cinders and ash, and CCPW and/or CCPW-impacted materials. Extensive excavation of the impacted fill has been implemented from 2010 through the present and is ongoing. In areas where impacted fill has been removed, clean fill material, either un-amended or amended with FerroBlack®-H, was placed to grade within the excavated areas.

Estuarine organic-rich deposits (meadow mat) were identified at a number of boring locations underlying the fill. Observations indicate that the meadow mat is not continuous across the Project Area, particularly along the former Morris Canal. Within the limits of the former canal, meadow mat was notably absent from northern and north-central portions of Site 114. In addition, in the southern and central portions of Site 114, it is possible that the meadow mat was removed during construction of the former canal. Depths to the meadow mat range from approximately 10 to 25 ft bgs. Shallow soils (predominantly fill) within the Project Area extend from the ground surface to the top of the meadow mat, where the meadow mat is present, or to a similar depth where meadow mat is not present. In areas where the meadow mat is absent due to natural conditions (not excavated), undisturbed native materials (Und) consisting of organic silts and clays indicative of a marshland depositional environment are present. The northeastern portion of the Project Area (in the Forrest Street area) was historically a topographic high and not part of the salt marsh; therefore, the meadow mat is absent in this area. **Figure 3-1** illustrates the approximate extent of the meadow mat across the Project Area based on current information. Below the meadow mat, soils are unconsolidated and characterized by sands, silts, clays, and gravel typical of the Project Area geologic and depositional environment.

Soils of the intermediate zone are found below the meadow mat where the meadow mat is present, or at about the expected depth of the meadow mat where the meadow mat is absent. These soils range from sandy silts, silty sands, silts, clays, and fine to coarse sand with lenses of gravel. Over most of the Project Area, the thickness of the intermediate zone ranges from approximately 20 to 40 ft, extending from the bottom of the meadow mat to approximately 55 ft bgs. In the southeastern portion of Site 114, the depth and thickness of the intermediate water-bearing zone increases with the drop in bedrock surface elevation (**Figure 3-4**). In the vicinity of 114-MW60C, the intermediate water-bearing zone extends to approximately 80 ft bgs and is up to 60 ft thick. This deeper and thicker segment of the intermediate water-bearing zone extends southeast from Site 114 onto Site 135.

The intermediate and deep zones are separated by a transition zone of low-permeability soils that are laterally extensive and encountered at depths ranging from 30 to 55 ft bgs. The transition zone is typified by sequences of laminated silts and clays with occasional stringers of sand and is variable in thickness across the Project Area.

Deep soils underlying the transition zone range in thickness from approximately 15 to 50 ft, extending from the bottom of the transition zone to a depth of 120 ft bgs at 114-MW60C and consist of silts, clays, sandy silts, silty sands, fine to coarse sands, gravel, and basal till. South of Carteret Avenue, deep zone soils transition to thicker sequences of massive silts and clays overlying the basal till. The bottom of the deep zone is typified by a layer of basal till atop bedrock. Consistent with the regional description for the Rahway Till, the basal till at the Project Area consists of silty clays, sandy silts, and silty sands with subrounded to subangular fine to coarse gravel and cobbles and occasional interbedded lenses of clay, silt, or fine sand. The thickness of the basal till (the compact, dense, massive facies of the Rahway Till) encountered within soil borings advanced at the Project Area ranges from 1 ft (114-MW55C) to 30 ft (114-MW66D), with the basal till continuous across the Project Area.

### 3.5.4 Project Area Bedrock Geology

Bedrock in the Project Area has been characterized by soil borings advanced using various drilling techniques, including sonic, mud rotary, air rotary, and water rotary. **Table 3-1** presents a summary of the borings in which bedrock was encountered and includes the inferred top of bedrock elevation and a determination of the bedrock type for each boring. Based on this information, **Figure 3-4** presents the inferred top of bedrock surface and spatial distribution of bedrock types within the Project Area. Development of the top of bedrock surface also took into consideration refusal depths of HPT probes advanced during implementation of the Phase II IRM drilling program and the Phase III IRM PDI. Although not indicative of bedrock elevation, HPT probe refusal depths provide a minimum depth to bedrock which can be used to refine the shape of the interpolated bedrock surface.

The bedrock surface in the Project Area was shaped by various factors, including weathering, erosion, and glacial activity. Weathered bedrock was observed above competent bedrock in the borings for 114-BSB-02, 114-MW49C, 114-MW52C, 114-MW52D, 114-MW53C, 114-MW55C, 114-MW57C, 114-MW58C, 114-MW60C, 114-MW61C, 114-MW61D, 114-MW62C, 114-MW64C, 114-MW66D, 114-MW67C, and 114-MW68C. For sedimentary formations, the thickness of the observed weathered bedrock ranged from 1 to 5.5 ft. For borings where diabase was encountered, the thickness of the observed weathered bedrock ranged from 1.5 to 11 ft, except at 114-MW61D where 46 ft of weathered diabase was observed and appeared to be near the contact between the Lockatong Formation and the Palisade Sill. Weathered bedrock forms via physical and chemical processes, which alter the structure of the rock, leaving residual materials derived from the original bedrock matrix. The permeability of the residual materials comprising the weathered rock depends on various factors, including the mineral composition of the parent rock, the type of weathering, and the duration of weathering processes. At several of the borings where weathered bedrock was encountered, the weathered rock was typified by highly fractured rock with varying degrees of clay content in the fractures (e.g., 114-MW52D, 114-MW55C, 114-MW60C, 114-MW62C, 114-MW64C, 114-MW66D).

Depth to bedrock ranges from 6 ft bgs in the northwestern portion of the Project Area (114-MW15A) to 119.5 ft bgs in the southeastern portion of Site 114 (114-MW60C). Within the Project Area, the bedrock surface is characterized by two bedrock valleys (or channels) defined by low points at 114-MW4D, 114-MW66D, and 114-MW67C, as well as at 114-MW60C and 114-MW19C. A bedrock high is evident in the central portion of Site 114, defined by shallower depths to bedrock at 114-MW53C, 114-MW65C, GT-9C, and GT-10A. The bedrock surface rises to the north, east, and west of these features, resulting in a northwest-southeast trending trough with its highest elevations in the northwestern portion of the Project Area and its lowest elevations in the southeastern portion of the Project Area.

Borehole geophysical logging was conducted in the open bedrock portions of the boreholes for wells 114-MW4D and 114-MW6D on September 22, 2020 and at wells 114-MW52D, 114-MW57D, 114-MW61D, and 114-MW66D from January 14 to 15, 2021. Borehole geophysical logging was conducted by Hager-Richter Geoscience, an AECOM subcontractor. A technical memorandum presenting the results and findings of the borehole geophysical logging and the borehole geophysics reports are included in **Appendix B**. Key findings from the borehole geophysics include:

- Wells 114-MW6D, 114-MW52D, 114-MW57D, and 114-MW66D were installed in the sedimentary unit identified as the Lockatong Formation at the Project Area. In general, the bedding and primary fracture features have shallow dipping angles on the order of 10 to 20 degrees toward the northwest. A secondary set of fractures dip more steeply (60 to 80 degrees) to the southeast. Bedding dip azimuth is 299 degrees northwest. The majority of flow observed in these wells was observed within the top 10 ft of the borehole, but some minor fractures with very low flow were identified at greater depths based on smaller perturbations in the logs as described for each well.
- Wells 114-MW4D and 114-MW61D were installed in the Jurassic Diabase unit. Regional bedrock geology maps identify this unit west of the Project Area, but based on drill logs and borehole geophysical logging, the boundary of this unit is farther east than indicated on the NJGS maps. The Jurassic Diabase is highly fractured without coherent structure, and fracture dip angles tend to be steeper than the sedimentary unit with the majority of fractures dipping in an easterly direction. Active fractures were identified in shallow portions of the logged hole where minor flow was present. The diabase is highly fractured and weak rock in the wells that were logged.

## 3.6 Hydrology

### 3.6.1 Surface Water

The only surface water in the vicinity of the Project Area is the Upper New York Bay, which is located approximately 3,800 ft to the southeast. Surface water from precipitation infiltrates into Project Area fill materials, including native fill and the DGA, which was put in place during soil remediation activities. Excess surface water runoff is directed into storm sewers, which discharge to the city-owned sewers beneath and along the nearby roadways. In some locations of Jersey City, the storm sewer lines are tied into the sanitary sewer system (combined sewer system).

### 3.6.2 Wetlands

There are no mapped wetlands on or adjacent to the Project Area.

## 3.7 Hydrogeology

### 3.7.1 Regional Groundwater Flow

Groundwater occurs regionally in the following geologic formations: the fill, the unconsolidated overburden soils/meadow mat, and the bedrock. A summary of groundwater flow in these formations is provided below:

- **Fill**: Groundwater in the fill is unconfined and is typically encountered within 10 ft bgs. In general, the shallow zone groundwater flow patterns represent a subdued version of land surface topography. Variations in these flow patterns can be attributed to heterogeneities in the fill. For instance, tightly compacted dredged sediments would be expected to restrict water flow much more than construction debris. Subsurface infrastructure features (e.g., basements, drains, sewers, sheet pile, etc.) also affect shallow groundwater flow patterns. Groundwater elevations in the shallow fill are also influenced by recharge events.
- **Native Unconsolidated Overburden and Meadow Mat**: Groundwater flow in overburden materials is controlled by permeability or flow through the connected pore spaces in the soil matrix. In this zone, groundwater is mostly unconfined, but may be semi-confined to confined in areas with complex stratigraphy consisting of alternating layers of less and more permeable materials. Groundwater generally flows horizontally in these soils but may be influenced by local recharge and discharge zones. The meadow mat is a dense matrix of organic material and fine-grained soils, and this layer generally exhibits permeability that is three or more orders-of-magnitude less than surrounding materials.
- **Bedrock**: Groundwater within bedrock is stored and transmitted along fractures, bedding planes, and interconnected cracks or voids in the rock. In general, although highly fractured, the diabase has low permeability and is understood to be a no-flow boundary. For sedimentary formations (Lockatong and Stockton), groundwater flow occurs primarily along bedding plane fractures with the prevailing direction parallel to bedding strike, with secondary flow along steeply dipping fractures (joints) which are pathways for leakage between bedding fractures; the vertical extent of such leakage between bedding plane fractures is commonly inhibited by the termination of the majority of the joints at bedding plane boundaries. Regionally, bedrock well yields have been reported to range from several gallons to several hundred gallons per minute, with yields generally decreasing with depth.

### 3.7.2 Project Area Groundwater

#### 3.7.2.1 Hydrostratigraphic Units

Similar to the regional hydrogeology, groundwater in the Project Area occurs within distinct hydrostratigraphic units, as follows:

- **Shallow Water-Bearing Zone**: consists of fill material; includes groundwater present in the fill from the water table to the top of the meadow mat. Where the fill has been excavated during soil remedial action, the backfill is a more uniform DGA material or DGA amended with FerroBlack®-H. In the northeastern corner of Site 114, beyond Forrest Street, a native sandy unit underlies the fill above the intermediate water-bearing zone deposits.
- **Intermediate Water-Bearing Zone**: consists of sandy silts, silty sands, silts, clays, and fine to coarse sand with lenses of gravel extending from the bottom of the meadow mat down to a silt and clay unit of lower hydraulic conductivity; includes groundwater present in the meadow mat, the underlying sand unit, and the underlying silt and clay unit. Where present, the

meadow mat is the transition zone between the shallow and intermediate water-bearing zones and generally limits vertical groundwater movement between these zones. Where meadow mat is absent, the shallow and intermediate water-bearing zones are in direct contact. The silt and clay unit is the transition zone between the intermediate and the deep water-bearing zones and, where present, behaves like an aquitard due to its lower permeability. The intermediate water-bearing zone pinches out against the rising bedrock surface west of the Project Area (beyond Garfield Avenue).

- **Deep Water-Bearing Zone**: north of Carteret Avenue, the deep zone consists primarily of sand and gravel with lenses of clay or silt underlain by basal till, extending from the bottom of the overlying silt and clay unit to bedrock; includes groundwater present in the sand and gravel unit and the basal till. South of Carteret Avenue, the deep zone becomes more heterogeneous, consisting of sand and gravel with lenses of clay or silt (like north of Carteret Avenue) as well as thicker sequences of lower permeability materials such as silts, clays, and fine sands with silt and clay. Based on information published by the NJGS and Project Area data, the basal till is present on top of bedrock throughout the Project Area. The deep water-bearing zone pinches out against the rising bedrock surface on the western margin of the Project Area (near Garfield Avenue).
- **Bedrock Water-Bearing Zone**: consists primarily of the Lockatong Formation, with the Palisades Sill (diabase) along the western edge of the Project Area and a section of the Stockton Formation in the eastern portion of Site 114; includes groundwater within bedrock fractures, bedding planes, cracks, and voids. Flow within weathered bedrock immediately below overburden materials is similar to porous media flow due to the high degree of interconnectivity between the weathered bedrock elements, except in areas where the weathered rock has higher clay content within fractures which reduces the permeability of the weathered horizon. Flow in competent rock occurs only within interconnected fractures, bedding planes, cracks, or voids in the rock, and not within the rock matrix itself. Based on borehole geophysical logging measurements and observations during bedrock well development and sampling, yields from bedrock wells in the Project Area are low. Overall, groundwater flow in bedrock is a small fraction of the total groundwater flux through the Project Area.

#### 3.7.2.2 Groundwater Flow and Hydraulic Gradients

To characterize groundwater flow conditions across the Project Area, water level measurements were collected using a Solinst® 101 electronic water level meter:

- **In 2018**: A total of 133 monitoring wells located throughout the Project Area and in adjacent areas (i.e., roadways and private properties) were gauged during a synoptic water level monitoring event conducted within a 24-hour period on May 29, 2018. An additional five monitoring wells (114-MW41A, 114-MW41B, 114-MW7D, 132-P3A-MW5, and 133-MW1C) were gauged on June 1, 2018, due to access issues (could not be readily located or opened). Four monitoring wells situated within the Forrest Street Properties (114-MW37A, 114-MW37B, 114 MW38A, and 114-MW38B) were inaccessible during the initial mobilization and were gauged on June 11, 2018. Water level gauging data are presented on **Table 3-2**. The 2018 synoptic groundwater elevation dataset was also used to calculate vertical hydraulic gradients for nested monitoring well clusters across the Project Area (**Table 3-3**).
- **In 2020**: A synoptic round of groundwater elevation data was collected from the 19 basal till/weathered bedrock wells and four bedrock wells (114-MW4D, 114-MW6D, 114-MW7D,

114-MW16B) on August 21, 2020, providing information regarding vertical hydraulic gradients between the basal till and the underlying bedrock (**Table 3-4**).

- **In 2021**: A synoptic round of groundwater elevation data was collected from wells 114-MW45C, 114-MW6D, 114-MW52C, 114-MW52D, 114-MW61C, 114-MW61D, 114-MW57C, 114-MW57D, 114-MW54C, and 114-MW7D on February 8, 2021 to provide information regarding vertical hydraulic gradients between the basal till, weathered bedrock, and bedrock (**Table 3-4**).

Depth to groundwater data were compiled and groundwater elevations were calculated from these measurements using the most current monitoring well reference elevations. The depth to groundwater measurements and the water level elevations were then added to the existing database of historical groundwater gauging data for the Project Area. A summary of historical groundwater elevations collected across the Project Area from 2003 to 2020 is provided in **Appendix C**.

From June 2016 to June 2017, information regarding vertical hydraulic gradients across the Project Area was collected at select well clusters completed in the shallow and intermediate water-bearing zones during implementation of a water level monitoring program using downhole pressure transducers and data loggers. A statistical summary of the pressure transducer data is presented in **Appendix D**.

Groundwater elevation contour maps were developed using the 2018 synoptic water level gauging data for the shallow water-bearing zone (**Figure 3-5**), the intermediate water-bearing zone (**Figure 3-6**), and the deep water-bearing zone (**Figure 3-7**) to characterize horizontal groundwater flow conditions across the Project Area. Groundwater elevation contours were developed by interpolating a raster surface from the groundwater elevation point data using the natural neighbor technique, and subsequently adjusting the resulting contours using professional judgement and Project Area knowledge. A groundwater elevation contour map was not developed for the bedrock water-bearing zone due to the limited number of monitoring wells installed in this zone.

The 2018 synoptic groundwater elevation dataset was also used to calculate vertical hydraulic gradients for nested monitoring well clusters (**Table 3-3**) to ascertain the direction of vertical groundwater flow between the shallow, intermediate, deep, and bedrock water-bearing zones. Evident vertical groundwater flow directions based on these data are depicted on **Figure 3-8**, **Figure 3-9**, and **Figure 3-10**. The directions of vertical groundwater flow depicted on these figures are representative of hydraulic conditions prevailing at the time of the 2018 synoptic gauging event.

Evaluation of groundwater elevation data indicate the following regarding groundwater levels, horizontal groundwater flow, and vertical hydraulic gradients across the Project Area:

- Shallow groundwater flow across the Project Area is complex and is affected by various on- and off-site activities and features, including excavations, placement of clean and/or amended fill, sheet pile, subsurface utilities, implementation of groundwater IRMs , the sumps at the Forrest Street Properties, other subsurface infrastructure, and localized variability in recharge. Groundwater flow patterns within the shallow water-bearing zone are highly variable and no single dominant horizontal groundwater flow direction is discernible. Localized groundwater mounding within the areas enclosed by sheet pile is evident on Site 114. Vertical groundwater flow directions within the shallow water-bearing zone are dominated by downward hydraulic gradients across most of the Project Area.

- Intermediate groundwater flow across the Project Area is affected by regional recharge, activities in the overlying shallow water-bearing zone, sheet pile, subsurface utilities, implementation of groundwater IRMs, and the sumps at the Forrest Street Properties. Horizontal groundwater flow within the intermediate water-bearing zone occurs primarily from northwest to southeast. Downward vertical hydraulic gradients provide groundwater influx to the intermediate zone from the overlying shallow water-bearing zone and groundwater outflow from the intermediate zone into the underlying deep zone. Groundwater flow into the intermediate water-bearing zone may also occur along upward vertical hydraulic gradients from the underlying deep water-bearing zone, thereby recharging the intermediate zone. Where present, utility corridors may serve as a preferential pathway for groundwater flow (e.g., sewer in Carteret Avenue).

- Horizontal groundwater flow within the deep water-bearing zone occurs generally from northwest to southeast. Vertical groundwater flow directions in the deep water-bearing zone are dominated by upward hydraulic gradients into the overlying intermediate water-bearing zone. Groundwater flow in the deeper portions of the deep water-bearing zone is influenced by the shape of the underlying bedrock surface, with a bedrock high in the middle of Site 114 disrupting flow and creating two migration pathways in the deepest portion of the overburden: one from northwest to southeast around the bedrock high to the west and one from northwest to southeast around the bedrock high to the east. Groundwater flow at the basal till/bedrock interface occurs horizontally along this interface with upward vertical hydraulic gradients dominant from the underlying bedrock, except in the southwestern corner of Site 114 where downward gradients from the basal till/weathered bedrock into the bedrock were observed (i.e., at wells 114-MW61C/61D and 114-MW57C/57D).

- Water levels in shallow and intermediate water-bearing zone monitoring wells respond to precipitation events.

- Seasonal variability in vertical hydraulic gradient directions is evident within the shallow and intermediate water-bearing zones at certain locations, as indicated by occasional reversals in the direction of vertical hydraulic gradients.

#### 3.7.2.3 Hydraulic Conductivity

Aquifer testing was performed via slug tests and specific capacity tests across the Project Area to derive estimated values of hydraulic conductivity for the shallow, intermediate, deep, and bedrock (diabase) water-bearing zones. Estimated hydraulic conductivity values for each water-bearing zone are presented in **Table 3-5** and on **Figure 3-11** and are summarized below.

| Water-bearing Zone | Material | Range of Estimated Hydraulic Conductivity (feet/day) |
|---|---|---|
| Shallow | Historic Fill | 1.68 - 152.55 |
| Shallow | DGA Fill | 1.24 - 181.35 |
| Intermediate | Native Soils | 0.14 - 43.65 |
| Deep | Native Soils | 0.01 - 8.16 |
| Bedrock | Diabase | 0.06 |

VAP was conducted from May 6 to June 17, 2015, at 18 locations across the Project Area, including Site 114, Site 135, Site 137, Forrest Street, Carteret Avenue, and Halladay Street (AECOM, 2016b). Key findings of this investigation relative to the permeability of subsurface materials are as follows:

- Permeability measurements at the following locations confirm that the meadow mat is characterized by low permeability: 114-VAP-7, -10, -12, -13, -14, -15, -16, and -17; P4-VAP-1, -2, and -11; and 133-P3B-VAP-4.
- Low permeability lenses were identified within the intermediate water-bearing zone at locations: 114-VAP-5, -6, -7, -8, -9, -14, -16, and -17; and 133-P3B-VAP-4.
- Lower permeability values were identified in the transition zone between the intermediate and the deep water-bearing zones at locations 114-VAP-5, -6, -7, -9, -10, -12, and -16.

In 2019 and 2020, 2,824 vertical ft of HPT was conducted at 54 different locations during implementation of the Phase II IRM drilling program and the Phase III IRM PDI to obtain high-resolution hydraulic conductivity data within the Project Area and to assess variation in hydraulic conductivity through the vertical extent of each boring. The relative hydraulic conductivities from the collective data set for these HPT programs were evaluated. Evaluation of these findings indicate that approximately 73% of the intermediate and the deep water-bearing zone soils (not inclusive of the basal till) are permeable and 27% of these soils are characterized by low permeability. A more detailed discussion of this evaluation is presented in **Appendix E**.

In 2020, jar shake tests were performed in the field during implementation of the basal till/weathered bedrock well drilling program to estimate the percentage of fines (silts and clays) in select soil intervals. The jar shake tests were conducted in accordance with Section X4.1 of ASTM D2488-09a, *Suggested Procedures for Estimating the Percentages of Gravel, Sand, and Fines in a Soil Sample* (ASTM, 2009). Depth intervals selected for the field test targeted significant changes in soil types within the intermediate and deep water bearing zones based on visual observations of logged soils. Results of the jar shake tests are presented on the soil boring logs for wells 114-MW48C through 114-MW65C (**Appendix F**) and on **Table 3-6**. **Table 3-6** also includes estimated hydraulic conductivity ranges for each soil type from which a jar shake test sample was collected, based on the Unified Soil Classification System (USCS) code assigned to the sample interval and Table B-2 from *Materials Testing Field Manual 5-472 NAVFAC MO 330 AFJMAN 32-1221(I)* (Department of the Army, 2001). Based on these data, well- to poorly-graded sands are characterized by high permeability, and silts and clays are characterized by low permeability. Wide ranges of permeability were assigned to soils within the transition zone where varved sands, silts, and clays were observed. The basal till consisted of a wide range of materials typically exhibiting low permeability and low water content (damp to dry) but included discontinuous stringers or lenses of more permeable sands. The observed thickness of sand stringers or lenses within the basal till ranged from 0.2 to 6.5 ft. Of the approximately 390 ft of basal till logged within the Project Area, only 21 ft consisted of sand stringers or lenses, which equates to less than 6% of the basal till (**Appendix G**).

### 3.7.3 Capillary Rise and Capillary Break

Capillary action, or capillary rise, is the ability of a liquid to flow upward in narrow spaces due to the intermolecular forces between the liquid and the surrounding solid surfaces. Theoretically, continuous void spaces in soil can behave as bundles of capillary tubes with variable cross-sections. However, the comparison of soil to a bundle of capillary tubes is a simplified concept to help visualize capillarity in porous media. Unlike a bundle of capillary tubes, soil pores are often discontinuous and variable in size, resulting in a variable distribution of groundwater saturation in soils above the groundwater table (vadose zone soils).

The capillary fringe is the zone above the groundwater table where soil pores can be saturated, or nearly saturated, and hold water in tension. Due to these aqueous connections, soils within the capillary fringe may be hydraulically conductive. The hydraulic connections also allow for chemical conductance and the potential transport of dissolved ions within the capillary fringe. Above the capillary fringe, water-filled pores transition to mixtures of localized capillary water and water that coats particle surfaces in thin films, and upon further drying they transition to water that is held only in thin films. Eventually, soils dry completely and capillary rise ceases.

During 2015 and 2016, a capillary rise study was performed to support the design and use of a capillary break at the Project Area (AECOM, 2017e) to prevent potentially-impacted groundwater from reaching the surface through capillary action. The capillary rise evaluation included field study components and laboratory bench-scale tests and evaluated aspects of chromium bloom formation associated with capillary action including:

- The height of the capillary fringe in a range of backfill materials;
- The effectiveness of a capillary break layer at limiting the height of the capillary fringe; and
- The vertical rise of groundwater above the capillary fringe through capillary rise.

Key findings and conclusions of the capillary rise study are as follows:

- The height of the capillary fringe in topsoil was determined to be less than 2.7 ft.
- In DGA and DGA amended with FerroBlack®-H (amended DGA [A-DGA]), the height of the capillary fringe was determined to be less than 1.7 ft.
- When a layer of ¾-inch open-grade stone (OGS) was added to the DGA and A-DGA, the height of the capillary fringe was reduced to 1.1 ft, indicating that the OGS capillary break is effective.
- Studies performed to quantify the rise of capillary water above the capillary fringe indicate that the height of total capillary rise in OGS is generally less than 6 inches, whereas in DGA and A-DGA it can be as high as 2.8 ft. The height of total capillary rise was not clearly discernable in topsoil.

Remediation of soil impacted with $Cr^{+6}$ is being conducted at the Project Area in advance of groundwater remediation; therefore, a capillary break is required in some areas to prevent the formation of surficial $Cr^{+6}$ blooms (chromium blooms) due to capillary rise. Capillary breaks create a discontinuity in water-filled pores that inhibit hydraulic connectivity across the break, thereby preventing potentially-impacted groundwater from reaching the surface through capillary action. The capillary break prevents the contamination of clean backfill that was placed in the remediation/excavation area.

The design of the capillary break for Sites 114, 132, 133, 135, 137, and 143, the Phase 4 Roadways, and the Phase 5 Off-Site Properties was completed in 2017, as described in the December 2017 *Capillary Break Design Final Report (Revision 2)* (“Capillary Break Design Report”) (AECOM, 2017e). Installation of the capillary break was complete in the target areas as part of restoration activities performed in 2017, with the exception of the washed stone capillary break in the Phase I IRM Area, which is pending completion of the shallow zone injection and sampling activities. Design of the capillary break for areas remediated since the December 2017 Capillary Break Design Report (i.e., Former Halsted Corporation Property, Carteret Avenue, and Halladay Street North) was described in an addendum to the Capillary Break Design Report submitted on February 3, 2021 (AECOM, 2021c).

### 3.7.4 Remediation Effects on Groundwater Flow

Remedial activities throughout the Project Area (i.e., excavation, placement of clean and/or amended fill, installation of sheet pile, groundwater injection/extraction via IRMs) have affected groundwater flow patterns, as follows:

- The replacement of heterogeneous, non-native, historic fill materials with clean, homogenous backfill (i.e., DGA) has resulted in greater uniformity in the groundwater flow field within the shallow water-bearing zone.
- The removal of impervious surfaces (e.g., buildings, roads) and the excavation and replacement of historic, low-permeability, fill has increased the rate of groundwater recharge to the shallow water-bearing zone due to direct infiltration of precipitation.
- Sheet pile was installed on Site 114 during soil remedial actions to assist in dewatering activities, shore up excavations, and to limit off-site migration of groundwater impacts and MGP residuals. In general, sheet pile begins at the ground surface, intersects the shallow and intermediate water-bearing zones, and terminates in the deep water-bearing zone. On the western margin of Site 114, along Garfield Avenue where bedrock is shallower, the sheet pile extends to the bedrock in some areas. On the eastern side of Site 114, along Halladay Street North where bedrock is deeper, the sheet pile is keyed into the low permeability soils of the transition zone (intermediate water-bearing zone). In some areas, there are vertical gaps below the sheet pile within the deep water-bearing zone which allow groundwater to flow beneath it; therefore, sheet pile has a less significant effect on groundwater flow in the deeper portions of the deep water-bearing zone.
    - The sheet pile contains groundwater on Site 114 and significantly limits off-site migration of Cr-related impacts within the intermediate water-bearing zone and the upper portions of the deep water-bearing zone.
    - In areas where the sheet pile has isolated the groundwater flow system, hydraulic heads fluctuate with precipitation events. Where there are sufficient hydraulic head differences between the shallow and intermediate water-bearing zones, the differences in head drive groundwater through gaps in the meadow mat. Localized groundwater mounding within the areas enclosed by sheet pile is evident on Site 114.
    - Since the installation of sheet pile, groundwater elevation measurements have been collected from outboard monitoring wells (i.e., monitoring wells located in areas not bounded by sheet pile) to evaluate the potential for mounding along the roadways. Data collected from these areas suggest that there is no mounding along the streets resulting from the placement of sheet pile.
- Operation of the Phase I and II IRMs has affected/continues to affect groundwater flow patterns on Site 114.
    - The Phase I IRM included delivery of remediation compounds to wells screened in the intermediate and deep water-bearing zones. Similarly, the Phase II IRM includes delivery of remediation compounds to wells screened in the intermediate and deep water-bearing zones. For both IRMs, remediation wells are screened to depths ranging from 48 bgs to 68 ft bgs. Therefore, the intermediate water-bearing zone and portions of the deep water-bearing zone that are shallower than 68 ft bgs (the Upper Deep Zone) are the vertical target areas of the Phase I and Phase II groundwater IRMs.

- The deep water-bearing zone extends to depths greater than the bottom of existing Phase I and II IRM remediation wells in certain areas of Site 114, especially in the southeastern and southwestern portions of Site 114. This lower portion of the deep water-bearing zone (the Lower Deep Zone) includes overburden materials below the bottom of the transition zone, above the top of the basal till, and below the bottom of existing IRM remediation wells, and has not been the target of active groundwater remediation activities to date. The portions of the Lower Deep Zone warranting active remediation will be targeted during implementation of the Phase III IRM.

- Where present, the portion of the capillary break consisting of a high-density polyethylene liner reduces recharge to the underlying shallow water-bearing zone.

## 3.8 Receptor Evaluation

A receptor evaluation report for the GA Group Sites was initially submitted in March 2012 (AECOM, 2012b). **Appendix H** provides an update to this receptor evaluation and includes the following components:

- Receptor Evaluation Form
- Attachment A: Property Search:
  - Table A.1: Properties within 200 feet of Groundwater Impacts for the GA Group Sites
  - Figure A.1: Land Use
- Attachment B: Well Search
  - Table B.1: Well Search based on the impacted groundwater area for the GA Group Sites
  - Table B.2: Well Search Results

Conclusions from the receptor evaluation are summarized below:

- Groundwater beneath the Project Area is not used as a source of potable water, as the area is served by the municipal water supply system.
- Land use surrounding the Project Area includes predominantly commercial and industrial properties (e.g., warehouses, garages, etc.).
- Residential properties are located to the west of the Project Area, between Garfield Avenue and Randolph Avenue (upgradient of the groundwater plume).
- No schools or childcare centers are present within 200 feet of the Project Area.
- No sensitive receptors are present within 200 ft downgradient of the 70 µg/L Cr isopleth in the shallow, intermediate, or deep water-bearing zones. In addition, the results of the well search included in the updated receptor evaluation show that no irrigation or domestic supply wells are located within a half-mile of the Project Area.

# 4.0 Remedial Investigation Activities

## 4.1 Summary of Field Activities

The following subsections provide a description of the activities performed during the groundwater RI within the Project Area. Unless otherwise noted, field investigation procedures were consistent with the methods and procedures described in the following documents:

- Field Sampling Plan/Quality Assurance Project Plan (FSP-QAPP) (AECOM, 2010);
- Health and Safety Plan (HASP) (AECOM, 2017c and AECOM, 2020a);
- NJDEP Field Sampling Procedures Manual (FSPM) (NJDEP, 2005); and
- Groundwater RIWP (Rev. 1) (AECOM, 2017b).

### 4.1.1 Access Agreements and Permits

The Project Area is located in a commercial and light industrial area of Jersey City, bordered by residential neighborhoods to the west and northeast. For investigation locations on private properties, access agreements were negotiated with the property owners and secured prior to implementation of the RI.

### 4.1.2 Subcontractors

The following subcontractors provided services during the groundwater RI:

- TPI Environmental, Inc. of New Hope, Pennsylvania provided utility clearance for each boring location.
- SGS North America, Inc. of West Creek, New Jersey and Aquifer Drilling and Testing (ADT) of Mineola, New York provided drilling services including advancement of soil borings, monitoring well installation, and soft-dig utility clearance.
- Borbas Surveying and Mapping of Boonton, New Jersey provided surveying services (horizontal locations and vertical elevations) for boring and well locations.
- SGS North America of Dayton, New Jersey, a NJDEP-certified analytical laboratory, provided laboratory analytical services.
- Hager-Richter of Fords, New Jersey provide borehole geophysical services.
- Laboratory Data Consultants (LDC) of Carlsbad, California, provided data validation services for samples collected as part of the 2017 - 2018 groundwater RI.

### 4.1.3 Sample Control and Site Security

Analytical samples were bottled in sterile containers provided by the laboratory and clearly labeled with the sample identification, depth, date of collection, and analysis to be performed. Analytical samples were collected, handled, and shipped in accordance with chain-of-custody protocols described in the FSP-QAPP.

A field office was maintained within a secured portion of the Project Area to provide field instrumentation and sample storage. A private security company was on site 24 hours a day to secure the Project Area. Each boring location was restored to previously existing surface conditions (e.g., asphalt or concrete) upon completion of the boring to prevent direct contact with potentially impacted materials.

### 4.1.4 Utility Protection and Geophysical Survey

Prior to any intrusive field operations (i.e., drilling), available utility maps for the Project Area were reviewed and additional utility surveying was performed using an experienced geophysical contractor.

In addition, New Jersey One Call was notified by the drilling subcontractors a minimum of three business days prior to the start of drilling operations in each area. Based on the results of the utility surveys, some locations were adjusted to avoid underground or overhead utilities. As an added precaution, soft-dig techniques (i.e., air-knife or vacuum boring) were utilized to a depth of approximately 5 ft bgs at investigation locations. Geophysical survey reports, along with a map of known utilities across the Project Area, are included in **Appendix I**.

### 4.1.5 Health and Safety

#### 4.1.5.1 Investigation-Derived Waste Management

Investigation-derived waste (IDW) generated during field investigations was handled in accordance with Section 9.0 of the FSP-QAPP. IDW generated during the RI included drill cuttings and fluids, contaminated personal protective equipment (PPE), decontamination fluids, purge water from monitoring wells, and general refuse. Solids such as soil cuttings and decontamination fluids were placed in United States Department of Transportation-approved 55-gallon drums and staged in designated temporary waste storage areas on Site 137. Drums from the RI program were shipped off site with other drums from ongoing site activities to licensed disposal facilities within 90 days of generation. Purge water generated during well development and sampling activities was managed at the on-site treatment plant located on Site 137.

#### 4.1.5.2 Ambient Air Monitoring

Air monitoring was performed during drilling activities to provide real-time measurements of total VOCs and particulate (airborne dust) concentrations in air in the work zone and at the downwind perimeter of each designated work area when intrusive investigation activities were in progress. The procedures followed methods described in the HASP.

### 4.1.6 Temporary Screening Points

#### 4.1.6.1 Temporary Screening Points 2017 - 2018

Per the groundwater RIWP, temporary screening points were advanced in December 2016 and November 2017 to collect groundwater samples to determine the need for installation of permanent monitoring wells for the groundwater RI. **Figure 4-1** presents the locations of these sampling points. Boring logs are provided in **Appendix F**. A summary of screening points advanced for the groundwater RI is presented below:

| Screening Point ID | Location |
|---|---|
| 10W-SS101S | Ten West Apparel |
| 10W-SS102S | Ten West Apparel |
| 10W-SS105I | Ten West Apparel |
| 132-P3A-SSI | Ten West Apparel |
| 114-SS-39B | Eden Wood Realty |
| 114-SS-40B | Eden Wood Realty |
| 114-SS43A | Garfield Avenue |
| GAR-PDI-C13B | Garfield Avenue |
| GAR-PDI-D14B | Garfield Avenue |
| GAR-PDI-B`2A | Garfield Avenue |
| GAR-PDI-B`3A | Garfield Avenue |

A total of eight temporary screening point locations were originally proposed in the Ten West Apparel area; of these, the advancement of four locations (two shallow and two intermediate) were proposed to be contingent upon sampling results from the remaining screening points. Based on analytical data collected from the four screening samples (10W-SS101S, 10W-SS102S, 10W-SS105I and 132-P3A-SSI), the additional borings were not advanced.

#### 4.1.6.2 Temporary Screening Points for Dense Non-Aqueous Phase Liquid Delineation at Site 137

During previous work performed at Site 137, dense non-aqueous phase liquid (DNAPL) was observed in intermediate monitoring well 137-P3B-MW101I. A sample of this DNAPL was collected on June 21, 2016 and submitted for fingerprint analysis. The analytical data indicate that the DNAPL is related to MGP impacts. Delineation of the extents of the DNAPL in the vicinity of monitoring well 137-P3B-MW101I was proposed in the groundwater RIWP. Two of the four proposed temporary well points were completed in November 2017. The remaining temporary well points were not installed due to unsafe accessibility due to traffic activity occurring in Carteret Avenue. Locations of DNAPL delineation borings DNAPL-S1 and DNAPL-W1 are presented on **Figure 4-1**, and boring logs are provided in **Appendix F**. Both borings were completed as temporary monitoring wells and groundwater screening samples were collected from each location at a depth similar to the screened interval depth of monitoring well 137-P3B-MW101I.

#### 4.1.6.3 Temporary Screening Points Installed for Other Field Programs

Additional temporary screening points were installed during HPT/VAP conducted for the following field programs:

- Phase II IRM monitoring and remediation well installation;
- Phase III IRM PDI;
- Forrest Street and Forrest Street Properties groundwater investigation;
- Site 199 groundwater investigation; and
- Pre-RI groundwater investigations conducted in 2015.

### 4.1.7 Monitoring Well Network

A total of 46 permanent monitoring wells were installed as part of the groundwater RI, including nine shallow wells, nine intermediate wells, five deep wells, 19 basal till/weathered bedrock wells, and four bedrock wells. Three multi-purpose wells were installed during the Phase III IRM PDI. Well records (permits, construction records, NJDEP Form A, and NJDEP Form B) for the 49 wells are presented in **Appendix J.1**. A summary of the active site-wide monitoring wells is provided in **Table 4-1** and presented on **Figure 4-1**. Drilling and well installation activities were performed in accordance with N.J.A.C. 7:9D by a NJ-licensed driller. Upon installation, monitoring wells were developed in accordance with the FSP-QAPP.

#### 4.1.7.1 Installation of Contingent Monitoring Wells

In the groundwater RIWP, it was proposed that the installation of certain monitoring wells would be contingent upon the analytical data obtained from nearby sample locations and/or groundwater screening samples. Upon review of analytical data from nearby sample locations and/or screening samples, the following contingent monitoring wells were installed:

- 114-MW42A
- 114-MW43A[1]
- 114-MW17B
- 114-MW39B
- 114-MW40B
- 10W-MW101S
- 10W-MW102S
- 10W-MW105I
- 132-P3A-MW105I

The following contingent monitoring wells proposed in the groundwater RIWP were not installed:

- **114-MW17A:** Installation of a shallow well north of Site 114 in Berry Lane Park was proposed in the groundwater RIWP and was contingent upon sampling results from nearby shallow well 114-MW2B1-2, located south of the light rail. Concentrations of COCs (Cr, $Cr^{+6}$, VOCs, and SVOCs) from 114-MW2B1-2 were less than their respective GWQS; therefore, this well was not installed.
- **133-MW6B:** Installation of intermediate well 133-MW6B next to existing shallow well 133-MW6A located south of Site 133 was proposed for the horizontal and vertical delineation of Cr and $Cr^{+6}$ south of Sites 133 and 135. Analytical data obtained from shallow well 133-MW6A

[1] Shallow well 114-MW43A was not originally proposed per the groundwater RIWP. The need for the installation of this well was determined based on a review of analytical data from groundwater screening samples collected from nearby boring GAR-PDI-D14B. Prior to well installation, a groundwater screening sample was collected (114-SS-43A) to ensure a "clean" well would be installed for the purposes of horizontal delineation of Cr and $Cr^{+6}$.

and intermediate well 10W-MW105I indicated that the concentrations of Cr and $Cr^{+6}$ were less than the GWQS; therefore, this well was not installed.

#### 4.1.7.2 Installation of Basal Till and Bedrock Monitoring Wells

In accordance with scopes of work approved by NJDEP during technical discussions, installation of 19 basal till/weathered bedrock wells (114-MW45C, and 114-MW48C through 114-MW65C) was completed from October 1, 2019 to August 7, 2020, and installation of four bedrock wells (114-MW52D, 114-MW57D, 114-MW61D, and 114-MW66D) was completed from December 1, 2020 to January 4, 2021.

#### 4.1.7.3 Monitoring Wells Installed for Other Field Programs

During the course of the groundwater RI, monitoring wells were installed for use in other ongoing field programs to support groundwater remediation at the Project Area (**Figure 4-1**). These include:

1) Installation of one shallow groundwater monitoring well (114-MW44A) in the Forrest Street Properties area to support remedial design work. Although not originally part of the groundwater RIWP sampling plan, data collected at this location is included in this RIR to support horizontal delineation of Cr and $Cr^{+6}$ in groundwater within the Forrest Street Properties.
2) Installation of three shallow groundwater monitoring wells (two on Site 135 [135-MW1AR, 135-P3C-MW101S and 135-P3C-MW102S] and one on Forrest Street [FS-MW101S]) to support the Site-Wide FerroBlack®-H PBR compliance monitoring program. Of these, one shallow well (135-P3C-MW102S) was intended to be shared with the RI program. This well is considered to be a replacement for decommissioned shallow well 135-MW3A. Data collected for the purposes of the FerroBlack®-H PBR program is submitted to the NJDEP under a separate cover, per the reporting requirements of the PBR authorization.
3) Replacement of three shallow groundwater monitoring wells (114-MW22AR, 132-P3A-MW1R and 114-P2B3-MW2R) and one intermediate groundwater monitoring well on Carteret Avenue (114-MW22BR), and two shallow groundwater monitoring wells on Halladay Street North (114-MW20AR, 114-P2B4-MW2R), to support groundwater monitoring for the FerroBlack®-H PBR and the capillary break groundwater monitoring program.
4) The groundwater RIWP proposed installing two intermediate wells (114-P1B-MW105I and 114-P1B-MW106I) and two deep wells (114-P2B3-MW102D and 114-P2B1-MW103D) on Site 114; however, it was later decided to consolidate field efforts and use the wells installed for the Phase I IRM at Site 114. As a result, IRM wells 114-P1-IRM 27D, 114-P1-IRM-40D, 114-PI-IRM5I, and 114-P1-MW2I were used in lieu of the originally proposed wells. This proposed change was approved by the NJDEP in an email dated October 9, 2017 (NJDEP, 2017b). Data collected from these locations are included in this RIR. Well construction details for these wells were provided in the *Groundwater IRM Phase I Quarterly Report – Q1 2018* (Arcadis, 2018).
5) Installation of three multi-purpose wells (114-MW67C, 114-MW68C, and 114-MW70C) and one soil boring (114-MW69C) during the Phase III IRM PDI in January 2021.
6) Installation of remediation wells and monitoring wells for the Phase I and Phase II IRMs.

#### 4.1.7.4 Monitoring Well Survey

Upon completion of well installation, horizontal locations and vertical elevations were surveyed by a NJ-licensed surveyor. Horizontal locations were surveyed in both latitude and longitude and NJ State Plane Coordinate System (ft) in North American Datum of 1983 (NAD83). Elevations were surveyed to the NAVD88. NJDEP Form Bs (Location Certification) for each monitoring well installed as part of the RI are provided in **Appendix J.1.**

Due to ongoing site restoration activities, the inner well casing of several monitoring wells within Sites 114, 132, 133, 135, and 137 were modified by placing a temporary polyvinyl chloride (PVC) riser, to prevent the wells from being damaged during restoration. To confirm the temporary elevations of the top of the measuring point for water level elevation measurements and vertical gradient calculations, these wells were re-surveyed by a NJ-licensed surveyor between June 8 and June 13, 2018. A well chart with this information is provided in **Appendix J.1.**

#### 4.1.7.5 Well Decommissioning

Certain monitoring wells located in the Project Area were decommissioned on April 13, 2017 by a NJ-licensed driller in preparation for soil remediation (i.e., excavation). Well decommissioning reports are provided in **Appendix J.2**. Of these, the wells proposed to be sampled for the groundwater RI were subsequently replaced. Monitoring wells 135-MW3A and 135-MW3B were not formally decommissioned and are believed to have been excavated and removed during soil remediation activities. Both of these monitoring wells have been replaced.

The following monitoring wells were decommissioned after the proposed work under the groundwater RIWP was completed in these areas:

- Monitoring wells located on Halladay Street North (114-MW20A, 114-MW20B, 114-MW20C, 114-P2B4-MW1, 114-P2B4-MW2, and 114-P2B4-MW3) were decommissioned on June 21, 2018, after the completion of the RI field work, to prepare for soil remediation work in the Halsted property. Select wells were replaced to support the FerroBlack®-H PBR program and the capillary break groundwater monitoring program, as noted in Section 4.1.7.3.
- Monitoring well 114-MW14B, located on Site 199 adjacent to Berry Lane Park, was decommissioned on May 18, 2018, after groundwater sampling for the RI was completed at this location.

### 4.1.8 Groundwater Sampling

#### 4.1.8.1 Low-Flow Groundwater Sample Collection

Low-flow groundwater sampling of permanent monitoring wells and open borehole bedrock wells was conducted as indicated below:

- A total of 100 groundwater monitoring wells were sampled between September 25, 2017 and May 31, 2018 to support the groundwater RI program, including 49 shallow wells, 41 intermediate wells, and 10 deep wells.
- Additional groundwater monitoring events were performed at the basal till/weathered bedrock wells on October 21, 2019 (114-MW45C only) and from August 19 to September 2, 2020 (the 19 basal till/weathered bedrock wells).

- Sampling of existing bedrock monitoring wells was performed in May 2019 at 114-MW4D, 114-MW6D, 114-MW7D, and in August 2020 at 114-MW4D, 114-MW6D, 114-MW7D, and 114-MW16B.
- Sampling of newly installed bedrock wells (114-MW52D, 114-MW57D, 114-MW61D, and 114-MW66D) was performed from February 9 to 15, 2021.

Low-flow groundwater sampling of permanent monitoring wells and open borehole bedrock wells was conducted in accordance with the FSP-QAPP and the NJDEP FSPM. Field parameters (pH, oxidation-reduction potential [ORP], dissolved oxygen [DO], specific conductivity, turbidity, temperature, and depth to water) were recorded and monitored to determine stabilization. Groundwater low-flow sample collection records are provided in **Appendix K**. **Table 4-2** provides a summary of the analyses performed on the collected groundwater samples.

Each well sampled was purged with a bladder pump, with dedicated tubing attached to the pump outlet using a stainless-steel hose clamp. Teflon-lined tubing was used for wells where VOC and SVOC samples were collected. One low-flow groundwater sample was collected per 5 ft of saturated well screen or open borehole interval (for the May 2019 and August 2020 bedrock well sampling events), with the following exceptions:

- MW7S: This shallow well has a history of poor recharge during low-flow purging and sampling. This well has a 10-ft screen and was initially attempted to be sampled on April 23, 2018. However, stabilization could not be achieved as the drawdown exceeded the depth at which the pump was set. A second attempt was made to sample this well on April 30, 2018. To avoid having the drawdown exceed the depth of the pump, only one sample was collected from the deeper of the two proposed sampling intervals (i.e., at 10 ft).
- 132-P3A-MW102S: This shallow well has a 10-ft screen; however, samples were collected only from one interval as drawdown exceeded the pump depth, similar to MW7S.
- 132-MW2A: This shallow well with a 10-ft screen was noted to be silted-in to approximately 14.5 ft below the top of inner casing, and only one sample was collected from a depth of 11 ft below the top of inner casing.
- 114-P2B4-MW101S: Samples were collected from this shallow well with a 10-ft screen from a depth of 16 ft below the top of casing. When the pump was set to the next sampling depth (approximately 11 ft), the turbidity of the purge water did not stabilize and was greater than 200 nephelometric turbidity units (NTU) and did not appear to be clearing. Therefore, only one sample was collected from this well location.
- 137-P3B-MW102S: Only one sample was collected from this shallow well with a 10-ft screen at 9 ft below the top of casing. The well was noted to have an obstruction at approximately 12 ft below the top casing and, therefore, samples could not be collected from the deeper interval.

Collection of groundwater samples from the open borehole intervals at wells 114-MW52D, 114-MW57D, 114-MW61D, and 114-MW66D was performed in accordance with Appendix C (Depth-Discrete Sampling and Profiling of Vertical Cross-Flows) of the *Groundwater Technical Guidance* (NJDEP, 2012a).

Analytical samples were bottled in certified containers provided by the laboratory and clearly labeled with the sample identification, depth, date of collection, and analysis to be performed. Analytical samples were collected, handled, and shipped in accordance with chain-of-custody protocols described in the FSP-QAPP. Samples were analyzed using methods with adequate sensitivity to accurately measure concentrations to the GWQS. Samples collected for $Cr^{+6}$ were also analyzed in the laboratory for pH and ORP. As outlined in the groundwater RIWP, Quality Assurance (QA)/Quality Control (QC) samples were collected, including field blanks, field duplicates, matrix spike/matrix spike duplicates, and trip blanks (for VOC analysis). A summary of QA/QC samples collected is provided in **Table 4-3**.

#### 4.1.8.2 Groundwater Sample Collection for Other Field Programs

Groundwater sampling of permanent monitoring wells was also conducted for the following field programs:

- Forrest Street and Forrest Street Properties groundwater investigation;
- Capillary break and FerroBlack®-H PBR monitoring; and
- Baseline monitoring for the Phase I and Phase II IRMs.

Data from these sampling events that are relevant to this groundwater RI are included in this RIR.

#### 4.1.8.3 Groundwater Sample Collection from Temporary Screening Points

Groundwater grab samples were collected from temporary screening points where advanced. Upon collection of samples, the boreholes were abandoned and filled using bentonite grout. Groundwater screening samples were submitted for the analyses noted on **Table 4-2**. Analytical results are included in **Appendix L**.

#### 4.1.8.4 Water Quality Sample Collection from Sumps on Forrest Street Properties

In accordance with the GA Group Sites Groundwater RIWP, water quality samples were collected from three sumps located inside the 90 Forrest Street boiler room using dedicated bailers, from September 25 to September 28, 2017. Samples collected from the sumps were analyzed for Cr and $Cr^{+6}$. The sump data are presented in Appendix L.

### 4.1.9 Variations from the Remedial Investigation Sampling Plan

#### 4.1.9.1 Filtered Sample Analysis

During low-flow purging and sampling, the turbidity of purge water from certain wells did not stabilize or stabilized at a turbidity greater than the criterion of 10 NTU, even while the other water quality parameters achieved stabilization according to the criteria specified in the NJDEP FSPM. In these instances, samples were collected for both filtered and unfiltered laboratory analyses. The samples to be filtered were indicated on the chain of custody and were filtered (and preserved, if applicable) by the analytical laboratory upon sample receipt. Samples that were filtered are identified on **Table 4-2.**

#### 4.1.9.2 Monitoring Wells Not Sampled

Certain monitoring wells proposed for sampling in the RIWP could not be sampled, as explained below:

- 114-P2A-MW101S: Attempts were made to locate this monitoring well using a Global Positioning System (GPS); however, the well could not be located. It is likely that this well was damaged or excavated during soil remediation activities. This well was proposed to be sampled for VOCs and SVOCs. As adequate spatial coverage across the shallow water-bearing zone in this area of Site 114 (i.e., the former MGP facility) was achieved, the absence of groundwater samples from this monitoring well does not affect the horizontal delineation of VOCs and SVOCs.

- 114-P1-IRM-40D: Samples were not collected during the RI at this well, but instead were collected from this location to support the ongoing Phase I IRM in Site 114. These groundwater samples were analyzed for $Cr^{+6}$ and TAL metals.
- 137-P3B-MW101I: Samples were not collected from this well due to the presence of DNAPL in the well.

### 4.1.10 Site-Wide Comprehensive Monitoring Well Gauging

A discussion of the site-wide comprehensive monitoring well groundwater elevation gauging program performed in the Project Area was presented in Section 3.7.2.

### 4.1.11 Analysis of Compounds with Interim Groundwater Quality Standards

At the time the groundwater RIWP was prepared, the NJDEP had added the following 12 constituents to the list of interim GWQS on November 25, 2015 (NJDEP, 2015):

- 1-Chloro-1,1-difluoroethane
- Cresols (mixed isomers)
- 1,1-Dichloro-1-fluoroethane
- 1-Methylnaphthalene
- Perfluorononanoic acid (PFNA)
- Strontium
- 1,1,2-Trichloro-1,2,2-trifluoroethane (Freon 113)
- Tri-cresyl phosphate (mixed isomers)
- 1,2,4-Trimethylbenzene
- Tri-ortho-cresyl phosphate
- 1,4-Dioxane

In addition, the NJDEP added the following constituents to the list of interim specific GWQS on March 13, 2019.

- Perfluorooctanoic acid (PFOA)
- Perfluorooctanesulfonic acid (PFOS)

Of these, analyses for 1-chloro-1,1-difluoroethane, 1,1-dichloro-1-fluoroethane, tri-cresyl-phosphate, and tri-ortho-cresyl phosphate were not conducted during the groundwater RI because there was no NJDEP-certified laboratory available to conduct the analyses. In addition, analysis of PFNA, PFOA, and PFOS, which are three of the many compounds known as Per- and polyfluoroalkyl substances (PFAS), was not conducted because PFAS have never been manufactured, used, handled, stored, disposed, or discharged on Site 114 (AECOM, 2019h), as concurred to by NJDEP (NJDEP, 2019d).

## 4.2 Data Management

### 4.2.1 Laboratory Analysis

The soil and groundwater samples were analyzed by a NJ-certified laboratory (SGS North America). Summary tables of groundwater analytical data are provided in **Appendix L** and laboratory data packages are provided in **Appendix M**. The EQuIS® environmental data management software from EarthSoft, Inc. was used to manage the data for the RI. Subsets of the field data, including spatial data and geologic information were loaded into the database either directly using an EQuIS® import utility or via entry into electronic templates. Electronic data deliverables (EDDs) from the laboratory, provided in the AECOM-specific format, were imported into the project database. Upon completion of validation, data qualifiers were loaded into the database.

Quality control checks were performed throughout the process to verify the integrity of the data. These checks included:

- Reviews to check that laboratories reported all requested analyses;
- Checks that analytes were consistently and correctly identified;
- Reviews to check that units of measurement were provided and were consistent;
- Queries to determine that codes used in the database were documented properly;
- Reports to review sample definitions (depths, dates, locations);
- Proofing manually-entered data against the hard copy original; and
- Reports to review groupings of sample locations and coordinate systems.

Samples collected for analysis of $Cr^{+6}$ were also analyzed for pH and ORP. The $Cr^{+6}$ data were provided by the analytical laboratory as full NJ Tier I data deliverables.

### 4.2.2 Data Validation and Data Usability

Data validation of laboratory analytical results generated during the groundwater RI was performed by LDC or by AECOM to evaluate whether analytical data collected for this program were scientifically defensible, properly documented, of known quality, and met the objectives of the RI.

#### 4.2.2.1 Validation Procedures

Data validation included the review of analytical procedures, QC results, calibration procedures, data reduction, and completeness of the laboratory data packages as specified in the groundwater RIWP and FSP-QAPP. Deficiencies noted were communicated to the laboratory and resolutions were documented in the data validation reports. If appropriate, data were qualified for use as described later in this section. The laboratory data packages were reviewed in accordance with the FSP-QAPP, organic validation guidelines from United States Environmental Protection Agency (USEPA) Region 2, and the NJDEP validation Standard Operating Procedures (SOPs) for $Cr^{+6}$ and inorganic data. The following NJDEP validation guidelines served as the basis for the actions taken during validation:

- NJDEP Office of Data Quality SOP 5.A.10, Rev 3 (September 2009), SOP for Analytical Data Validation of Hexavalent Chromium – for USEPA SW-846 Method 3060A, USEPA SW-846 Method 7196A and USEPA SW-846 Method 7199;

- NJDEP Office of Data Quality SOP 5.A.16, Rev 1 (May 2002), Quality Assurance Data Validation of Analytical Deliverables for Inorganics (based on USEPA SW-846 Methods);
- Inductively Coupled Plasma Atomic Emission Spectroscopic (ICP-AES) Data Validation, SOP No. HW-3a Revision 0 (July 2015);
- Validating Volatile Organic Compounds By Gas Chromatography/Mass Spectrometry SW-846 Method 8260B, SOP HW-24, Revision 2; and
- Validating Semi-Volatile Organic Compounds By Gas Chromatography/Mass Spectrometry SW-846 Method 8270, SOP HW-22, Revision 4.

The level of validation ranged from a comprehensive validation per the NJDEP guidelines to a limited validation based on QC summary information, depending on the analyte. The validation procedures for the $Cr^{+6}$ data included full validation, which involved a comprehensive review of both summary forms and raw data, whereas the metals, SVOC, and VOC data received limited validation. Limited validation for metals, SVOC, and VOC data was based on information provided by the laboratory on their QC summary forms and did not include raw data review. At a minimum, limited validation included the following data elements:

- Agreement of analyses conducted with chain-of-custody requests;
- Holding times and sample preservation;
- Method blanks/field equipment blanks/ trip blanks;
- Surrogate spike recoveries;
- Laboratory Control Samples (LCS) or equivalent results;
- Matrix Spike (MS)/Matrix Spike Duplicate (MSD) results;
- Laboratory duplicate results;
- Field duplicate results; and
- Quantitation limits and sample results (limited to evaluating dilutions and re-analyses).

Validation reports were prepared for each data package that was validated. Validation reports are provided in **Appendix N**. These reports summarize the samples and parameters reviewed, nonconformance with established criteria, and validation actions (including application of data qualifiers), presented in accordance with the NJDEP "hit list" format. Validation data qualifiers were based on the USEPA Region 2 validation guidelines for organic data and the NJDEP validation SOPs for $Cr^{+6}$ and inorganic data. The qualifiers used in data validation consisted of the following:

- J Indicates the result was an estimated value; the associated numerical value was an approximate concentration of the analyte in the sample. J+ or J- is used when the direction of bias can be determined.
- U Indicates the analyte was not detected in the sample above the sample reporting limit.
- UJ Indicates the analyte was not detected above the reporting limit and the reporting limit was approximate.
- UB The analyte concentration is less than or equal to three (3) times the concentration in the associated method/preparation blank. The presence of the analyte in the sample is negated due to laboratory blank contamination

- JB The analyte concentration is greater than three (3) times, but less than or equal to ten (10) times the concentration in the associated method/preparation blank. The presence of that analyte in the sample is considered "real" but the concentration is quantitatively qualified due to method blank contamination.
- R The sample result was rejected due to serious deficiencies; the presence or absence of the analyte could not be confirmed.

Pursuant to N.J.A.C. 7:26E-3.13, laboratory data included as part of this RIR have been prepared in the HAZSITE EDD file format. EDDs will be electronically submitted with the Final RIR. A list of sample delivery groups (SDGs) submitted is provided as **Appendix O**.

#### 4.2.2.2 Data Usability Assessment

This data usability assessment has been prepared to address the usability of the groundwater samples collected from monitoring wells using low-flow sampling and purging methods. Groundwater samples collected to demonstrate compliance with the RI objectives were sent to SGS-North America Laboratories in Dayton, NJ (NJ Certification 12129). The analyses were performed in accordance with USEPA- and NJDEP-approved analytical protocols. QA analytical measures were implemented in accordance with the NJDEP TRSR (N.J.A.C. 7:26E) and complied with the requirements for a NJDEP-certified laboratory (NJDEP, 2017a). Specific QC issues identified during validation are documented in the individual data validation reports provided in **Appendix N.** Results of the data validation indicated that, in general, the analytical data were of adequate quality to meet the project objectives. However, there were some QA/QC issues identified during data validation that resulted in rejection of data or qualification of data as estimated. Data usability for groundwater samples collected from monitoring wells for the RI ("the RI dataset") was evaluated using the data quality indicators of precision, accuracy, representativeness, comparability, completeness, and sensitivity. Data that were not rejected during validation are regarded as usable.

**Precision**

Precision is the measure of agreement among repeated measurements of the same property under identical or substantially similar conditions and includes both field and analytical components. The information used to evaluate precision included results for field duplicates, matrix duplicates, and laboratory duplicates. For the RI dataset, relative percent difference (RPD) non-conformances were observed for field and/or laboratory duplicates associated with CCPW metals and SVOC data and field duplicates associated with other metals and VOC data.

Field precision was assessed through the collection and analysis of field duplicates and expressed as the RPD of the sample and field duplicate pair results. For the RI dataset, field duplicate precision resulted in qualification of 1.0% of $Cr^{+6}$ results, 0.4% of the CCPW metals results, 1.0% of non-CCPW metals results, 0.3% of SVOC results, and 0.3% of VOC results.

Laboratory precision was assessed through the RPD results for MS/MSDs, LCS/Laboratory Control Sample Duplicate pairs, and duplicate sample analyses. Laboratory precision resulted in qualification of 2.1% of the $Cr^{+6}$ results, 0.4% of the CCPW metals results, and 0.1% of the SVOC data. None of the non-CCPW metals or VOC results were qualified on the basis of laboratory precision in the RI dataset.

## Accuracy

Accuracy is the degree of agreement between an observed value and an accepted reference or true value. The results of LCS data, surrogate recoveries, method blanks, and MS/MSDs were used as the primary indicators of accuracy; information such as sample container type, preservation, and holding time were also considered as impacts to analytical accuracy. Some of this information was assessed by the laboratory at the time of receipt (container type and preservation); other parameters were evaluated during the validation process.

The RI dataset included results for five (0.06%) non-detect SVOC results that were rejected based on matrix spike recoveries below the control limits and 30 (0.4%) non-detect SVOC results that were rejected based on surrogate recoveries below the control limits. No other were rejected for any of the analyses.

Qualification of data as estimated (J/UJ) for accuracy was related to issues such as field or laboratory blank contamination, LCS results, MS results, and holding time. A summary of the validation findings are presented by QC parameter type below.

The presence of target analytes in laboratory blanks and/or blanks related to field activities (i.e., field blanks) was cited as a reason for qualification of 2.8% of the CCPW metals results, 2.6% of the $Cr^{+6}$ results, 1.1% of the other metals results, and 0.2% of the SVOC results. None of the VOC results were qualified on the basis of blank results. For those blanks in which contaminants were detected, action levels were established per the NJDEP or USEPA Region 2 validation guidance documents. Associated sample results were qualified accordingly.

Six $Cr^{+6}$ results (3.1% of the $Cr^{+6}$ results reported) associated with the groundwater RI set were qualified for negative instrument drift with the potential for a false negative.

In this RI dataset, 2.1% of the $Cr^{+6}$ results, 0.1% of the non-CCPW metals data, 0.05% of the SVOC data, and 0.1% of the VOC data were qualified on the basis of MS or MSD recoveries that fell outside their respective control limits. Data points impacted by MS and/or MSD recoveries within this range were flagged as J or UJ; individual validation memoranda address the potential for high or low bias to sample results based on matrix interferences.

A single pair of Cr/$Cr^{+6}$ results were qualified as estimated (J/UJ) because the $Cr^{+6}$ result was greater than the Cr result. This can be a result of the different analytical methods used to test these two analytes. Total chromium was analyzed using an ICP-AES method, while hexavalent chromium was analyzed using a colorimetric method. Differences can result from the analytical error associated with each method, which can become more significant at lower concentration levels. The filtration step can also introduce error, which can impact the final results. The colorimetric procedure can be prone to interferences from other sample constituents, which impact color development; the Cr determination by ICP-AES is generally considered a more reliable measurement. There is no NJDEP GWQS for $Cr^{+6}$. Therefore, these results are used for informational purposes only. The analysis for Cr is considered accurate and was used for comparison with the NJDEP GWQS.

In the SVOC analysis, two results (0.03%) were qualified as estimated with a low bias (J-) based on low surrogate recovery; surrogate recoveries are indicative of matrix interferences or extraction efficiency. SVOC results that were rejected in the case of non-detect values associated with a very low surrogate recovery have been discussed previously.

**Representativeness**

The representativeness of any field program is a function of the planning and procedures used to collect the samples and the locations and density of samples collected. Sampling and preservation methods were based on established methods and SOPs outlined in the groundwater RIWP (AECOM, 2017b) and FSP-QAPP (AECOM, 2010), which are known to minimize error associated with the disturbance of environmental samples from their natural setting.

Factors to be considered in evaluating representativeness are the use of standard analytical procedures, sample preservation, and use of the appropriate sample container. The analytical methods, preservation procedures, and containers used in this program were as specified in the FSP-QAPP.

**Comparability**

Comparability of the data generated as part of the RI was maximized by using standard methods for sampling, analysis, and data validation.

**Completeness**

Completeness is the measure of the amount of valid data obtained from a measurement system; valid data are defined as those data judged to be usable (i.e., not rejected as a result of the validation process). For the RI dataset, 16,120 individual data points were validated; 0.22% (35 SVOC results) were rejected and are considered unusable for project decisions; and 99.8% of the reported RI values generated are considered usable for project decisions.

**Sensitivity**

Analytical dilutions were necessary for certain samples due to the sample matrix or elevated concentrations of target or non-target analytes. In some cases, analyses may have been performed using less than the nominal sample volume due to insufficient sample volume. The detection limits reported by the laboratory were adjusted to reflect the actual volume used and any dilution factors. Limitations in analytical methodologies, sample dilutions, lower sample volume, or the presence of substances that interfere with detection of specific analytes can result in detection limits that exceed the GWQS. In total, 386 individual CCPW metals, non-CCPW metals, VOC, and SVOC non-detect results had detection limits greater than the GWQS as follows:

| Compound | Number of Instances where Detection Limit is Greater Than GWQS |
|---|---|
| 1,1,2,2-TETRACHLOROETHANE | 5 |
| 1,1,2-TRICHLOROETHANE | 2 |
| 1,1-DICHLOROETHYLENE | 3 |
| 1,2,4-TRICHLOROBENZENE | 2 |
| 1,2-DIBROMO-3-CHLOROPROPANE (DBCP) | 113 |
| 1,2-DIBROMOETHANE(EDB) | 113 |
| 1,2-DICHLOROETHANE | 2 |

| Compound | Number of Instances where Detection Limit is Greater Than GWQS |
|---|---|
| 1,2-DICHLOROPROPANE | 6 |
| ANTIMONY | 41 |
| ARSENIC | 16 |
| BERYLLIUM | 6 |
| BROMODICHLOROMETHANE | 6 |
| BROMOMETHANE | 5 |
| CARBON TETRACHLORIDE | 6 |
| CHLORODIBROMOMETHANE | 5 |
| CHLOROETHANE | 5 |
| DICHLOROMETHANE | 6 |
| LEAD | 13 |
| SELENIUM | 5 |
| TETRACHLOROETHENE | 5 |
| THALLIUM | 3 |
| TRIBROMOMETHANE | 5 |
| TRICHLOROETHYLENE | 5 |
| VANADIUM | 1 |
| VINYL CHLORIDE | 7 |

**Data Quality/Data Usability Conclusions**

The findings of this Data Quality Assessment and Data Usability Evaluation indicate that the data presented for the RI are sufficiently representative of actual conditions and may be used to support decisions with the exceptions identified below:

- Results for SVOCs qualified R are considered to have serious quality deficiencies and should not be used for project decisions.

Data qualifiers and reason codes were applied by the data validator to identify data limitations found in the validation process. Specific details regarding analytes and samples can be found in the individual data validation reports in **Appendix N.**

# 5.0 Remedial Investigation Findings

## 5.1 Summary of Groundwater Remedial Investigation Analytical Results

This section presents analytical results for samples collected during implementation of groundwater RI activities. Groundwater analytical data from RI monitoring events performed from September 26, 2017 to February 15, 2021 ("the groundwater RI data") were used to assess groundwater quality within the Project Area. Groundwater analytical results are compared to the NJDEP GWQS in accordance with N.J.A.C. 7:9C (NJDEP, 2020c). Analytical data are presented in tables, with concentrations greater than the applicable NJDEP GWQS shown in bold font. In addition, non-detect data reported on the tables to a detection limit that exceeds the applicable regulatory standard are also bolded. As discussed in Section 5.2, additional data have also been collected to support delineation for the groundwater RI and these data are integrated into the groundwater RI report in Section 5.3. During implementation of groundwater RI field activities, field blanks and trip blanks were collected in accordance with the FSP-QAPP, as described in Section 4. Groundwater monitoring well sample results are presented on **Table 5-1**, **Table 5-2**, **Table 5-3**, and **Table 5-4**. Analytical results from quality assurance samples are presented on **Table 5-5, Table 5-6,** and **Table 5-7**.

Groundwater RI analytical results from monitoring wells are presented in the following sections and grouped into the following categories:

- $Cr^{+6}$ and CCPW metals
- Non-CCPW metals
- VOCs
- SVOCs

Figures depicting groundwater RI analytical results for the CCPW metals, non-CCPW metals, VOCs, and SVOCs for the shallow, intermediate, and deep water-bearing zones are presented in **Appendix P**. **Appendix P** also includes figures showing analytical results for CCPW metals from monitoring wells completed in the basal till/weathered rock and in the bedrock. These figures include text boxes with concentrations greater than the NJDEP GWQS shown in bold font and non-detect data at a reporting limit that exceeds the applicable regulatory standard included, but not bolded. Sampled locations shown on the figures are color-coded based on the analytical results, with the coloring identifying which constituents were detected at concentrations greater than the NJDEP GWQS, if any (refer to legend on each figure for constituent color representations).

### 5.1.1 Hexavalent Chromium and Chromate Chemical Production Waste Metals

Hexavalent chromium and CCPW metals were sampled in soil and groundwater extensively throughout the Project Area and are associated with historic chromate ore processing operations at Site 114. The CCPW metals include five of the TAL metals considered most likely to be associated with CCPW impacts: Sb, Cr, Ni, Tl, and V. Groundwater analytical results for $Cr^{+6}$ and the CCPW metals are presented on **Table 5-1**. The following table summarizes, by water-bearing zone, the total number of CCPW metals results from the groundwater RI data that were detected at concentrations greater than the applicable NJDEP GWQS.

| | | | | Water-Bearing Zone | | | |
|---|---|---|---|---|---|---|---|
| | | | | Shallow | Intermediate | Deep | Bedrock |
| Number of Samples | | | | 59 | 40 | 37 | 42 |
| Analyte | Fraction | GWQS | Units | Number of Samples Exceeding NJDEP GWQS | | | |
| ANTIMONY | T | 6 | µg/L | - | - | 3 | - |
| CHROMIUM | T | 70 | µg/L | 14 | 17 | 16 | 13 |
| NICKEL | T | 100 | µg/L | - | 1 | - | - |
| VANADIUM | T | 60 | µg/L | 1 | 1 | - | - |
| | | | | | | | |
| | | | | | | | |
| Number of Samples | | | | 6 | 5 | 1 | 0 |
| Analyte | Fraction | GWQS | Units | Number of Samples Exceeding NJDEP GWQS | | | |
| CHROMIUM | D | 70 | µg/L | 2 | 2 | - | - |

Notes:
D = dissolved fraction
T = total/unfiltered fraction
- = indicates no samples exceeded the NJDEP GWQS for this analyte in this water-bearing zone

### 5.1.2 Non- Chromate Chemical Production Waste Metals

Although the CCPW metals (Sb, Cr, Ni, Tl, and V) are included in the TAL metals analytical suite, they are discussed separately above because they are related to chromate ore processing operations. The remaining 19 TAL metals are the non-CCPW metals, and include: Ag, Al, As, Ba, Be, Ca, Cd, Co, Cu, Fe, Hg, K, Mg, Mn, Na, Pb, Se, Sr, and Zn. Groundwater analytical results for non-CCPW metals are presented on **Table 5-2**. The following table summarizes, by water-bearing zone, the total number of non-CCPW metals results from the groundwater RI data that were detected at concentrations greater than the applicable NJDEP GWQS. Because they are naturally occurring within the regional groundwater and are not indicative of site-related impacts, Al, Fe, Mn, and Na are not included on the table.

| | | | | Water-Bearing Zone | | |
|---|---|---|---|---|---|---|
| | | | | Shallow | Intermediate | Deep |
| Number of Samples[1] | | | | 23 | 24 | 10 |
| Analyte | Fraction | GWQS | Units | Number of Samples Exceeding NJDEP GWQS | | |
| ARSENIC | T | 3 | µg/L | 10 | 14 | 3 |
| CADMIUM | T | 4 | µg/L | - | 1 | 2 |
| LEAD | T | 5 | µg/L | 4 | 2 | 3 |
| STRONTIUM | T | 2000 | µg/L | - | 1 | - |
| | | | | | | |
| Number of Samples[2] | | | | 1 | 3 | 1 |
| Analyte | Fraction | GWQS | Units | Number of Samples Exceeding NJDEP GWQS | | |
| ARSENIC | D | 3 | µg/L | - | 2 | 1 |
| STRONTIUM | D | 2000 | µg/L | - | 1 | - |

Notes:
[1]Number of samples for Strontium total fraction: 15 shallow, 16 intermediate, 9 deep.
[2]Number of samples for Strontium dissolved fraction: 0 shallow, 1 intermediate, 0 deep.
D = dissolved fraction
T = total/unfiltered fraction
- = indicates no samples exceeded the NJDEP GWQS for this analyte in this water-bearing zone

### 5.1.3 Volatile Organic Compounds

Volatile organic compounds on or emanating from Site 114 may have multiple sources including the former MGP and other on-site and off-site sources. Groundwater analytical results for VOCs are presented on **Table 5-3**. The following table summarizes, by water-bearing zone, the total number of VOC results from the groundwater RI data that were detected at concentrations greater than the applicable NJDEP GWQS.

| | | | | Water-Bearing Zone | | |
|---|---|---|---|---|---|---|
| | | | | Shallow | Intermediate | Deep |
| Number of Samples | | | | 46 | 58 | 9 |
| Analyte | Fraction | GWQS | Units | Number of Samples Exceeding NJDEP GWQS | | |
| 1,1-DICHLOROETHYLENE | N | 1 | µg/L | - | 9 | 4 |
| 1,2,4-TRICHLOROBENZENE | N | 9 | µg/L | 1 | - | - |
| 1,2,4-TRIMETHYLBENZENE[1] | N | 100 | µg/L | - | 4 | - |
| 1,2-DICHLOROBENZENE | N | 600 | µg/L | 1 | - | - |
| 1,2-DICHLOROETHANE | N | 2 | µg/L | - | 5 | 1 |
| 1,4-DICHLOROBENZENE | N | 75 | µg/L | 1 | - | - |
| BENZENE | N | 1 | µg/L | 19 | 20 | 2 |
| CHLOROBENZENE | N | 50 | µg/L | 1 | - | - |
| CIS-1,2-DICHLOROETHENE | N | 70 | µg/L | - | 2 | 1 |
| ETHYLBENZENE | N | 700 | µg/L | - | 1 | - |
| STYRENE (MONOMER) | N | 100 | µg/L | 3 | 2 | - |
| TETRACHLOROETHENE | N | 1 | µg/L | 3 | 6 | 1 |
| TOLUENE | N | 600 | µg/L | - | 1 | - |
| TRICHLOROETHYLENE | N | 1 | µg/L | 2 | 6 | 1 |
| VINYL CHLORIDE | N | 1 | µg/L | - | 2 | - |
| XYLENES | N | 1000 | µg/L | - | 1 | - |

Notes:
[1]Number of samples for 1,2,4-trimethylbenzene: 32 shallow, 28 intermediate, 4 deep.
N = total/unfiltered fraction
- = indicates no samples exceeded the NJDEP GWQS for this analyte in this water-bearing zone

### 5.1.4 Semi-volatile Organic Compounds

Semi-volatile organic compounds on or emanating from Site 114 may have multiple sources including the former MGP, other on-site and off-site sources, and historic fill. Groundwater analytical results for detected SVOCs are presented on **Table 5-4**. The following table summarizes, by water-bearing zone, the total number of SVOC results from the groundwater RI data that were detected at concentrations greater than the applicable NJDEP GWQS.

| | | | | Water-Bearing Zone | | |
|---|---|---|---|---|---|---|
| | | | | Shallow | Intermediate | Deep |
| Number of Samples | | | | 46 | 60 | 9 |
| Analyte | Fraction | GWQS | Units | Number of Samples Exceeding NJDEP GWQS | | |
| 1,4-DIOXANE | N | 0.4 | µg/L | - | 10 | 5 |
| 2-METHYLNAPHTHALENE | N | 30 | µg/L | 1 | 7 | - |
| BENZO(A)ANTHRACENE | N | 0.1 | µg/L | 9 | 16 | 4 |

| | | | | Water-Bearing Zone | | |
|---|---|---|---|---|---|---|
| | | | | Shallow | Intermediate | Deep |
| Number of Samples | | | | 46 | 60 | 9 |
| Analyte | Fraction | GWQS | Units | Number of Samples Exceeding NJDEP GWQS | | |
| BENZO(A)PYRENE | N | 0.1 | µg/L | 2 | 5 | - |
| BENZO(B)FLUORANTHENE | N | 0.2 | µg/L | 1 | 5 | - |
| BENZO(K)FLUORANTHENE | N | 0.5 | µg/L | - | 3 | - |
| BIS(2-ETHYLHEXYL)PHTHALATE | N | 3 | µg/L | 1 | 1 | - |
| HEXACHLOROBENZENE | N | 0.02 | µg/L | - | 1 | 1 |
| INDENO(1,2,3-CD)PYRENE | N | 0.2 | µg/L | - | 3 | - |
| NAPHTHALENE | N | 300 | µg/L | - | 7 | - |
| 1-METHYLNAPHTHALENE | N | 5 | µg/L | 7 | 12 | - |
| PENTACHLOROPHENOL | N | 0.3 | µg/L | 2 | - | - |

Notes:
N = total/unfiltered fraction
- = indicates no samples exceeded the NJDEP GWQS for this analyte in this water-bearing zone

## 5.2 Additional Groundwater Investigations

### 5.2.1 Other Groundwater Investigations in the Project Area

Data from the following activities were used to supplement the groundwater RI data, as necessary, to delineate the nature and extent of groundwater impacts:

- Previous RI groundwater investigation activities performed from September 1, 2015 to September 2017, as described in the 2018 Draft Groundwater RI Report (AECOM, 2018b);
- Baseline groundwater monitoring for the Phase I IRM performed from December 21, 2017 to January 31, 2018 (ARCADIS, 2018);
- Groundwater monitoring performed by JCRA in Berry Lane Park at monitoring wells MW-CR-3I, MW-CR-7I, and MW-CR-8I in February 2018 (Dresdner-Robin, 2018);
- FerroBlack®-H PBR compliance monitoring (site-wide) performed between June and December 2016 (AECOM, 2016c and AECOM, 2017a).
- Installation of three soil borings to confirm depth to bedrock and overburden geology in the northwest corner of Site 114 (114-BSB-01, 114-BSB-02, 114-BSB-03);
- Installation of Phase II IRM monitoring wells and remediation wells;
- HPT and VAP conducted during implementation of the Phase II IRM drilling program;
- Baseline groundwater monitoring for the Phase II IRM performed from March 16, 2020 to March 27, 2020 (AECOM, 2020f);
- Installation of soil borings and HPT/VAP for the Hydraulic Fracture Pilot Test on Site 114 (AECOM, 2019m);

- Groundwater monitoring conducted at FS/FSP in February and March 2019 (AECOM, 2019e);
- HPT, VAP, and groundwater monitoring conducted at FS/FSP in March/April and September of 2020 (AECOM, 2020e and AECOM, 2020i);
- HPT and VAP conducted during the PDI for the Phase III IRM in September 2020 and December 2020 (AECOM, 2021a);
- HPT and VAP conducted on Site 199 in September 2020;
- Installation of four borings and three wells during the Phase III IRM PDI completed in January 2021; and
- FerroBlack-H® Permit-by-Rule monitoring in the following areas:
    - Forrest Street and Site 135 (May 2018 to March 2019) (AECOM, 2020e)
    - Carteret Avenue and Halladay Street North (July and August 2020) (AECOM, 2020i)
- Capillary rise groundwater monitoring (Site 114) completed between July and August 2020 (AECOM, 2020i).

Groundwater analytical results from these investigations have already been reported to the NJDEP in various data submittals, technical memoranda, and/or regulatory reports. The groundwater RI analytical results presented in Section 5.1 are integrated with these additional data into an updated CSM for the Project Area, discussed in Section 5.3. Comprehensive tables with Project Area groundwater analytical results that were collected during other programs but used in this RIR are presented in **Appendix L**.

### 5.2.2 Dense Non-Aqueous Phase Liquid Investigation

DNAPL has been encountered in multiple locations at the GA Group Sites (refer to **Appendix A**, which includes PSEG's 2014 Groundwater RIR and **Appendix Q**, which provides additional supporting information related to observations of DNAPL in the Project Area). PSEG has accepted responsibility for the investigation and remediation of MGP-related impacts in the Project Area.

Visual, olfactory, and field instrument observations collected from temporary screening locations DNAPL-S1 and DNAPL-W1 confirm the presence of DNAPL in the area around monitoring well 137-P3B-MW101I. Previous investigations performed by PSEG (refer to **Appendix Q**, which includes Figure 5 from PSEG's 2012 Remedial Action Work Plan Addendum and Figure 5-10 from PSEG's 2007 Remedial Investigation Report) identified DNAPL in the same area along Carteret Avenue. Fingerprint analysis results from the sample of DNAPL collected at well 137-P3B-MW101I by PPG indicate that the DNAPL is related to MGP impacts. Communications between PPG and PSEG document that PSEG has agreed to this conclusion and that PSEG has accepted responsibility for the investigation and remediation of MGP-related impacts. The laboratory analytical report for the DNAPL fingerprint sample and documentation demonstrating that PSEG has acknowledged that this DNAPL appears to be MGP-related are included in **Appendix Q**. These analytical data were transmitted to PSEG and no further DNAPL delineation work was performed by PPG.

### 5.2.3 Investigations on Forrest Street and Forrest Street Properties

An overview of previous work and findings of investigations conducted at FS/FSP between 2003 and 2015 is presented in the March 17, 2016 technical memorandum entitled Technical Memorandum *FOR-005 Additional Forrest Street Remedial Investigation – Soil & Groundwater* (AECOM, 2016a), previously submitted to NJDEP. Additional monitoring well installation and groundwater monitoring activities were completed at FS/FSP from 2016 to 2018 during implementation of the groundwater RI for the GA Group Sites. Results from the investigation activities conducted from 2016 to 2018 are documented herein. Several investigations were subsequently conducted on FS/FSP in 2019 and 2020 to further characterize groundwater conditions in this portion of the Project Area, including groundwater elevation gauging, continuous monitoring of groundwater elevations using pressure transducers at select wells, groundwater sampling, and completion of VAP and HPT borings along the sheet pile between FS/FSP and Site 114.

Activities, findings, and conclusions from the 2019 and 2020 investigations are documented in the following technical memoranda previously submitted to NJDEP and included in **Appendix A**:

- *Evaluation of Groundwater Conditions at Forrest Street and Forrest Street Properties, City of Jersey City, Hudson County, New Jersey*, dated May 22, 2019 (AECOM 2019b).
- *Summary of Field Activities and Results for Work Conducted at Forrest Street and Forrest Street Properties – March/April 2020, City of Jersey City, Hudson County, New Jersey (GW-092)*, dated May 29, 2020 (AECOM, 2020b).
- *Addendum to GW-092, Summary of September 2020 Field Activities and Results for Work Conducted at Forrest Street and Forrest Street Properties, City of Jersey City, Hudson County, New Jersey (GW-096)*, dated October 30, 2020 (AECOM, 2020g).

Key findings from the investigations conducted at FS/FSP include:

- Prior to the installation of sheet pile along the northern border of Site 114 and Forrest Street in September 2012, groundwater flow direction in the shallow water-bearing zone was primarily northeastward from Site 114 toward the 90 and 98 Forrest Street buildings with Cr-impacted groundwater flowing northeastward from Site 114 onto FS/FSP. Residual CCPW-related impacts to groundwater from this historical migration pathway remain on FS/FSP.
- The meadow mat/peat layer present beneath most of Site 114 was not observed north of Forrest Street. Historical topographic maps indicate that the area north of Forrest Street was not part of the salt marsh that was filled to create the properties currently located in the GA Group Sites south of Forrest Street.
- Vertical hydraulic gradients at FS/FSP are primarily downward, from the shallow water-bearing zone to the intermediate water-bearing zone.
- The direction of shallow groundwater flow at FS/FSP was affected by the installation of sheet pile on Site 114. Prior to the sheet pile installation, CCPW-impacted groundwater flowed from Site 114 onto FS/FSP. Installation of the sheet pile and addition of DGA above the meadow mat on Site 114 substantially limited this groundwater flow path.
- The groundwater flow regime established at FS/FSP after installation of the sheet pile on Site 114 is dynamic and influenced by local recharge, the sumps in the basement of the building at 90 Forrest Street, and localized vertical hydraulic gradients. Currently, the dominant components of groundwater flow onto FS/FSP are from the northwest (Site 199), and from the southeast within the areas influenced by pumping of the sumps at 90 Forrest Street.

- Based on the results of the VAP/HPT investigation conducted in 2020, migration of CCPW-impacted groundwater from Site 114 onto FS/FSP is not currently occurring either through, or under, the sheet pile installed on Site 114.
- Residual CCPW source materials remain in soils at FS/FSP and are contributing to groundwater impacts on FS/FSP.

Residual CCPW source materials remain in soils on Site 199 and are contributing to the migration of CCPW-related impacts in shallow and intermediate water-bearing zone groundwater from Site 199 onto FS/FSP.

## 5.3 Updated Conceptual Site Model

This CSM update integrates data collected during groundwater RI activities completed from 2017 to February 2021 with data from additional Project Area investigations to provide the most current understanding of Project Area geology, hydrogeology, source areas, and nature and extent of CCPW-related impacts to groundwater. The information presented in this CSM has been prepared in accordance with the NJDEP guidance document *Technical Guidance for Preparation and Submission of a Conceptual Site Model* (NJDEP, 2019b). As stated in the NJDEP Technical Guidance, the CSM is an iterative tool that is updated and refined as additional information becomes available during implementation of the RI or other activities. This CSM will be updated as necessary upon completion of subsequent investigation activities, the implementation of ongoing groundwater IRMs and their associated monitoring programs, and performance of ongoing soil remedial actions being conducted at the Project Area.

**Figure 4-1** depicts the location of soil borings, monitoring wells, HPT/VAP points, and other Project Area features. Ten fence diagrams were developed to depict interpreted subsurface conditions within the Project Area based on existing information derived from previous investigations as well as information generated during groundwater RI activities (**Figures 5-1 through 5-9**). Fence diagram alignments are depicted on **Figure 4-1**. The fence diagrams include the following:

- Current ground surface along the alignments;
- Interpreted subsurface lithology;
- Current location of sheet piling;
- Select monitoring wells situated along the alignments;
- Interpreted water table within the shallow water-bearing zone;
- Direction of vertical hydraulic gradients based on the 2018 synoptic gauging event;
- Index of hydraulic conductivity logs indicative of relative soil permeability for HPT locations situated along the alignments; and
- Total Cr concentrations at monitoring wells and interpreted isoconcentration contours.

### 5.3.1 Geology and Hydrogeology

Comprehensive discussions of Project Area geology and hydrogeology are presented in Sections 3.5 and 3.7, respectively.

### 5.3.2 Source Areas

The sources of CCPW-related impacts to groundwater in the shallow water-bearing zone in the Project Area (**Figure 2-1**) include:

- The former chromite ore processing facility on Site 114;
- The former stockpiles of CCPW, which consisted of:
  - A stockpile of COPR extending from the eastern portion of Site 114 southward onto Site 137 (north and south of Carteret Avenue); and
  - A stockpile of green-gray mud (GGM) immediately south of the processing facility (identified as the Light Toned Pile on **Figure 2-1**);
- Fill materials impacted with CCPW; and
- Fill materials, which included CCPW, used to abandon the former Morris Canal.

The former chromite ore processing facility operated on the northwestern portion of the Project Area from approximately 1909 to 1963. Waste materials produced at the facility included CCPW. Some CCPW was reprocessed, but the majority was stockpiled on portions of the Project Area. Historical information shows that the waste stockpiles were gone by 1958 and the chromite ore processing facility structures were demolished by 1966 (AECOM, 2009). While the above-grade structures associated with the former chromite ore processing facility were demolished, some residual source materials associated with this facility remain in the subsurface, including chromium-impacted soils. Soil remedial actions consisting of source material excavation and off-site disposal are currently ongoing. Other than the chromite ore processing operation and the related CCPW metals, there have been no other metals processing operations on Site 114.

Operations at the former chromite ore processing facility included extraction of Cr from Transvaal chromite ore to produce aluminum hydrate, sodium chromate, sodium bichromate, sodium sulfate, vanadium pentoxide, and potassium bichromate in solid form (ENSR, 2003). The liquid generated in the process by leaching the roasted ore contained chromate, aluminate, and vanadate among other ionic species. The ionic species in the liquid were separated, purified, dried, and packaged for sale using a variety of chemical and physical processes such as acid addition, precipitation, evaporation, filtration, crystallization, and drying. No liquid effluents (wastes) were generated from these processes. The residue remaining after the leaching of the roast (COPR) and GGM constituted the only wastes generated at the former plant.

### 5.3.3 Extent of CCPW Related Impacts to Groundwater

This section defines the extent of CCPW-related impacts to groundwater within the Project Area, with a focus on the distribution of Cr. Groundwater analytical results are compared to the NJDEP GWQS in accordance with N.J.A.C. 7:9C (NJDEP, 2020c) to delineate the extent of groundwater impacts within the Project Area. Currently there is no GWQS for $Cr^{+6}$; therefore, chromium-related impacts are evaluated using the GWQS for Cr of 70 µg/L and $Cr^{+6}$ data are not used to delineate the extent of impacts to groundwater. **Figure 5-10**, **Figure 5-11**, and **Figure 5-12** depict the horizontal extent of Cr in the shallow, intermediate, and deep water-bearing zones, respectively. **Figure 5-13** depicts the horizontal extent of Cr in the basal till/weathered bedrock. The vertical extent of Cr in groundwater within the Project Area is depicted on **Figures 5-1** through **5-9**.

### 5.3.4 Fate and Transport of Chromium in Groundwater

Fate and transport processes consider the source of contamination and the changes that take place in constituents and their concentrations as they move through environmental media. In general, Cr leached from source areas infiltrated into the subsurface and migrated downward through the unsaturated zone. Once within the saturated zone, migration occurs primarily along the prevailing direction of groundwater flow, either horizontally or vertically, depending on hydraulic conditions via either advection or diffusion based on soil type. When low-permeability soils are encountered, Cr-impacted groundwater may spread laterally along the permeability contrast or the Cr may diffuse into and, given sufficient time, through the lower permeability soil horizon. Back-diffusion of Cr from the lower-permeability soils into surrounding higher-permeability soils may also occur over time, depending on concentration gradients or hydraulic conditions. The implications of soil heterogeneities on the fate and transport of chromium in the Project Area, including an evaluation of the relationship between soil heterogeneities and fate and transport, and an evaluation of matrix diffusion effects, is presented in **Appendix E**. The presence of natural (meadow mat) and anthropogenic (MGP residuals) organic matter within soils may also impact the mobility of Cr in groundwater via reduction and precipitation.

No liquid wastes were generated from operations at the former chromite ore processing facility. Therefore, groundwater impacts related to liquid wastes that may have migrated via density-driven flow are not present on Site 114 or in the Project Area. To evaluate for the potential of density-driven flow of groundwater with high concentrations of Cr, groundwater samples were collected from select monitoring wells for analysis of specific gravity (**Table 5-8**). For reference, the standard of comparison for solids and liquids subject to a density test is water at 4 degrees Celsius, which has a density of 1.0. Based on these results, groundwater with high concentrations of Cr appears to exhibit a specific gravity equivalent to unimpacted groundwater; therefore, migration of Cr-impacted groundwater is not likely to occur via density-driven flow.

Despite the amount of time that has passed since the chromate ore processing facility was decommissioned, the Cr groundwater plume in the Project Area does not extend very far from the former source areas, even where preferential pathways exist, such as utilities or other anthropogenic features. This indicates significant attenuation stemming from the natural mechanisms that affect the migration of Cr in groundwater. The fate and transport of Cr-related impacts to groundwater for each of the water-bearing zones within the Project Area is presented in the following subsections.

#### 5.3.4.1 Shallow Water-Bearing Zone

Prior to source removal, shallow fill materials and CCPW-impacted soils above the meadow mat were sources of Cr impacts to the shallow water-bearing zone groundwater. At pH greater than 6.5, $Cr^{+6}$ present as the water soluble chromate anion $CrO_4^{-2}$ is the dominant Cr species in CCPW-impacted groundwater. $Cr^{+6}$ is a strong oxidant and is rapidly reduced in the presence of $Fe^{+2}$ ions and minerals, reduced sulfur, microbes, and organic matter (USEPA,1999). Total Cr is the sum of trivalent chromium ($Cr^{+3}$) and $Cr^{+6}$ species. $Cr^{+6}$ is generally more mobile in groundwater with the $Cr^{+3}$ form less soluble and less mobile. Mobility of Cr in groundwater is chemically controlled by conditions such as pH, Eh, competing anions such as sulfate, the presence of certain minerals, and organic matter. Cr-impacted groundwater migrated along downward vertical hydraulic gradients from the shallow water-bearing zone into the underlying intermediate water-bearing zone through gaps in the meadow mat (where present). Holes in the meadow mat can be attributed to natural drainage features that formed when the meadow mat was the surficial layer of an estuarine setting, prior to initial filling. In addition, the former Morris Canal bisected the Project Area and local areas of the meadow mat were removed during construction of the canal. Materials used to fill the canal, which included CCPW (primarily GGM), also serve as sources of groundwater impacts to the shallow water-bearing zone. Where meadow mat is present, the low permeability of the meadow mat limits vertical migration of Cr-impacted groundwater to underlying water-bearing zones. The meadow mat may also promote localized reducing conditions, where $Cr^{+6}$ is reduced to $Cr^{+3}$ and can complex to organic matter or precipitate out of solution. Meadow mat is a natural barrier to the migration of $Cr^{+6}$ in groundwater (Higgins,1998).

The shallow sources of Cr to groundwater are being eliminated as impacted shallow soils are removed and clean/amended fill is placed. Since 2010, soil remediation activities have removed the majority of the impacted shallow fill to the top of the meadow mat, or deeper where the meadow mat was not present. Backfill was amended with FerroBlack® H, an amendment that reduces $Cr^{+6}$ to $Cr^{+3}$. The reduction of $Cr^{+6}$ to $Cr^{+3}$ by ferrous iron is generally quite rapid, whereas the oxidation of $Cr^{+3}$ to $Cr^{+6}$ by soil manganese minerals or dissolved oxygen is quite slow. Thus, once impacted shallow soils are completely replaced by clean/amended fill, there will be no source of Cr to groundwater in the shallow water-bearing zone.

Current groundwater monitoring data indicate that soil remedial actions completed to date have significantly reduced Cr concentrations in the shallow water-bearing zone, with only a few localized areas remaining where Cr concentrations are greater than the NJDEP GWQS. The Cr concentrations in the shallow water-bearing zone are expected to continue decreasing as remediation activities progress.

#### 5.3.4.2 Intermediate Water-Bearing Zone

The primary source of Cr-impacts to the intermediate water-bearing zone is the overlying shallow water-bearing zone. Materials used to fill the former Morris Canal also serve as sources of impacts to the intermediate water-bearing zone. In the intermediate water-bearing zone, Cr migration occurs both horizontally and vertically, depending on hydraulic conditions. The sewer installed along Carteret Avenue appears to have served as a preferential pathway for migration of contaminants into downgradient areas to the east (Halladay Street and the Halsted Property) along the interface between the shallow and the intermediate water-bearing zones. Based on recent VAP data and groundwater analytical results, fine-grained, lower-permeability soils in the intermediate zone may be sequestering Cr within the soil matrix. Common soil minerals such as gibbsite ($Al_2O_3$), hematite ($Fe_2O_3$), pyrite ($FeS_2$), amorphous iron oxide ($Fe_2O_3$-$H_2O$), and silica ($SiO_2$) can absorb $Cr^{+6}$ or reduce the Cr oxidation state to $Cr^{+3}$. This change in Cr valence can precipitate Cr as insoluble $Cr(OH)_3$ or the Cr may become sorbed to other $Fe^{+3}$ minerals such as $Fe(OH)_3$ in solid mixtures (USEPA,1999). When the pH of the groundwater is between 5 and 12, this form of attenuation (i.e., $Cr^{+6} \rightarrow Cr^{+3} \rightarrow Cr(OH)_3$) by soil minerals can keep the dissolved $Cr^{+3}$ concentrations to below 50 µg/L (USEPA,1994).

While groundwater flux and Cr mass transport within low-permeability soils is expected to be low, these materials represent zones that may act to retain diffused Cr with the potential to discharge Cr into surrounding higher permeability soils over time. In northern portions of the Project Area (north of Carteret Avenue), the intermediate zone is less homogenous than in southern portions (south of Carteret Avenue), with layers of hydraulically-conductive sands and gravels interbedded with layers of finer-grained materials of lower permeability (silty sands, silts, and clays). In the southeastern corner of Site 114, the intermediate zone thickens near Carteret Avenue as the elevation of the bedrock surface lowers, with deposits becoming more homogeneous (sands and gravels prevail) and permeability increasing. South of Carteret Avenue and east of the former Morris Canal, the intermediate zone is characterized by thicker and more continuous sequences of silts and clays.

Where present, the interbedded silts and clays of the transition zone limit vertical migration of Cr-impacted groundwater into underlying soils.

Prior to placement of the sheet pile on Site 114, the declining bedrock surface, thickening and coarsening of intermediate zone deposits, and the presence of thick sequences of silts and clays south of Carteret Avenue shifted the intermediate zone groundwater flow pattern in the southeastern portion of Site 114 to the east/southeast, resulting in preferential contaminant migration into downgradient areas east of Site 114. Placement of the sheet pile and sealing of the sheet pile joints has significantly reduced horizontal migration into downgradient areas east of Site 114 within the intermediate zone.

Current monitoring data indicate that groundwater in the intermediate water-bearing zone is impacted by levels of Cr greater than the NJDEP GWQS, both within the GA Group Sites and in off-site areas. An overall improvement in groundwater quality with respect to Cr is evident at Site 114 in response to the soil remediation completed in the overlying shallow zone and implementation of the groundwater IRMs. Baseline data representative of groundwater conditions prior to full-system startup and operation of the Phase I and II IRMs were used to characterize the extent of Cr impacts to groundwater in the intermediate water-bearing zone. Operation of the groundwater IRMs is expected to affect future groundwater hydraulics and contaminant distribution within the intermediate water-bearing zone.

#### 5.3.4.3 Deep Water-Bearing Zone

The source of Cr impacts to the deep water-bearing zone is the overlying intermediate water-bearing zone. Migration of groundwater impacts from the intermediate water-bearing zone into the deep water-bearing zone occurs primarily along downward vertical hydraulic gradients within portions of the former Morris Canal, such as in the vicinity of wells 114-MC-PZ103 (intermediate zone well) and MW6C (deep zone well). Based on the distribution of Cr within the deep water-bearing zone, similar conditions can be expected in other portions of the former Morris Canal with Cr migration within the deep water-bearing zone primarily to the east-southeast along the prevailing direction of groundwater flow.

Similar to the intermediate water bearing zone, the deep water-bearing zone north of Carteret Avenue is less homogenous than in southern portions (south of Carteret Avenue), with layers of permeable sands and gravels interbedded with layers of finer-grained materials of lower permeability (silty sands, silts, and clays) overlying the basal till. In the southeastern corner of Site 114, the deep zone thickens near Carteret Avenue as the elevation of the bedrock surface lowers, with deposits grading into less permeable silts and clays underlain by basal till.

Where present, the lower-permeability unit separating the intermediate and deep water-bearing zones (the transition zone) attenuates the flux of Cr into the deep zone. For example, a downward vertical hydraulic gradient from the intermediate to the deep zone is evident at wells MW8D and MW8F; however, the concentration of Cr in well MW8D (intermediate zone) decreases with depth from 70,800 µg/L at 41 ft bgs to 1,398 µg/L at 45 ft bgs, with Cr detected at a concentration of 2 µg/L in underlying deep-zone well MW8F. Similar trends are evident at other well clusters with intermediate- and deep-zone monitoring well pairs (114-MW20B/C, MW4B/C, MW6B/C, MW7B/C). This indicates that Cr impacts are attenuated within the transition zone between the intermediate and deep water-bearing zones at these locations. These observations are consistent with results from the VAP borings completed at Site 114, many of which indicate decreasing concentrations of Cr with depth.

The bottom of the deep water-bearing zone consists of a layer of basal till sitting atop bedrock. The basal till is continuous across the Project Area and consists of dense and compact silty clays, sandy silts, and silty sands with subrounded to subangular fine to coarse gravel and cobbles and occasional interbedded lenses of clay, silt, or fine sand. Given this composition, the basal till limits vertical migration of Cr-impacted groundwater into the underlying bedrock by serving as an aquitard separating the overlying more permeable unconsolidated deposits from the bedrock. Sand stringers or lenses of sand within the basal till are evident in some borings (e.g., 114-MW49C, 114-MW56C, 114-MW57C, 114-MW60C, 114-MW62C, 114-MW66D). Of the approximately 390 ft of basal till logged within the Project Area, only 21 ft consisted of sand stringers or lenses, which equates to less than 6% of the basal till (**Appendix G**). The observed thickness of sand stringers or lenses within the basal till ranged from 0.2 feet to 6.5 feet. Where present, these higher permeability intervals within the basal till may serve as preferential migration pathways for Cr-impacted groundwater. This migration pathway is exemplified by visual observations at well 114-MW66D, where a 1-ft interval of loose fine-to-medium sand seeping yellow-colored water was observed in the basal till from 50 to 51 ft bgs. These higher-permeability zones within the basal till appear to be discontinuous or of limited extent, based on observations from boring logs across the Project Area. For example, at well 114-MW61C sand stringers were encountered within the basal till from 55 to 55.5 ft bgs and 60 to 61 ft bgs, whereas at nearby well 114-MW-66D sand stringers were encountered within the basal till only from 50 to 51 ft bgs. This finding is consistent with deposition in the glaciofluvial and glaciolacustrine environments that prevailed in the Project Area.

Groundwater conditions in the basal till are influenced by the shape of the bedrock surface. Based on the extensive monitoring well and remediation well network completed on Site 114 within the intermediate and deep water-bearing zones (hundreds of wells) and the 19 monitoring wells completed as part of the till/weathered bedrock investigation, basal till underlying the northwestern and eastern portions of Site 114 that contain elevated levels of Cr in groundwater does not exhibit Cr concentrations greater than the GWQS, demonstrating vertical attenuation of Cr as the overburden geology transitions into the basal till. This is evident at deep monitoring wells installed in the eastern portion of Site 114 (114-MW45C, 114-MW51C, 114-MW54C, and 114-MW59C) and in wells installed in the northwestern quadrant of Site 114 (114-MW48C, 114-MW49C, and 114-MW50C). In the central portion of Site 114, the basal till is encountered at shallower depths due to the bedrock high situated in this area (114-MW53C and 114-MW65C). In this area, the basal till is adjacent to higher-permeability deep-zone deposits with elevated concentrations of Cr in groundwater. Over time, migration of Cr-impacted groundwater into the basal till occurred to a limited extent horizontally via discontinuous sand stringers and vertically via diffusion. Similar conditions exist at well 114-MW63C, which is also situated in an area where the bedrock is higher than in surrounding areas.

Groundwater flow within the deep water-bearing zone is strongly influenced by the shape of the underlying bedrock surface. The bedrock high in the middle of Site 114 disrupts flow in the deep water-bearing zone effectively creating two migration pathways in the deep overburden: one from northwest to southeast around the bedrock high to the west and one from northwest to southeast around the bedrock high to the east. In the southwestern portion of Site 114 (west of the bedrock high), a localized bedrock valley creates a restricted flow regime, with groundwater flowing into the valley from upgradient areas to the north (near 114-MW67C) and discharging from the valley to the southeast over a rise in the bedrock surface in the vicinity of 114-MW57C. The southern limit of the valley coincides with the location of the former CCPW stockpile identified as the Light Toned Pile on **Figure 2-1**. Over time, the restricted groundwater flow regime in this area allowed for vertical migration of Cr-impacted groundwater into the basal till/weathered bedrock, as evidenced by the elevated Cr concentrations in wells 114-MW52C, 114-MW56C, 114-MW57C, and 114-MW61C. Migration of Cr within the basal till to the south of these wells (onto Site 132 and Site 143) is limited by the rising bedrock surface near well 114-MW4D (**Figure 5-7**) and is delineated by well 132-P3-MW001D (**Figure 5-13**). In the southeastern portion of Site 114 (east of the bedrock high), the declining bedrock surface, thickening of deep zone deposits, and the presence of less permeable materials south of Carteret Avenue shifted the deep water-bearing zone groundwater flow pattern to the east/southeast. Chromium concentrations in the deep water-bearing zone in this portion of Site 114 attenuate quickly as the deep zone deposits become lower in elevation and fall below the areas of impacted groundwater (**Figure 5-8, Figure 5-12**).

Current monitoring data indicate that groundwater in the deep water-bearing zone is impacted by concentrations of Cr greater than the NJDEP GWQS, both within the GA Group Sites and in off-site areas. An overall improvement in groundwater quality with respect to Cr is evident at Site 114 in response to implementation of the groundwater IRMs. Baseline data representative of groundwater conditions prior to full-system startup and operation of the Phase I and II IRMs were used to characterize the extent of Cr impacts to groundwater in the deep water-bearing zone. Operation of the groundwater IRMs is expected to affect future groundwater hydraulics and contaminant distribution within the deep water-bearing zone.

#### 5.3.4.4 Bedrock Water-Bearing Zone

Based on data collected to date, the only portion of bedrock groundwater within the Project Area which exhibits CCPW-related impacts is situated in the southwestern quadrant of Site 114. The source of bedrock groundwater impacts in the southwestern portion of Site 114 is the overlying overburden. Migration of groundwater impacts from overburden soils into the bedrock in this area occurs along downward vertical hydraulic gradients, such as in the vicinity of wells 114-MW57C and 114-MW57D. Chromium-impacted groundwater may also enter the bedrock horizontally in areas where the elevation of the bedrock fluctuates significantly, thereby placing bedrock in lateral contact with adjacent overburden soils, such as in the vicinity of wells 114-MW52D and 114-MW53C. Migration of Cr-impacted groundwater within weathered bedrock is similar to porous media due to the high degree of interconnectivity between the weathered bedrock elements. Zones of highly-weathered bedrock where the rock has higher clay content within fractures exhibit lower permeability with reduced potential for contaminant migration. Within competent bedrock, migration occurs along bedding planes and interconnected fractures, cracks, or voids in the rock.

Based on the results of the till/weathered bedrock and bedrock investigations, the following findings relate to the migration of Cr-impacted groundwater from overburden into bedrock within the Project Area:

- Vertical delineation of Cr-related impacts to groundwater within the overburden in the areas targeted by the till/weathered bedrock well installation program has been achieved in several locations by monitoring wells exhibiting concentrations of Cr that are either not detected or are less than the GWQS (**Figure 5-13**).
- Migration of Cr-related impacts in groundwater into the upper portion of the weathered bedrock was observed at monitoring wells 114-MW53C, 114-MW57C, and 114-MW61C (**Figure 5-13**). The weathered bedrock at 114-MW53C and 114-MW61C consists of highly fractured rock with varying degrees of clay content in the fractures, which is expected to limit the potential for vertical migration into the underlying competent rock. This conclusion is supported by findings at 114-MW61D, which is an open borehole bedrock well completed at elevations below the screened interval of 114-MW61C and exhibits concentrations of Cr that are either not detected or significantly below the GWQS.

- Cr-related impacts to bedrock groundwater were observed at wells 114-MW52D, 114-MW57D, and 114-MW66D (Figure P-5**, Appendix P**), with concentrations of Cr greater than the GWQS ranging from 82.4 µg/L to 46,500 µg/L. All of these wells were installed in the Lockatong Formation. Based on geophysical logging data, the Lockatong Formation strikes to the northeast and dips to the northwest at approximately 14 degrees. Primary fracture features within the formation also dip to the northwest at angles ranging from 10 to 20 degrees. A secondary set of fractures dip more steeply to the southeast at angles ranging from 60 to 80 degrees. Migration of Cr-impacted groundwater is expected to occur along these features within the bedrock.
- Upward hydraulic gradients from bedrock into the basal till at well pairs 114-MW45C/114-MW6D, 114-MW54C/114-MW7D, and 114-MW52C/114-MW52D limit the potential for downward migration of groundwater impacts from overburden materials into bedrock in these areas. Downward gradients from the basal till/weathered bedrock into the bedrock were observed in the southwestern corner of Site 114 at well pairs 114-MW57C/114-MW57D and 114-MW61C/114-MW61D (**Table 3-4**).

## 5.4 Evaluation of non-CCPW Constituents Emanating from Site 114

The main focus of RI activities in the Project Area has been the delineation of $Cr^{+6}$, CCPW, and CCPW-related materials. However, based upon PPG's former ownership of Site 114, RI activities also included sampling and analysis for non-CCPW compounds on and off Site 114. Non-CCPW constituents that may be on or emanating from Site 114 include the non-CCPW metals (Ag, Al, As, Ba, Be, Ca, Cd, Co, Cu, Fe, Hg, K, Mg, Mn, Na, Sr, Pb, Se, and Zn), VOCs, and SVOCs. PPG's responsibility for these compounds is limited to those found to be on or emanating from Site 114 and does not include exceedances of regulatory criteria in off-Site areas that are not emanating from Site 114. PSEG has accepted responsibility for the former MGP operations on the eastern portion of Site 114 and has conducted a comprehensive RI program to identify the nature and extent of the former MGP impacts.

An evaluation of non-CCPW constituents in groundwater that may have emanated, or are emanating, from Site 114 onto adjacent properties is included in **Appendix A** (AECOM, 2021b). Key findings from this evaluation include:

- The following non-CCPW constituents in groundwater have been determined to be emanating from Site 114 and related to former MGP operations on Site 114. MGP-related constituents will be addressed by PSEG pursuant to their NJDEP SRP case.
    - Arsenic
    - Lead
    - 1,2,4-Trimethylbenzene
    - Benzene
    - Ethylbenzene
    - Toluene
    - Xylenes
    - 1-Methylnaphthalene
    - 2-Methylnaphthalene
    - Benzo(a)anthracene
    - Benzo(a)pyrene
    - Benzo(b)fluoranthene
    - Benzo(k)fluoranthene
    - Indeno(1,2,3-c,d)pyrene

  - Naphthalene
  - Ammonia
  - Cyanide

- One additional non-CCPW constituent, tetrachloroethene, was determined to be emanating from Site 114 only in the shallow water-bearing zone at well 114-MW41A.

The NJDEP asserts that 1,4-dioxane is emanating from Site 114 onto adjacent properties within the intermediate water-bearing zone in the southeast corner of Site 114, downgradient of wells 114-P2B4-MW101I and 114-P2B4-MW102I and within the limited area between monitoring wells MW8D, 114-MW19B, 114-MW20B, and 114-MW40B. In addition, NJDEP considers the delineation of 1,4-dioxane in this area to be complete. PPG disagrees with the NJDEP's position that 1,4-dioxane is emanating from Site 114 in this area but concurs that the delineation of 1,4-dioxane is complete. Furthermore, PPG reserves the right to revisit this evaluation in the future.

# 6.0 Conclusions and Recommendations

## 6.1 Conclusions

The primary objective of this groundwater RI was to delineate the horizontal and vertical extent of CCPW-related impacts to groundwater within the Project Area. Delineation of the extent of groundwater impacts related to non-CCPW metals, VOCs, and SVOCs that are on or emanating from Site 114 was also within the scope of the groundwater RI due to PPG's brief ownership of the Site 114 property. This groundwater RI includes the shallow, intermediate, deep, and bedrock water-bearing zones.

Based on the data collected to date, the following conclusions pertaining to the distribution of CCPW-related impacts to groundwater are identified for the Project Area:

- Horizontal delineation has been achieved for the shallow, intermediate, and deep water-bearing zones in accordance the TRSR (NJDEP, 2012b).
- Horizontal delineation within bedrock has been achieved on the eastern and northern portions of Site 114. Additional delineation in the bedrock is required south of 114-MW57D and to the west of wells 114-MW52D, 114-MW57D, and 114-MW66D (**Figure 6-1**).
- Vertical delineation within the overburden has been achieved in several parts of the Project Area; however, additional vertical delineation is required in bedrock in the southwestern portion of Site 114 within the area bounded by monitoring wells 114-MW67C, 114-MW65C, 114-MW53C, 114-MW57D, 114-MW68C, and 114-MW66D (**Figure 6-1**).

Based on the data collected to date, the following conclusions pertaining to non-CCPW metals, VOCs, and SVOCs that are on or emanating from Site 114 are identified for the Project Area:

- The constituents emanating from Site 114 have been identified and the horizontal and vertical extents of these constituents have been delineated.

## 6.2 Recommendations

The following recommendations are identified for the Project Area:

- A limited bedrock investigation should be conducted in the southwestern portion of Site 114 and northern portions of Site 143 and Site 132 (**Figure 6-1**) to complete the delineation requirements of the TRSR (NJDEP, 2012b).

Pursuant to this recommendation, a Scope of Work for additional bedrock remedial investigations in the Project Area was developed and submitted to NJDEP for review and approval on April 22, 2021. NJDEP provided comments on the proposed scope of work on July 30, 2021 and PPG responded to comments on August 17, 2021. PPG anticipates implementing the proposed scope of work in Fall of 2021. Documentation of the additional investigation activities and associated findings will be submitted to NJDEP as an addendum to this groundwater RI report.

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Grid P41A (AOC HSS-1A), Hudson County Chromate (HCC) Site 114 – Garfield Avenue Site (specific to Halladay Street South), Portion of Halladay Street between Caven Point Avenue and Carteret Avenue. June 30, 2020.

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