Appendix C

Geotechnical Evaluation of Active Remedies at Hudson County Chromate Site 199

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Memorandum

Subject	Geotechnical Evaluation of Proposed Groundwater Treatment within Site 199 and Forrest Street Properties – Phase III Groundwater Interim Remedial Measures PPG Garfield Avenue Group, Hudson County Chromate Sites, Jersey City, New Jersey
Date	October 4, 2021

1. Introduction

On behalf of PPG, AECOM has prepared this technical memorandum to document the geotechnical evaluation of interim remedial measures (IRMs) proposed to address groundwater impacts at Site 199 and Forest Street Properties. Site 199 is located adjacent to the Hudson County Chromate Site 114, which is part of the Garfield Avenue (GA) Group Sites in Jersey City, Hudson County, New Jersey (NJ) (Project Area). Site 199 is part of the broader Phase III IRM area (see **Figure 1)** that includes select water-bearing zones outside of Site 114 and strategic areas of the lower portion of the deep water-bearing zone within Site 114.

Site 199 is adjacent to the NJ Transit Hudson-Bergen Light Rail (HBLR) tracks between Garfield Avenue and Halladay Street and the Forrest Street Properties which is referred to as “Target Area 1” in the April 20, 2021 Discharge to Groundwater Permit-By-Rule (PBR) Authorization Request (AECOM, 2021b). The objectives of the geotechnical evaluation (documented below) are: to determine if the IRM implementation can cause ground deformations (or pose other risks) that would disrupt HBLR operations; and to identify mitigation, limits, and controls that would facilitate safe implementation of the IRM at Site 199.

This technical memorandum provides the following information:

- Background information including a description of subsurface conditions and ground movements that occurred at the HBLR during Site 114 remediation (**Section 2**);
- Description of the Site 199 proposed IRMs and identification of potential risks to the HBLR posed by each activity (**Section 3**);
- Evaluation of the risks identified and the limits of controls required to mitigate those risks (**Section 4**);
- Geotechnical recommendations regarding IRM implementation (**Section 5**); and
- References for documents that are cited in the memorandum (**Section 6**).

2. Background

This section provides information on the geology and hydrogeology of the Project Area as well as a description of the previously observed settlement and vibration in the vicinity of the HBLR tracks during the installation of a shoring systems (sheet pile) and soil excavation conducted as part of the Site 114 remediation. This section also provides a discussion of the completed Phase I and ongoing Phase II groundwater IRMs.

The groundwater Cr plume within Site 199, which is the focus of the Phase III IRM, includes areas beneath the HBLR from Garfield Avenue to the Forest Street Properties. Sheet pile installed during the Site 114 remediation forms the boundary between Site 199 and Site 114. The HBLR tracks and catenary structures are elevated on an earth embankment supported by a concrete block retaining wall. The embankment and retaining wall slope upward as the track approaches the Garfield Avenue bridge crossing.

2.1 Project Area Geology and Hydrogeology

The Project Area is located on miscellaneous fill material that was used to reclaim the salt marsh for the construction of this portion of Jersey City. Native materials beneath the fill include an organic meadow mat layer, unconsolidated deposits of glacial origin, and bedrock. The geology within the Project Area consists of:

- Fill (*the shallow zone*), comprised of:
  - Non-native fill materials in areas where soil remediation is not needed or has not yet been implemented. Native fill is present beneath Site 199 (north of the sheet pile).
  - Clean fill (unamended or amended with FerroBlack®-H reductant) where the previously existing non-native fill materials and subsurface structures were excavated to remove sources of chromium (Cr). Clean fill is present beneath Site 114 (south of the sheet pile).
- 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);*
- 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);* and
- Underlying the overburden, bedrock of the Lockatong and Stockton Formations with a diabase sill intruding into the Lockatong formation along the western edge of the Project Area (*the bedrock zone*).

Groundwater in the Project Area occurs within distinct hydrostratigraphic water-bearing zones (units), as follows:

- *Shallow Water-Bearing Zone*: includes groundwater present in the fill from the water table to the top of the meadow mat. Where the fill was excavated during soil remediation, the backfill is a more uniform dense-graded aggregate (DGA) material or DGA amended with FerroBlack®-H (A-DGA). 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:* includes groundwater present in the meadow mat, the underlying sand unit, and the transition zone. 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. Where present, the transition zone 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. South of Carteret Avenue, the deep zone becomes more difficult to differentiate from the intermediate zone as both zones grade into thicker sequences of lower conductivity materials such as silts, clays, and fine sands with silt and clay. 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. Groundwater flow within the bedrock occurs only within interconnected bedrock fractures, bedding planes, cracks, and voids. Yields from bedrock wells in the Project Area are low (0.02 to 0.05 gallons per minute [gpm]). Groundwater flow in bedrock is a small fraction of the total groundwater flux through the Project Area.

The locations of two lithologic cross sections within Site 199 are shown on **Figure 2**. Cross sections depicting the geologic units and groundwater table are included on **Figure 3A** and **Figure 3B**. Results from geotechnical borings installed near or within Site 199 are included in **Attachment 1**.

2.2 Previously Observed Light Rail Ground Movements

Remediation activities, including the installation of sheet pile and excavation at Site 114, took place between 2013 and 2014 as a part of Phase 1C and Phase 2B-1. Site 114 is located at the intersection of Garfield Avenue and Carteret Avenue and the New Jersey Transit Right-of-Way (ROW) is located on the northwest boundary of Site 114. The HBLR runs within the ROW and the sheet pile installation and excavations occurred approximately 45 feet from the HBLR. This section describes movement and vibrations that occurred associated with the installation of the shoring systems (sheet piles) and the soil excavations.

2.2.1 Ground Movements During Shoring Installation

Sheet piles were installed parallel to the HBLR from April 25 to 29, 2013. During this time, a total of 39 sheets comprising approximately 162 linear feet to depths of 38.5 to 42.5 feet below ground surface were installed using a vibratory hammer. Two seismographs were used to continuously monitor vibration. These monitors were placed at the base of the retaining wall near RW-E and CP-H (see **Figure 4**). During this installation period, the vibration warning action limit of 0.5 inches/second and the stop work limit of 2.0 inches/second were exceeded. The maximum vibration observed was 2.5 inches per second.

Movement stop work levels (i.e., ±0.04 feet) at the retaining wall were exceeded on April 29, 2013 and work was subsequently stopped. The most significant movement along the retaining wall was observed within Row G. Movement at this location was measured as follows:

- Northing: -0.19 feet (movement towards the Site)
- Easting: -0.07 feet (movement towards Garfield Avenue)
- Elevation: -0.14 feet (movement downward)

Movement at the railroad ties was also observed as follows:

- Northing: -0.04 feet (movement towards the Site)
- Easting: 0.0 feet (i.e. no movement towards Garfield Avenue)
- Elevation: -0.01 feet (movement downward)

Settlement monitoring continued after the work stoppage at an increased frequency starting the week of April 29, 2013. The monitoring indicated slow, small-scale movement of the retaining wall, railroad ties, and catenary structures in a southerly direction (towards the Site) during the week of April 29 to May 5, 2013. Separation on the back side of the retaining wall between the wall and a concrete swale that runs behind the top of the wall, and between the concrete swale and the ground surface, was also visually observed during the week of April 29 to May 5, 2013. Sheet pile installation locations and indications of observed movement are shown on **Figure 4**.

As a result of the vibrations and settlement observed during the sheet pile installation, a revised design was developed. Shoring installation resumed on August 26, 2013 and was completed on October 4, 2013. During this time, sheet piles were installed using an ABI hydraulic press to reduce vibrations. No stop work exceedances of vibration or movement were observed during the use of the hydraulic press to install sheet piles.

The ground movement was likely due to vibration-induced consolidation of the loose fill, meadow mat soil, and loose soil lenses in the intermediate zone. Soil shifting during pre-drilling and excavation of obstructions along the shoring alignment may also have caused the movements.

2.3.2 Ground Movement During Excavations

On November 22, 2013, soil excavation between the permanent and temporary sheet pile began in Grid D. The excavation progressed west to east, with backfilling following excavation. Excavation between the sheet piles progressed slowly due to the need to iteratively install levels of bracing and the tight working environment between the sheet piles and bracing.

In mid-December 2013, AECOM observed an increase in the movement trend (as observed at settlement monitors) that appeared to be related to the ongoing excavation work. This trend slowed in late December, but movement (at a lower rate) was still observed (even in areas that had been backfilled) into January 2014. On January 17, 2014, a sudden increase in movement was observed over the course of the afternoon and evening. The excavation was backfilled and work was stopped.

Settlement monitoring was conducted on the retaining wall, rail lines, catenary structures, sheet pile, and nearby structures during the excavation work. Manual measurements were collected from March 26, 2013 to July 1, 2013 and real-time measurements began on July 1, 2013. From March 26, 2013 to January 21, 2014, the following minimum and maximum movements were observed:

Settlement Monitoring Results – March 26, 2013 to January 21, 2014

Prism Location	Southing (inches)		Elevation (inches)	
	Minimum	**Maximum**	**Minimum**	**Maximum**
Sheet Pile	0.58 (SP-F)	1.39 (SP-H)	-0.013 (SP-H)	-0.99 (SP-I)
Retaining Wall	1.2 (RW-D)	4.94 (RW-G)	-0.12 (RW-D)	-3.02 (RW-G)
Rail Line	0.48 (RR-D)	2.14 (RR-I)	-0.002 (RR-L)	-0.73 (RR-I)

Loose soils along the HBLR embankment may have shifted in response to the sheet pile deformations resulting in the even greater movements observed the retaining wall and rail line presented in the table above.

2.3 Phase I and II Groundwater IRMs

The three IRMs (implemented, Phase I; ongoing, Phase II and Phase III), that are being implemented under PBR authorizations issued by the New Jersey Department of Environmental Protection (NJDEP), use a combination of demonstrated active remediation technologies, including in situ anaerobic bioprecipitation (ISAB) and in situ chemical reduction (ISCR), to achieve the IRM objectives (i.e., to treat Cr and hexavalent chromium [Cr^{+6}] concentrations in groundwater).

During Phase I and Phase II IRMs, both injection and extraction wells were used to balance the water table and help spread the injected fluids throughout the groundwater table. During the injection process, some break out or mounding was observed at the injection points. This was typically observed at the location of the injection well where the injection caused the water level to rise to the surface and fluid was observed breaking out or mounding at the surface. On rare occasions, mounding was observed approximately 10 to 20 feet away from the injection well. Mounding was more common in areas where wells were installed in rows, which resulted in a more localized injection zone. The surface mounding is impacted by the injection pressure and volume, as well as the site geology. The fluid will flow through a zone of preferential flow and potentially emerge at the surface. During the Phase I and II IRM phases, extraction wells were located hundreds of feet from the injection wells; due to this distance, the extraction wells are not expected to have a significant impact on mounding effects. Extraction wells will not be used in the Phase III IRM.

3. Summary of Site 199 Phase III IRM

As presented in the PBR authorization request for the Phase III IRM, the planned strategy for Site 199 (Target Area 1) includes in situ reagent injections using a permanent well network screened at target depths or direct push reagent injections. Injection of three different types of reagents (molasses and emulsified vegetable oil (EVO), calcium polysulfide (CPS), and FerroBlack®-H) are contemplated for select areas or portions of the shallow, intermediate, and deep injection wells as shown on **Figures 5** through **7**.

The following subsections present the planned strategy for Site 199, including injection flow rates, pressures, and total volumes for the three reagent types and identify potential risks to the HBLR operations posed by the reagent injection activities.

3.1 Molasses and Emulsified Vegetable Oil (EVO)

The Site 199 Phase III IRM proposes injection of a molasses and EVO solution at individual wells with flow rates that vary from 0 to 1.5 gpm based on experience gained during the Phase I and II IRMs. Injection pressures will not exceed 25 pounds per square inch (psi) based on the depth of injection and the response of the treatment zones to injection flows and pressures. The following injection volumes are proposed at Site 199 (Target Area 1):

Proposed Injection Volumes: Target Area 1

Water Bearing Zone	Local Maximum Injection Solution Volume (Gallons)		Number of Injection Wells
	Molasses (0.05%)	EVO (1.5%)	
Shallow	47,000	9,000	7
Intermediate	1,400,000	230,000	24
Deep	13,000	3,000	4
Contingency	1,460,000	242,000	

3.2 Calcium Polysulfide (CPS)

CPS provides ISCR of constituents of concern. A CPS solution may be substituted for up to 50% of the anticipated injection volume of molasses if baseline or treatment monitoring data suggest the presence of areas of elevated Cr^{+6} concentrations (i.e., greater than 1,000,000 micrograms per liter [µg/L]). If employed, the CPS solution will be injected using the same injection flow rates and pressures as molasses.

3.3 Potential Risks to HBLR Operations – Molasses, EVO, and CPS

Implementation of the molasses, EVO and CPS injections would pose the following risks to HBLR operations:

- Track fouling during injection well installation – A drill rig will work close to the HBLR retaining wall. If the drill rig tipped over with the mast up, it could cross the track or catenary lines.
- Ground movement during injection well installation – Drilling techniques including sonic drilling may generated ground vibrations that could cause soil movement beneath the retaining wall and tracks.
- Ground movement from groundwater mounding – Injection of the molasses and EVO solution will cause a temporary rise in the water table. If the rise in water table saturates soils that are not saturated by normal water table fluctuations, the soils will consolidate under the changing effective stress as the water table recedes; this may cause settlement of the retaining wall and tracks.

3.4 FerroBlack®-H

FerroBlack®-H is a proprietary reagent of Redox Solutions, LLC, and is a reductive, colloidal suspension of soluble and insoluble iron sulfides. In areas planned for FerroBlack®-H treatment, the reagent will be delivered into the target zones to establish a reducing environment within the zone of influence of the injected material.

Injection wells will be pre-drilled using roto-sonic (sonic) drilling technology. At each location, after logging and photographing the soil to the target depth, the evacuated borehole will be backfilled with hydrated bentonite to seal the borehole wall. A direct push rig will then be used to install probe rods fitted with specialized tips to push through the column. The tool head will be customized for directional injections. Wells will be installed in transects spaced 25 feet on center with three nested well installations completed in each transect. Each boring will have five injection intervals with an injection interval range of 40 to 65 feet. The injected reagent slurry may include up to 54,000 gallons of water and 285,000 pounds of FerroBlack®-H.

The proposed injection flow rates can be up to 280 gpm with injection pressures up to 2,000 pounds per square inch gauge (psig). Based on the existing site geology, it is anticipated that the system will operate at flows of 70 to 200 gpm and pressures of 500 psig realized in the subsurface (not including system pressure losses).

3.4.1 Potential Risks to HBLR Operations - FerroBlack®-H

Implementation of the FerroBlack®-H injection would pose the following risks to HBLR operations:

- Track fouling during injection well installation;
- Ground movement during injection well installation;
- Ground movement from groundwater mounding; and
- Changes to the soil structure – High pressure is used to loosen the soil and allow the FerroBlack®-H slurry to permeate the pore space surrounding the injection point. The initial pressure gradient at the injection point may result in critical pore pressure gradients and temporary soil liquefaction. As the slurry flows into the surrounding soils and pressures dissipate, soil heave or expansion may occur. Both the localized liquification and heave may cause retaining wall, catenary structure or track movement.

4. Risk Evaluation and Mitigation

Four specific types of risks to the HBLR operations posed by the Site 199 Phase III IRM are identified in **Section 3**. They include:

- Track fouling during injection well installation;
- Ground movement during injection well installation;
- Ground movement from groundwater mounding; and
- Changes to the soil structure.

Each risk is evaluated and mitigation measures are identified in the following subsections.

4.1 Track Fouling During Inject Well Installation

Given the proximity of the proposed injection wells and points (for the three proposed reagent types) to the retaining wall and tracks, there is potential for track or catenary line fouling. The track fouling risk can be mitigated by maintaining drill rig masts below the fouling zone. If the rig mast must extend into the fouling zone, then the railroad operator would be notified and a flagger may be required to direct train traffic during the drilling activities. In addition, measures to ensure the rig is level and properly stabilized with outriggers would be implemented.

Soil borings and monitoring wells have been installed in Site 199 without incident. The track fouling risk does not preclude implementation any of the three reagent injections if proper planning and mitigation measures are in place during the well or injection point installation.

4.2 Ground Movement During Injection Well Installation

Sonic drilling techniques that generate ground vibration may be used to install injection wells or points for the three reagent types. As noted above, the loose soils beneath the HBLR are susceptible to vibration-induced movements. However, the ground vibrations caused by sonic drilling are typically much less than those generated by sheet pile installation. If injection wells and points must be installed with sonic drilling, then a vibration monitoring program should be implemented during the well installation to ensure that vibration levels are less than prescribed thresholds where ground movement may occur.

4.3 Ground Movements from Groundwater Mounding

The proposed injection volumes for the three reagents are sufficient to generate a groundwater mound. As described above, temporary groundwater mounding beyond normal water table fluctuations may cause settlement of the retaining wall and tracks as the mounded water table recedes.

To determine the potential for the three proposed reagent injection types to create a groundwater mound above normal water table fluctuation and induce settlement, historical water levels were reviewed to establish the fluctuation range. In addition, groundwater modeling simulations were conducted to estimate the extent of the water level mound that would occur from the molasses EVO or CPS injections. These are described in the following subsections.

4.3.1 Review of Historical Water Levels

Groundwater levels were measured in the vicinity of the Site 199 beginning in 2004. Discrete water level measurements taken from the shallow wells range from elevation 2.5 feet in the North American Vertical Datum of 1988 (NAVD88) to elevation 13.2 feet (NAVD88). Statistical review of the data in the Site 199 area show that the water level is below elevation 11.2 feet NAVD88 90% of the time.

During 2015 and 2016, a capillary rise study was performed to support the design and use of a capillary break at the Project Area to prevent potentially impacted groundwater from reaching the surface through capillary action (AECOM, 2017). Pressure transducer data collected during the capillary rise study were analyzed to estimate the natural range of water table fluctuations and the water table rise in response to rainfall events. Five wells were selected for this analysis including three near Site 199 that are within sheet piles and two to the southwest, further from Site 199, that are located outside of the sheet piles. The table below shows the minimum, maximum, and range of water levels for each of the five selected wells for the period from June through October of 2016. The range of the water level fluctuation within the wells during this timeframe fluctuated between 1.73 and 4.08 feet with a maximum water level elevation of 9.72 feet NAVD88 and a minimum value of 5.64 feet NAVD88.

Range of Water Levels

Well ID	Inside Sheet Piles	Min Water Level (ft NAVD88)	Max Water Level (ft NAVD88)	Range (feet)
132-P3A-MW104S	No	6.99	9.25	2.26
PZ1	Yes	5.64	9.72	4.08
114-P1C-MW101S	Yes	6.73	8.85	2.12
114-P2B1-MW101S	Yes	5.96	8.65	2.69
137-P3B-MW102S	No	6.88	8.61	1.73

Note: ft NAVD88 = feet in the North American Vertical Datum of 1988

The water level response to several rainfall events was evaluated by comparing each rainfall event to the corresponding water level rise at each well. The projected baseline water level in the following table reflects the expected water level extrapolated from the trendline of the available dataset. The peak water level is the highest water level measured after the rainfall event. The two wells outside the sheet piles showed 7.14 and 14.33 inches of water table rise for each inch of rainfall. The water table rise within the three wells within the sheet piles, located closer to Site 199, ranged from 12 to 20 inches of rise for each inch of rainfall. Because some runoff gets trapped within the sheet piles, recharge to groundwater in wells within the sheet pile may be higher than what is expected at Site 199. A summary of the water table fluctuations in response to rainfall events is shown in the following table:

Water Table Fluctuations in Response to Rainfall Events

Well ID	Inside Sheet Piles	Projected Baseline Water Level (ft NAVD88)	Peak Water Level Time After Rainfall	Peak Water level (ft NAVD 88)	Increase (inches)	Rainfall (inches)
132-P3A-MW104S	No	7.83	7/10/2016 7:00	8.00	2.00	0.28
PZ1	Yes	6.46	7/26/2016 22:00	8.09	19.54	0.99
114-P1C-MW101S	Yes	7.40	7/26/2016 0:00	8.39	11.85	0.99
114-P2B1-MW101S	Yes	6.57	7/27/2016 20:00	8.18	19.34	0.99
137-P3B-MW102S	No	7.40	7/26/2016 7:00	8.58	14.19	0.99

Note: ft NAVD88 = feet in the North American Vertical Datum of 1988

Based on the review of the groundwater elevation data, an injection-induced groundwater mound maintained below elevation 11.2 feet NAVD88 would be within the water table fluctuation range and would not cause settlement.

4.3.2 Groundwater Modeling – Molasses/EVO and CPS Injections

A numerical groundwater model was created for the Project Area using the United States Geological Survey (USGS) software MODFLOW-USG Transport with the Groundwater Vistas graphic user interface. This model was developed to advance the Phase III IRM design and was used to assess the potential for mounding due to Phase III injections at Site 199. Model simulations were created to evaluate an injection system that would only allow a maximum of 1 foot of mounding (conservative assumption) at the wells to minimize the potential for saturation of fill beneath the light rail tracks which could cause movement (settlement).

The Phase III IRM design for Site 199 includes the following injection wells – four in the shallow water-bearing zone (WBZ), 14 in the intermediate WBZ, and two in the deep WBZ. In addition, during the operation of these injection wells, four injection wells in the intermediate WBZ in Forrest Street would be in operation, as well as (potentially) some select wells along Carteret Avenue.

Model simulations included several scenarios, each evaluating combinations of these injection wells operating concurrently or in series. Each model simulation began with all wells injecting at 0.6 gpm for 90 days. **Figure 8** shows mounding contours for the scenario with only the Site 199 wells in operation, which resulted in a maximum of 2.21 feet of mounding. **Figure 9** shows mounding contours for the scenario with Site 199 and Forrest Street wells in operation, which resulted in a maximum of 2.28 feet of mounding. Based on a simulation of only the selected Carteret wells in operation, the estimated contribution from those wells to groundwater level increase at Site 199 was less than 0.2 feet.

Based on these model simulations (which do not meet the criterion for a maximum of 1 foot of mounding), several additional simulations were performed iteratively, whereby the injection rates were reduced to limit mounding to below 1 foot, while still achieving adequate reagent spread around the injection wells. Through these simulations it was estimated that by reducing the injection rates in all Site 199 wells from 0.6 gpm to 0.3 gpm, the mounding would be reduced to less than 1 foot and adequate reagent spread would be achieved to cover the target areas in the shallow, intermediate, and deep WBZs. **Figure 10** shows mounding contours and reagent concentrations after 90 days with Site 199 wells injecting at 0.3 gpm and Forrest Street wells injecting at 0.6 gpm. **Figure 11** shows mounding contours and reagent concentrations after 90 days with Site 199 wells injecting at 0.3 gpm and Forrest Street and selected Carteret wells injecting at 0.6 gpm. Both of these scenarios satisfy the mounding criteria and adequate reagent concentration spread.

Based on the review of the historical groundwater levels and the groundwater model simulations, the molasses and EVO or CPS injections (at flow rates of 0.3 gpm to 0.6 gpm) would not generate a groundwater mound beyond normal water table fluctuations and would not cause ground movements beneath the HBLR. Groundwater level response to the relatively low injection rates will be gradual so that groundwater monitoring in piezometers screened around the injection zones can be conducted during injection to ensure the mounding is maintained below elevation 11.2 feet NAVD88. If water levels in the piezometers approach this level, then injection can be stopped, or the rate further reduced. A detailed water level monitoring plan should be developed as part of the final design for the EVO or CPS injections.

Given the high injection pressures and flow rates required deliver the FerroBlack®-H slurry, the resulting groundwater level response to the injection could not be simulated with the groundwater flow model. The FerroBlack®-H slurry (54,000 gallons of water and 285,000 pounds of FerroBlack®-H) will be injected over approximately 10 days. The resulting response in groundwater levels is likely to be rapid and could exceed the 11.2 feet NAVD88 threshold. Groundwater level monitoring may not identify elevated groundwater levels in time to shut down the injection and prevent the groundwater levels from exceeding 11.2 feet NAVD88.

4.4 Changes to the Soil Structure

The risk of change to the soil structure does not preclude the use of the molasses and EVO or CPS injections. These injections are at sufficiently low flow rates and pressure so that soil pore space and grain structure would not be altered.

The proposed FerroBlack®-H injection (flow rates of 70 to 200 gpm and pressures of 500 psig) will initially loosen the soil around the injection points. Pressure gradients in the pore spaces may become critical (i.e., vertically upward) causing localized soil liquefaction. **Figure 12** shows the stress distribution from the HBLR embankment within the underlying soils. The stress distribution contours (percent of total embankment load developed from Boussinesq theory) shows that soils within the proposed FerroBlack®-H injection zone are supporting the embankment. Localized liquefaction caused by the high-pressure injections would result in embankment settlement.

As the FerroBlack®-H slurry is forced into the pore spaces, soils may expand or shift. Injection pressures may erode and displace fine-grained particles in the treatment zone causing additional heave and soil movement within the soils that are supporting the embankment.

Initial soil movement in response to the injection is likely to be rapid and may continue after injection has stopped. Settlement monitoring along the retaining wall and tracks would be unable to identify problematic ground movements in time stop the injection and halt the movements.

AECOM performed a pilot test to evaluate FerroBlack®-H emplacement through hydraulic fracturing of low-permeability layers at the southeast corner of Site 114 (AECOM, 2019). Tilt meters at the ground surface detected small movements (less than an inch) during the pilot injection. Lithology within the injection zone (low-permeability soils) is not similar to the Site 199 injection zone and the injection methods used in the pilot test (injection of a thin layer of reagent within the low permeable stratum) are not the same as those proposed at Site 199 (injection is a slurry across a three- to five-foot interval).

5. Conclusions and Geotechnical Recommendations

Based the review of the Site 199 subsurface conditions, a review of previously observed ground movements, and the evaluation of the potential risks identified for each of the proposed reagent injections, AECOM recommends that the Site 199 Phase III IRM proceed as follows:

- Molasses and EVO or CPS injection and monitoring wells should be installed in a manner that addresses the risks of track fouling. If a drill rig mast needs to extend into the fouling zone, the HBLR operator should be notified and rail operator procedures must be followed.
- If sonic drilling is required to install injection or monitoring wells, then a vibration monitoring plan should be developed and implemented during the well installation.

- A groundwater level monitoring plan should be developed and implemented to ensure the molasses and EVO or CPS injections do not result in groundwater mounding above elevation 11.2 feet NAVD88.
- Initial molasses and EVO or CPS solutions injection rates should be at or less than 0.3 gpm and should be adjusted, as necessary, based on the groundwater level monitoring results. Injections should take place during periods of lower groundwater elevation, if possible.
- Injection of the FerroBlack®-H slurry should not be attempted at Site 199.

6. References

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Arcadis, 2021. *Groundwater Interim Remedial Measure Phase I Quarterly Report – Fourth Quarter 2020, Garfield Avenue Group Site 114.* February 23, 2021.

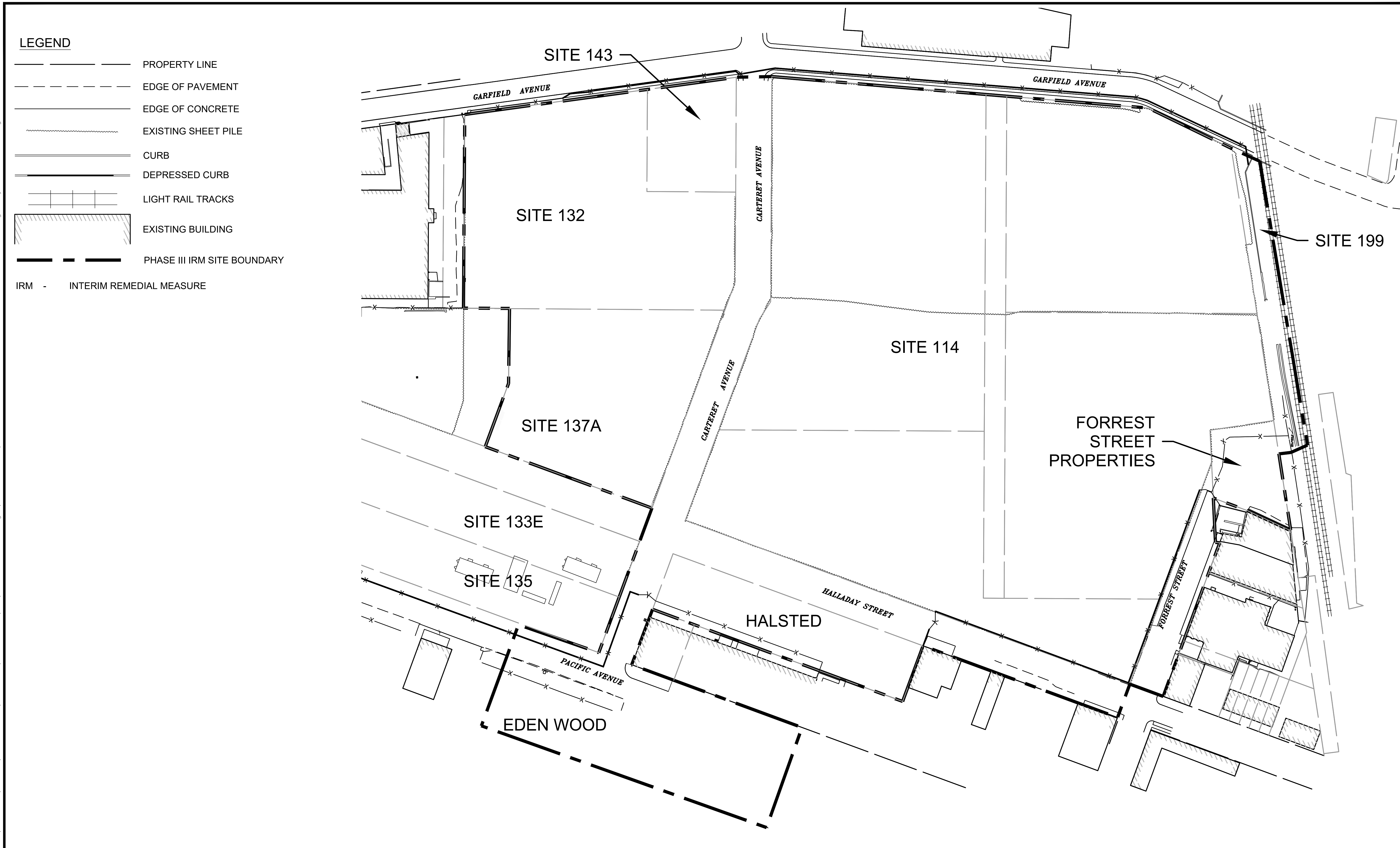
NJDEP, 2017. *Discharge Approval and Monitoring Requirements Associated with Permit-By-Rule Discharge Authorization for PPG Industries (COPR), Garfield Avenue Group and Former Halladay Street Gas Works, 900 Garfield Avenue, Block: 21501, Lots 16, 17, 18, 19, and 20, Jersey City, Hudson County, NJ Program Interest Numbers G000008791*. September 21, 2017.

NJDEP, 2019. *Discharge to Groundwater Authorization, PPG Industries (COPR), Garfield Avenue Group and Former Halladay Street Gas Works, 900 Garfield Avenue, Block: 21501, Lots 16, 17, 18, 19, and 20, Jersey City, Hudson County, NJ Program Interest Numbers G000005480*. May 9, 2019.

Figures:

Attachment 1: Geotechnical Boring Data

FIGURES



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GRAPHIC SCALE IN FEET

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PPG
GARFIELD AVENUE GROUP SITES
JERSEY CITY, NEW JERSEY

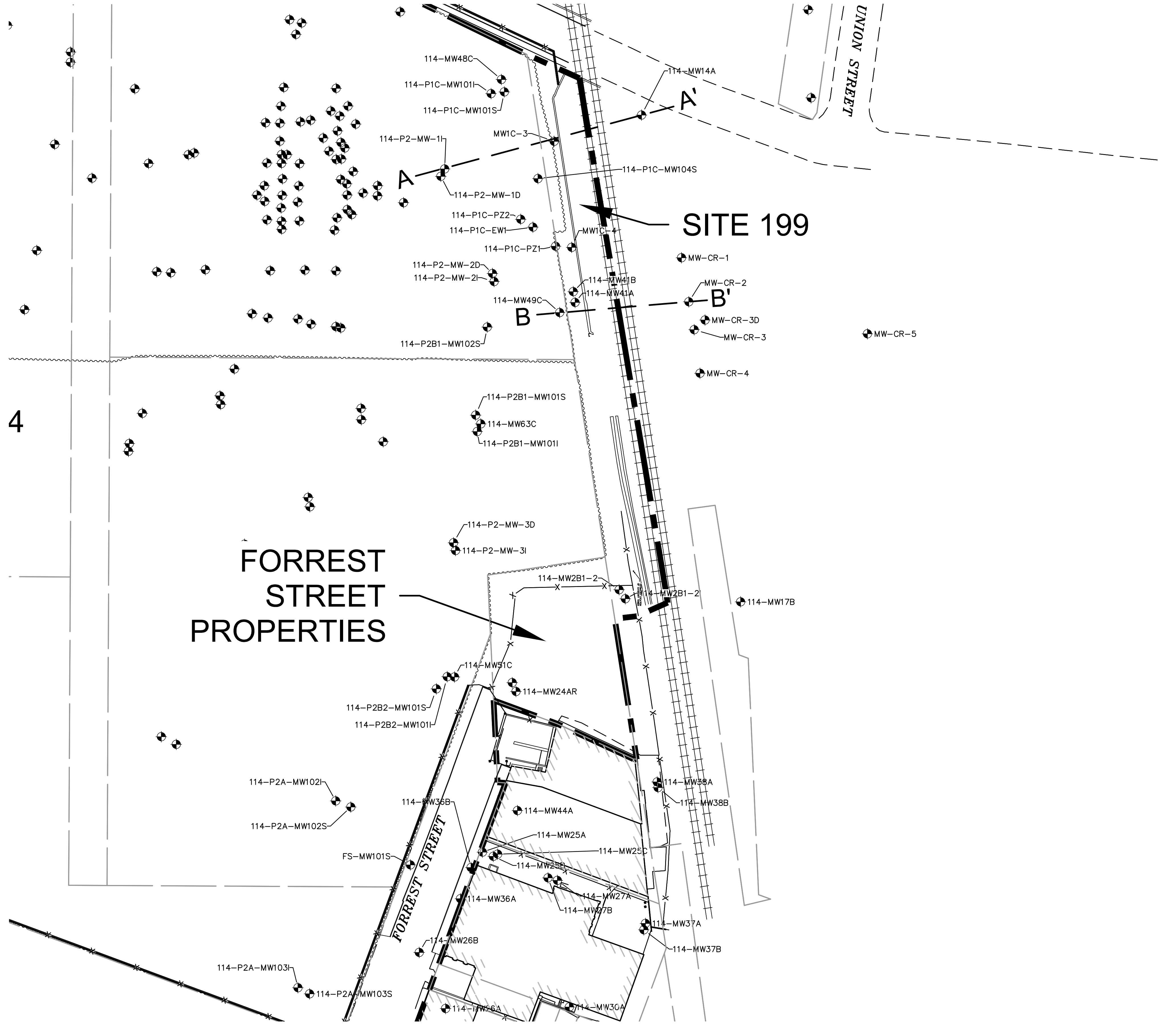
DATE: 09/03/2021 | DRWN: JJA/AC

PHASE III GROUNDWATER IRM SITE MAP

FIGURE 1

LEGEND

PROPERTY LINE
EDGE OF PAVEMENT
EDGE OF CONCRETE
EXISTING SHEET PILE
CURB
DEPRESSED CURB
LIGHT RAIL TRACKS
EXISTING BUILDING
PHASE III IRM SITE BOUNDARY
A — A' CROSS SECTION LOCATION
EXISTING MONITORING WELL
IRM - INTERIM REMEDIAL MEASURE

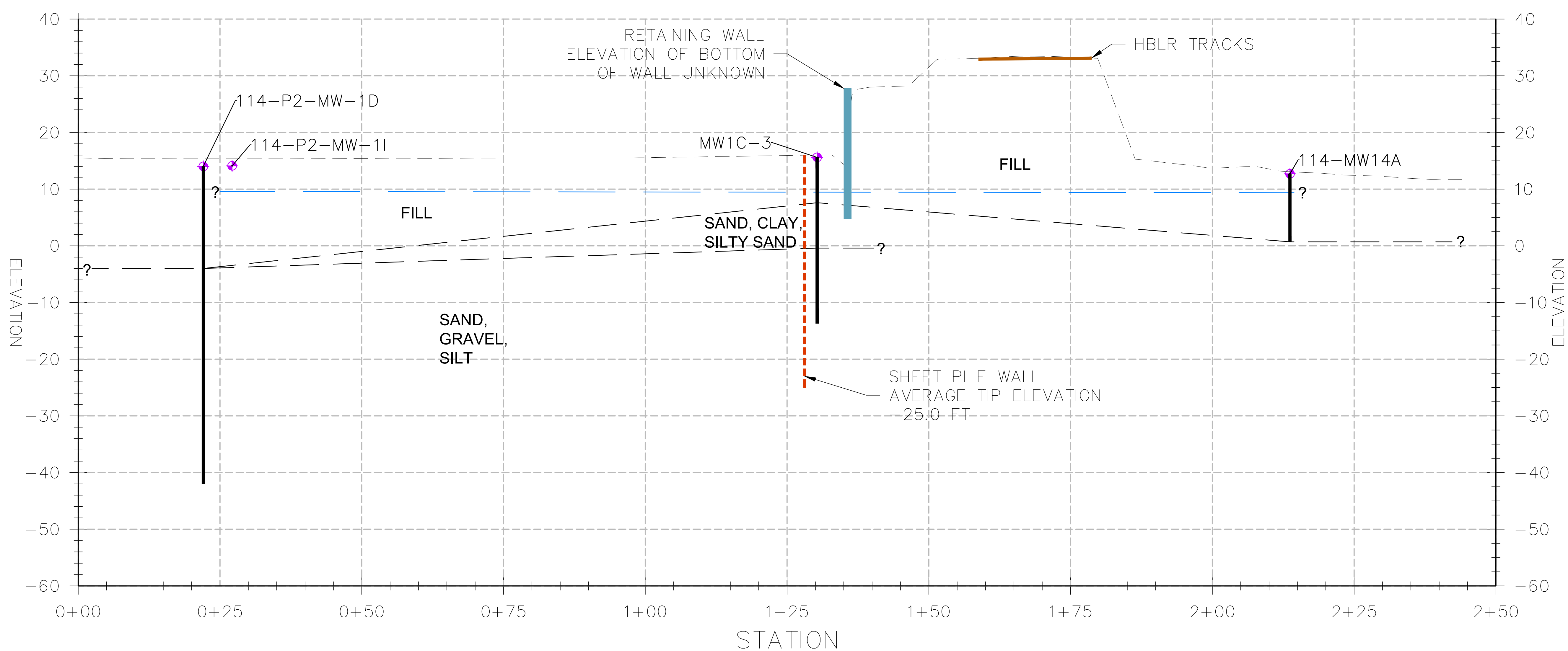


50 0 100
GRAPHIC SCALE IN FEET

AECOM

PPG GARFIELD AVENUE GROUP SITES JERSEY CITY, NEW JERSEY	PHASE III GROUNDWATER IRM MONITORING WELL AND CROSS SECTION LOCATIONS
DATE: 09/03/2021 DRWN: JJA/AC	FIGURE 2

SECTION A–A'



LEGEND

— — —?	APPROXIMATE STRATIGRAPHIC LIMIT
- - - -	EXISTING GROUND SURFACE
—— ——	GROUNDWATER SURFACE, SHALLOW WELLS (MAY/JUNE 2018)
114–MW25C	GROUNDWATER MONITORING WELL
|	BORING
——	HBLR TRACK
¦	SHEET PILE
|	RETAINING WALL

10 0 20
GRAPHIC SCALE IN FEET

NOTES:

1. CROSS SECTION LOCATION SHOWN ON FIGURE 2.

IRM - INTERIM REMEDIAL MEASURE
HBLR - HUDSON BERGEN LIGHT RAIL

AECOM

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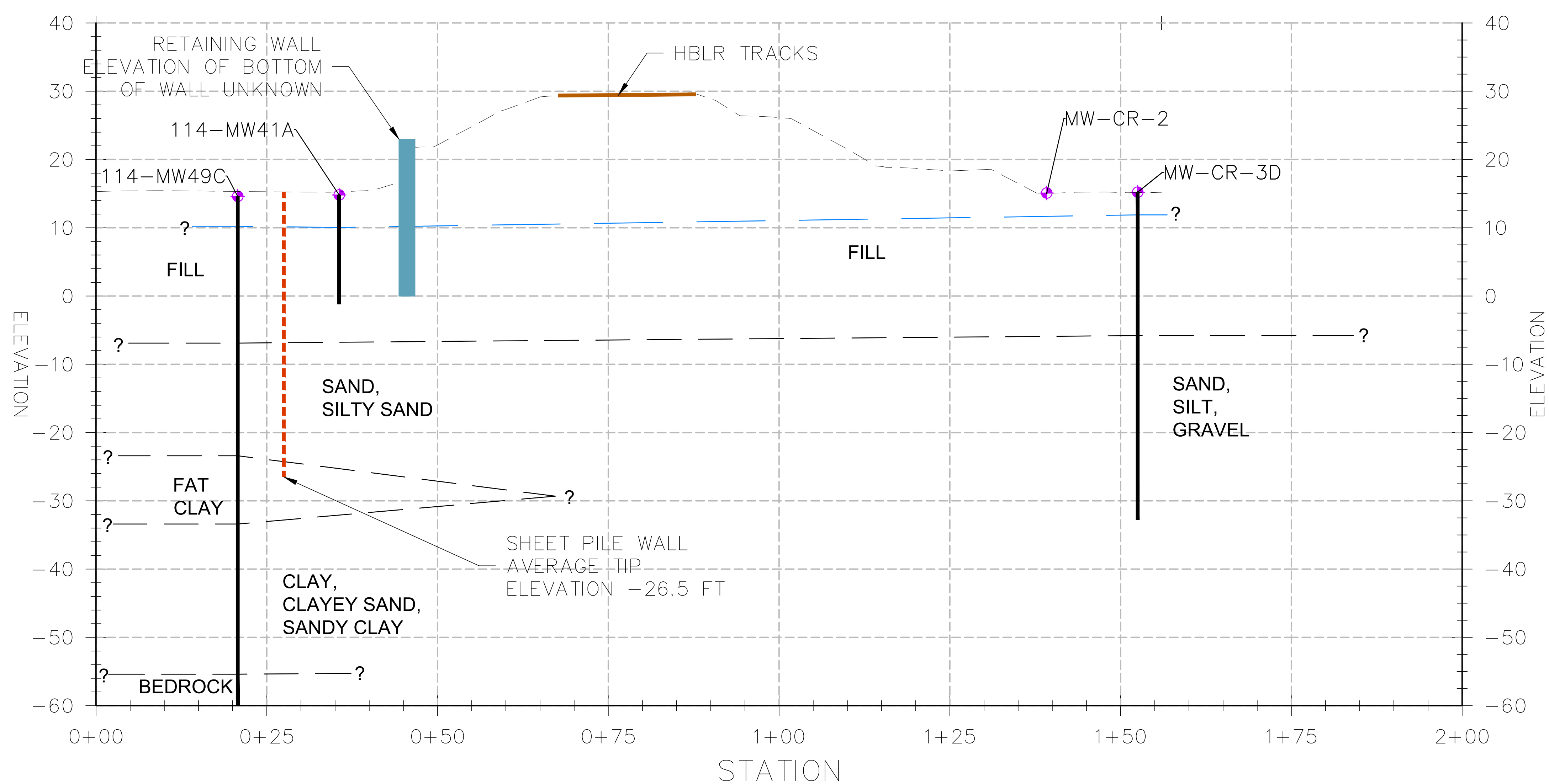
GARFIELD AVENUE GROUP SITES
JERSEY CITY, NEW JERSEY

DATE: 10/20/2021 | DRWN: AC

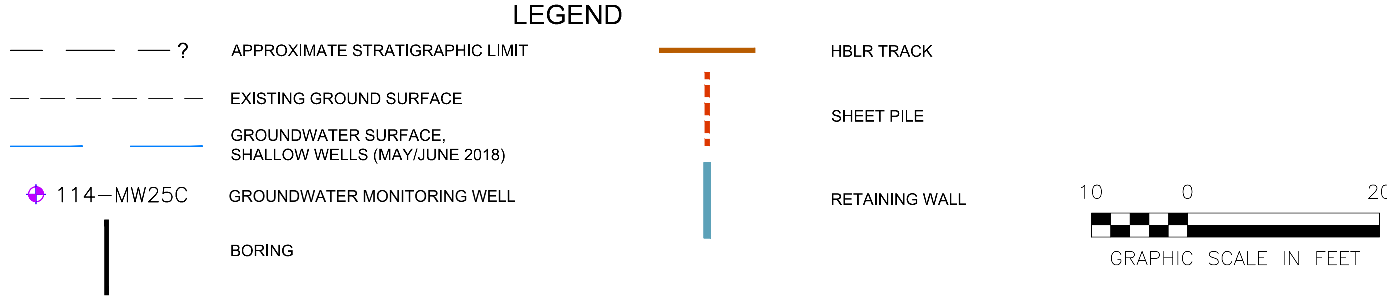
PHASE III GROUNDWATER IRM
CROSS SECTION A-A'

FIGURE 3A

SECTION B–B'



LEGEND



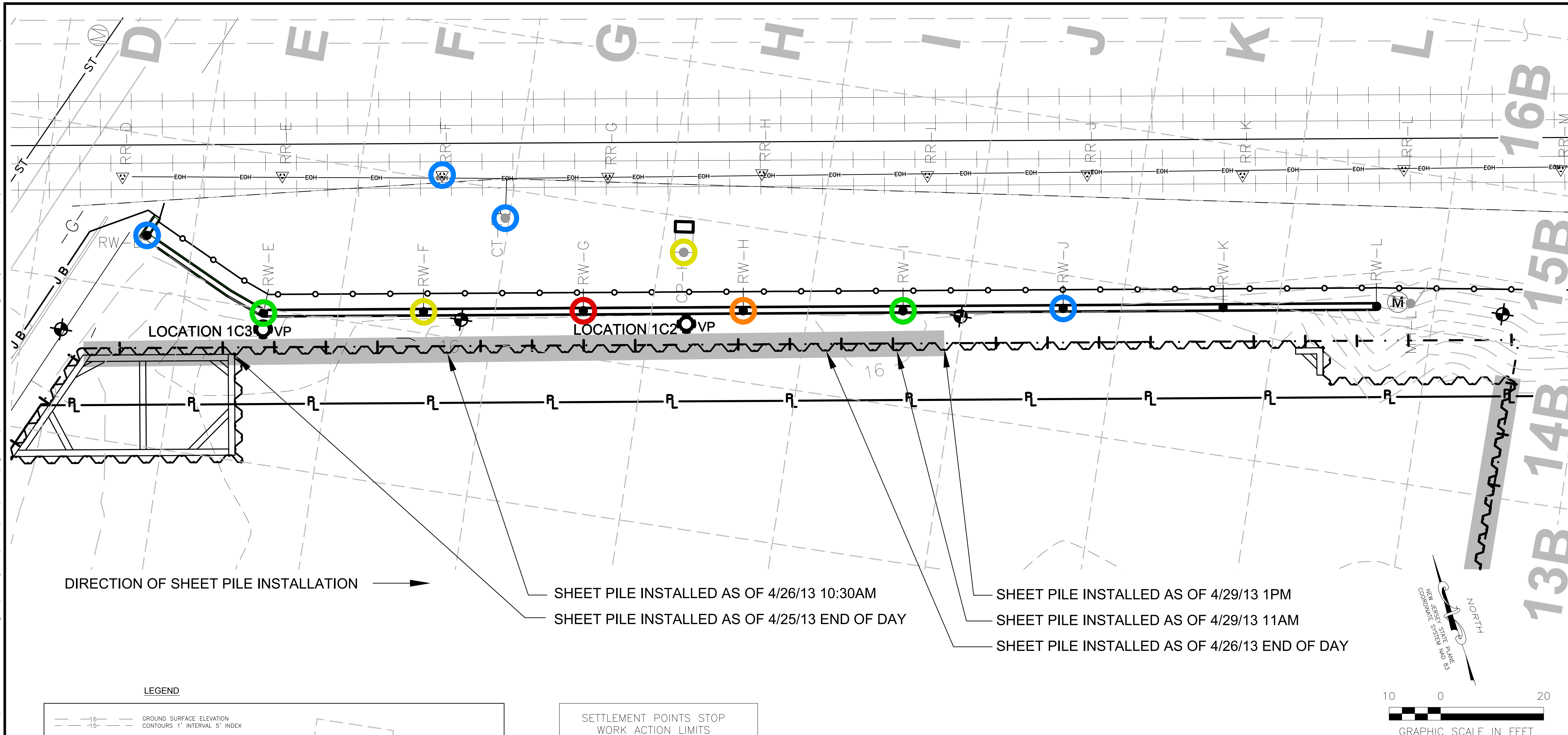
NOTES:

1. CROSS SECTION LOCATION SHOWN ON FIGURE 2.

IRM - INTERIM REMEDIAL MEASURE
HBLR - HUDSON BERGEN LIGHT RAIL

AECOM

PPG GARFIELD AVENUE GROUP SITES JERSEY CITY, NEW JERSEY	**PHASE III GROUNDWATER IRM CROSS SECTION B-B'**
DATE: 10/20/2021 DRWN: AC	**FIGURE 3B**



LEGEND

- GROUND SURFACE ELEVATION CONTOURS 1' INTERVAL 5' INDEX
- PROPERTY LINE
- EDGE OF CONCRETE
- CURB
- DEPRESSED CURB
- RETAINING WALL
- SEWER UTILITY LINE
- SANITARY SEWER UTILITY LINE
- GAS UTILITY LINE
- WATER UTILITY LINE
- OVERHEAD WIRES
- OVERHEAD CATENARY WIRE
- UTILITY POLE
- CATCH BASIN INLET
- MANHOLE
- RAILROAD TRACKS
- TEMPORARY CONSTRUCTION FENCE
- JERSEY BARRIER W/FENCE
- PROPOSED AZ19-700 SHEET PILE
- PROPOSED PZ-35 SHEET PILE
- PROPOSED SHEET PILE BRACING
- B — EXCAVATION GRID
- GROUNDWATER MOUNDING MONITORING WELL
- RR-X — RAILROAD SETTLEMENT MONITORING POINT
- CT-X — CATENARY TOWER SETTLEMENT MONITORING POINT
- CP-X — CONCRETE PAD SETTLEMENT MONITORING POINT
- RW-X — RETAINING WALL SETTLEMENT MONITORING POINT
- MH-X — MANHOLE SETTLEMENT MONITORING POINT
- VP — VIBRATION MONITORING POINT 04-05-2013

SETTLEMENT POINTS STOP WORK ACTION LIMITS REACHED – 4/29/13

- Blue: VECTOR SUM MOVEMENT GREATER THAN 0.05 FT
- Green: VECTOR SUM MOVEMENT GREATER THAN 0.10 FT
- Yellow: VECTOR SUM MOVEMENT GREATER THAN 0.15 FT
- Orange: VECTOR SUM MOVEMENT GREATER THAN 0.20 FT
- Red: VECTOR SUM MOVEMENT GREATER THAN 0.25 FT

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GARFIELD AVENUE GROUP SITES
JERSEY CITY, HUDSON COUNTY, NEW JERSEY

FIGURE 4

60279171.GE.DE.P1CD

RETAINING WALL
SETTLEMENT EVALUATION

REVISION:

DRWN: BcV/C-MA

DATE: 05/07/13

AECOM

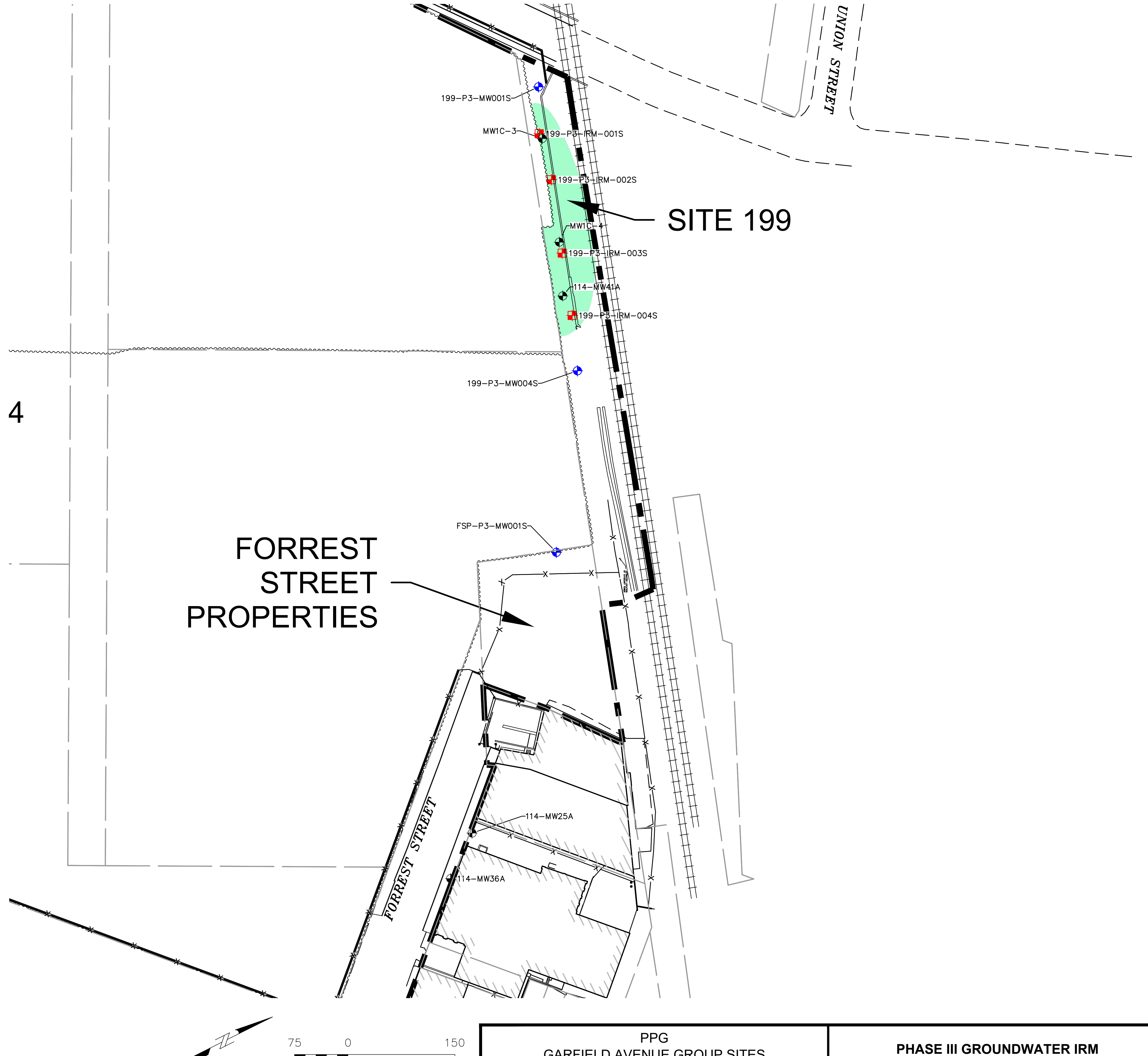
LEGEND

- PROPERTY LINE
- EDGE OF PAVEMENT
- EDGE OF CONCRETE
- EXISTING SHEET PILE
- CURB
- DEPRESSED CURB
- LIGHT RAIL TRACKS
- EXISTING BUILDING
- PHASE III IRM SITE BOUNDARY
- APPROXIMATE PROPOSED SHALLOW ZONE INJECTION WELL LOCATION
- APPROXIMATE PROPOSED SHALLOW ZONE MONITORING WELL LOCATION
- EXISTING SHALLOW ZONE MONITORING WELL
- PHASE III IRM SHALLOW TARGET ZONE

NOTES:

1. PROPOSED INFRASTRUCTURE PRESENTED ON THIS FIGURE IS APPROXIMATE AND SERVES AS GENERAL GUIDANCE FOR THE REMEDY IMPLEMENTATION. IRM PHASE III INFRASTRUCTURE MAY BE ADJUSTED BASED ON PHASE III IRM PERFORMANCE AND OBSERVED MONITORING RESULTS.

IRM - INTERIM REMEDIAL MEASURE



AECOM

PPG GARFIELD AVENUE GROUP SITES JERSEY CITY, NEW JERSEY	**PHASE III GROUNDWATER IRM INJECTION AND MONITORING WELL NETWORK SHALLOW ZONE**
DATE: 09/03/2021 DRWN: JJA/AC	**FIGURE 5**

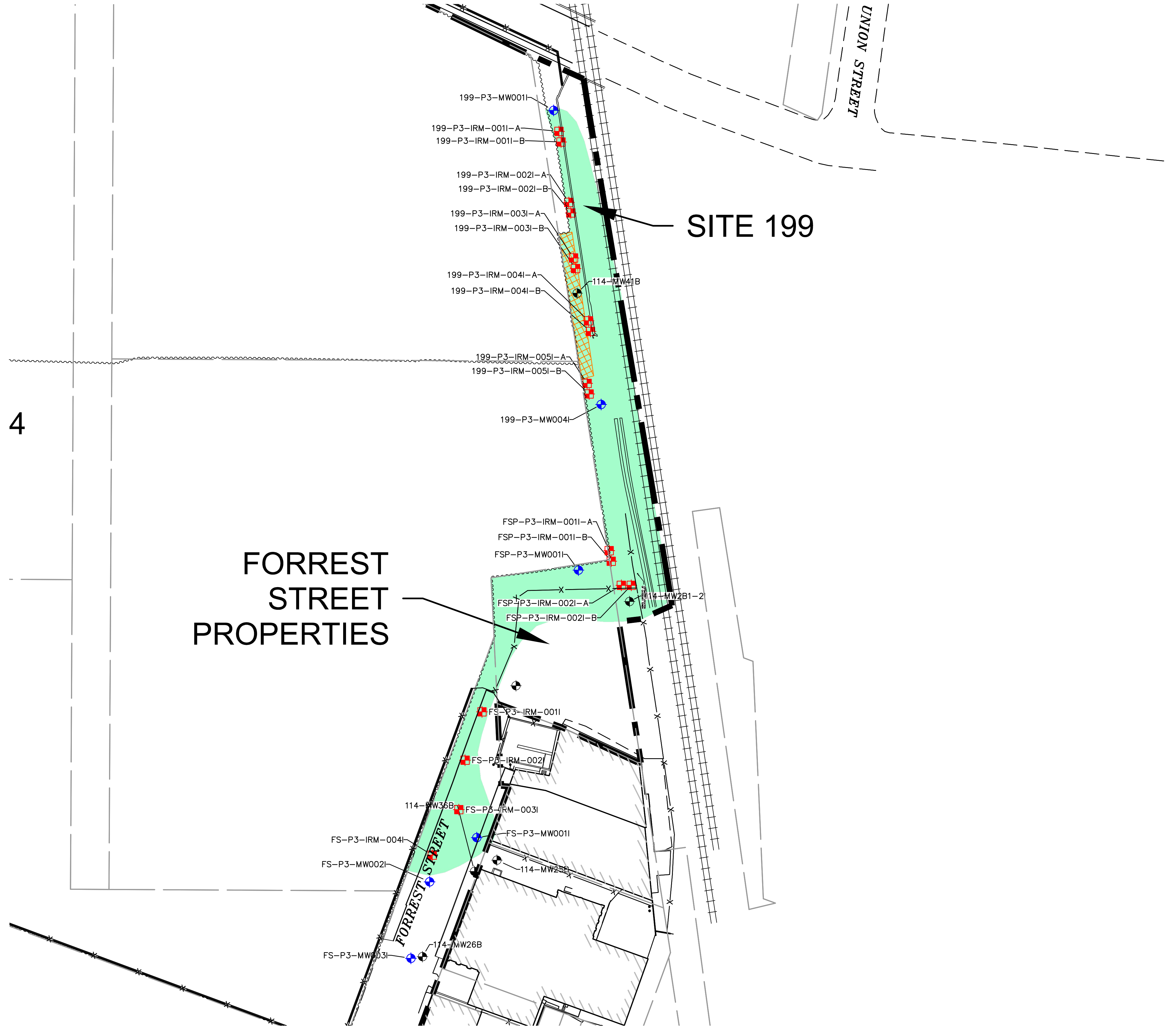
LEGEND

- PROPERTY LINE
- EDGE OF PAVEMENT
- EDGE OF CONCRETE
- EXISTING SHEET PILE
- CURB
- DEPRESSED CURB
- LIGHT RAIL TRACKS
- EXISTING BUILDING
- PHASE III IRM SITE BOUNDARY
- APPROXIMATE PROPOSED FERROBLACK®-H REACTIVE ZONE
- APPROXIMATE PROPOSED SHALLOW ZONE INJECTION WELL LOCATION
- APPROXIMATE PROPOSED SHALLOW ZONE MONITORING WELL LOCATION
- EXISTING SHALLOW ZONE MONITORING WELL
- PHASE III IRM SHALLOW TARGET ZONE

NOTES:

1. PROPOSED INFRASTRUCTURE PRESENTED ON THIS FIGURE IS APPROXIMATE AND SERVES AS GENERAL GUIDANCE FOR THE REMEDY IMPLEMENTATION. IRM PHASE III INFRASTRUCTURE MAY BE ADJUSTED BASED ON PHASE III IRM PERFORMANCE AND OBSERVED MONITORING RESULTS.

IRM - INTERIM REMEDIAL MEASURE



50 0 100

GRAPHIC SCALE IN FEET

AECOM

PPG GARFIELD AVENUE GROUP SITES JERSEY CITY, NEW JERSEY	PHASE III GROUNDWATER IRM INJECTION AND MONITORING WELL NETWORK INTERMEDIATE ZONE
DATE: 09/03/2021 DRWN: JJA/AC	FIGURE 6

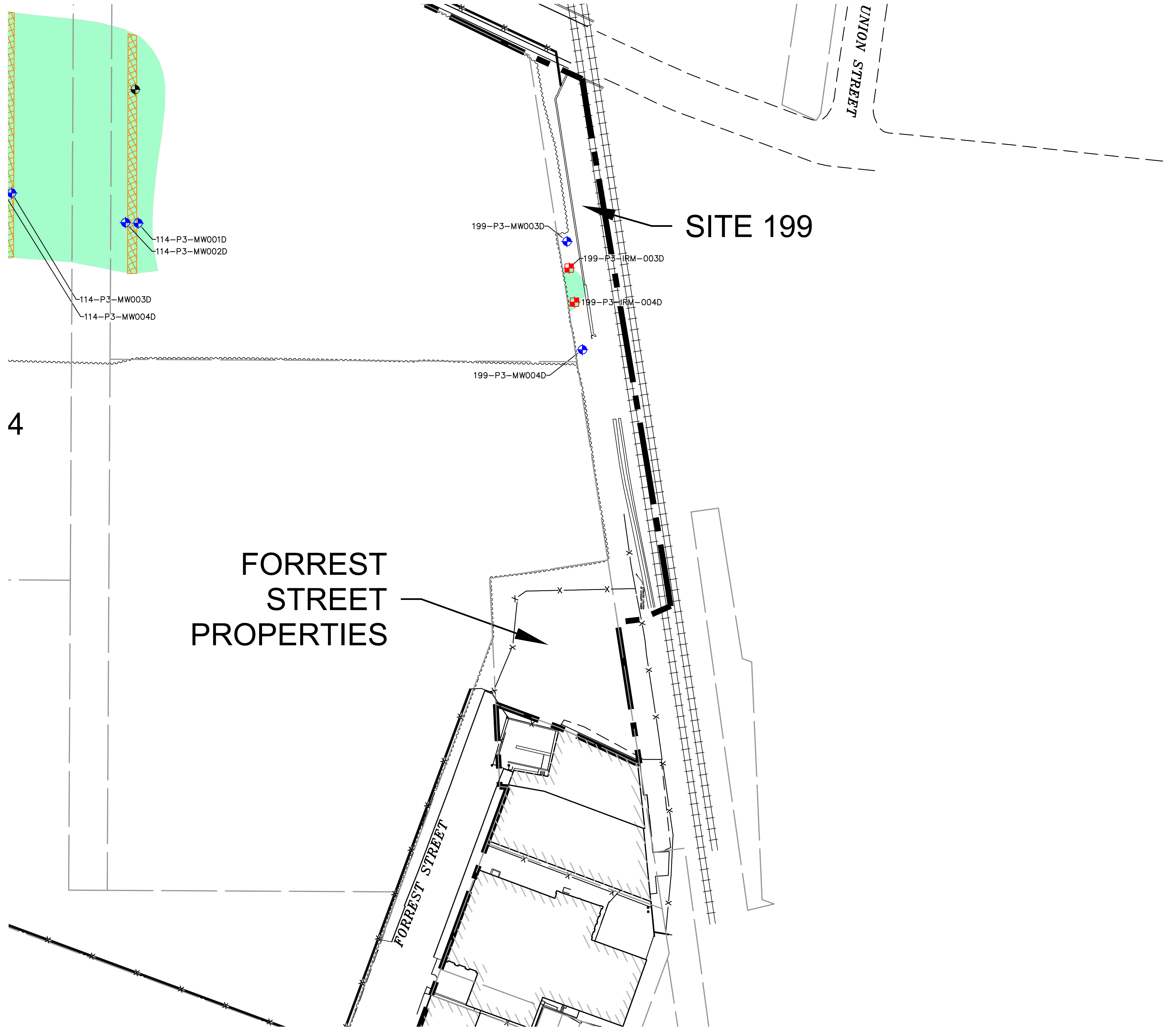
LEGEND

- PROPERTY LINE
- EDGE OF PAVEMENT
- EDGE OF CONCRETE
- EXISTING SHEET PILE
- CURB
- DEPRESSED CURB
- LIGHT RAIL TRACKS
- EXISTING BUILDING
- PHASE III IRM SITE BOUNDARY
- APPROXIMATE PROPOSED FERROBLACK®-H REACTIVE ZONE
- APPROXIMATE PROPOSED SHALLOW ZONE INJECTION WELL LOCATION
- APPROXIMATE PROPOSED SHALLOW ZONE MONITORING WELL LOCATION
- EXISTING SHALLOW ZONE MONITORING WELL
- PHASE III IRM SHALLOW TARGET ZONE

NOTES:

1. PROPOSED INFRASTRUCTURE PRESENTED ON THIS FIGURE IS APPROXIMATE AND SERVES AS GENERAL GUIDANCE FOR THE REMEDY IMPLEMENTATION. IRM PHASE III INFRASTRUCTURE MAY BE ADJUSTED BASED ON PHASE III IRM PERFORMANCE AND OBSERVED MONITORING RESULTS.

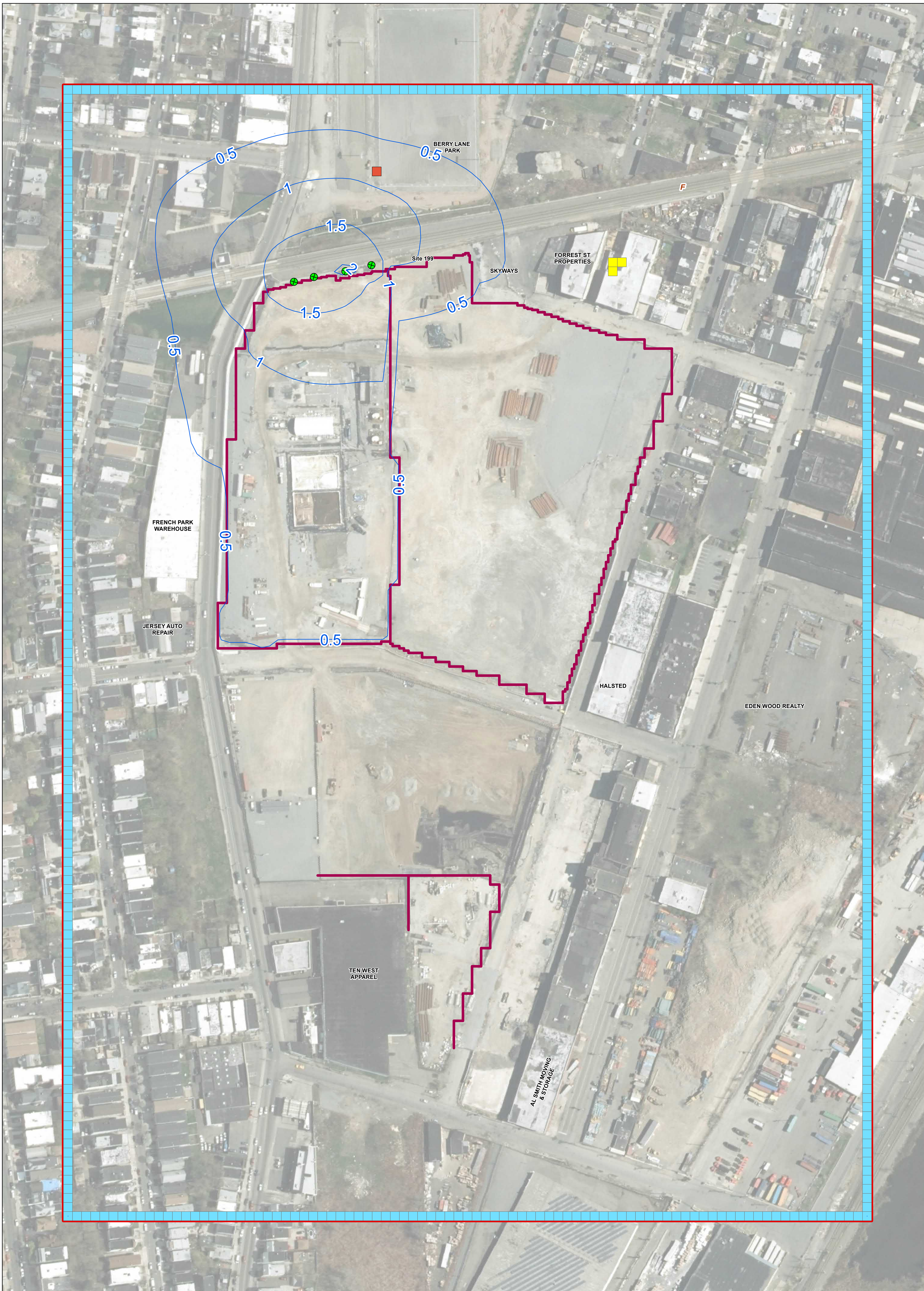
IRM - INTERIM REMEDIAL MEASURE



50 0 100
GRAPHIC SCALE IN FEET

AECOM

PPG GARFIELD AVENUE GROUP SITES JERSEY CITY, NEW JERSEY	PHASE III GROUNDWATER IRM INJECTION AND MONITORING WELL NETWORK DEEP ZONE
DATE: 09/03/2021 DRWN: JJA/AC	FIGURE 7



LEGEND

- Model Domain

Model Boundary Conditions

- General Head Boundary
- Well Boundary (represents leaking water line)
- Drain Boundary Condition
- Injection Well
- Horizontal Flow Barrier (Sheetpile)
- Groundwater Level Increase Contour (0.5 ft Interval)

0 100 200 Feet

N E S W

Map Notes:
1. New Jersey State Plane North American Datum 1983 Coordinates (NAD83), U.S. Survey Feet.
2. Parcels of Hudson County, New Jersey State Plane NAD83, Hudson County Department of Planning, Jersey City, New Jersey, May 21, 2013.

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60550261

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DATE: 9/7/2021 | DRAWN BY: DE | CHECKED BY: AC

FIGURE 8
GROUNDWATER LEVEL INCREASE CONTOURS (FEET)
SIMULATED IN MODFLOW MODEL
SITE 199 INJECTIONS

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LEGEND

- Model Domain

Model Boundary Conditions

- General Head Boundary
- Well Boundary (represents leaking water line)
- Drain Boundary Condition
- Injection Well
- Horizontal Flow Barrier (Sheetpile)
- Groundwater Level Increase Contour (0.5 ft Interval)

0 100 200 Feet

Map Notes:
1. New Jersey State Plane North American Datum 1983 Coordinates (NAD83), U.S. Survey Feet.
2. Parcels of Hudson County, New Jersey State Plane NAD83, Hudson County Department of Planning, Jersey City, New Jersey, May 21, 2013.

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JERSEY CITY, NEW JERSEY
60550261

DATE: 9/7/2021 | DRAWN BY: DE | CHECKED BY: AC

FIGURE 9
GROUNDWATER LEVEL INCREASE CONTOURS (FEET)
SIMULATED IN MODFLOW MODEL
SITE 199 AND FORREST STREET INJECTIONS

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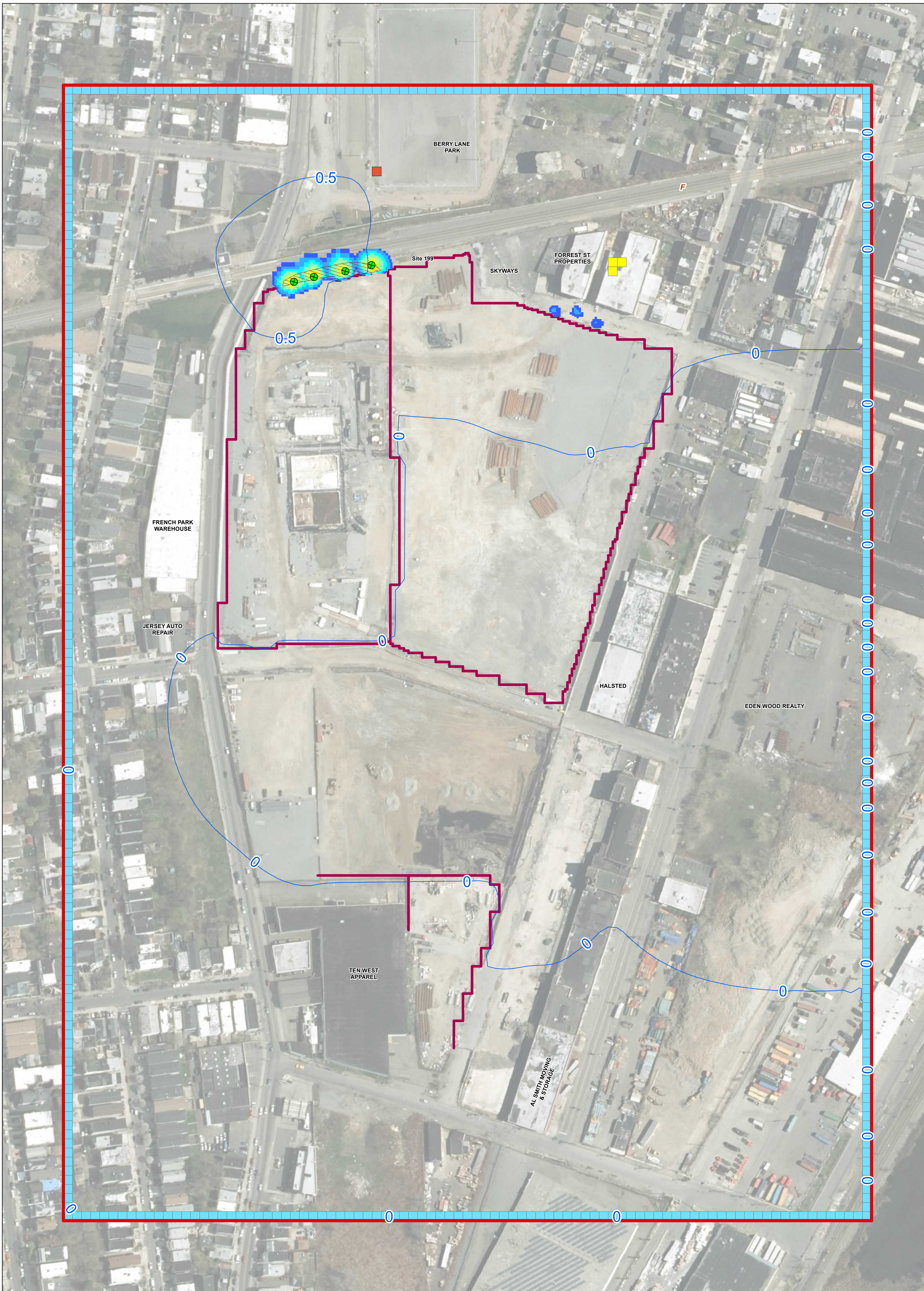
Last Saved By: dave.estrella



LEGEND

Model_Domain

Model Boundary Conditions

- General Head Boundary
- Well Boundary (represents leaking water line)
- Drain Boundary Condition
- Injection Well
- Horizontal Flow Barrier (Sheetpile)
- Groundwater Level Increase Contour (0.5 ft Interval)
- Shallow Target Zone

Reagent Concentration (parts per million)

- < 100
- 100 - 200
- 200 - 500
- 500 - 1000
- 1000 - 2000
- 2000 - 3000
- 3000 - 4000
- 4000 - 5000
- 5000 - 10000
- 10000 - 28000

0 100 200 Feet

Map Notes:
1. New Jersey State Plane North American Datum 1983 Coordinates (NAD83), U.S. Survey Feet.
2. Parcels of Hudson County, New Jersey State Plane NAD83, Hudson County Department of Planning, Jersey City, New Jersey, May 21, 2013.

AECOM

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GARFIELD AVENUE GROUP SITES
JERSEY CITY, NEW JERSEY
60550261

DATE: 9/7/2021	DRAWN BY: DE	CHECKED BY: AC

FIGURE 10
GROUNDWATER LEVEL INCREASE CONTOURS (FEET) SIMULATED IN MODFLOW MODEL
SITE 199 (REDUCED PRESSURE) AND FORREST STREET INJECTIONS

Last Saved By: dave.estrella
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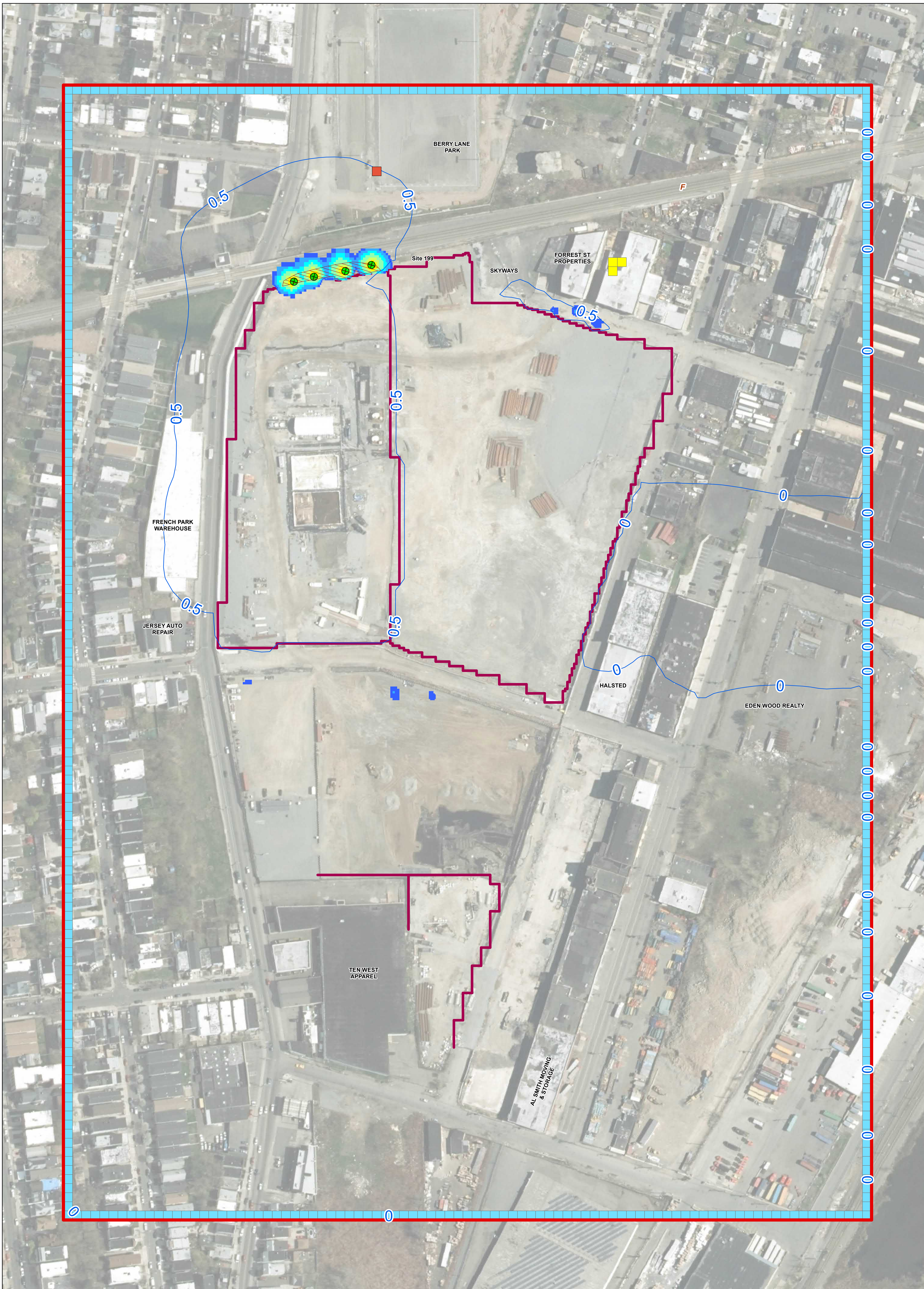

LEGEND

Model Domain

Model Boundary Conditions

- General Head Boundary
- Well Boundary (represents leaking water line)
- Drain Boundary Condition
- Shallow Target Zone
- Injection Well
- Horizontal Flow Barrier (Sheetpile)
- Groundwater Level Increase Contour (0.5 ft Interval)

Reagent Concentration (parts per million)

- < 100
- 100 - 200
- 200 - 500
- 500 - 1000
- 1000 - 2000
- 2000 - 3000
- 3000 - 4000
- 4000 - 5000
- 5000 - 10000
- 10000 - 28000

0 100 200 Feet

N E S W

Map Notes:
1. New Jersey State Plane North American Datum 1983 Coordinates (NAD83), U.S. Survey Feet.
2. Parcels of Hudson County, New Jersey State Plane NAD83, Hudson County Department of Planning, Jersey City, New Jersey, May 21, 2013.

Last Saved By: dave.estrella
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GARFIELD AVENUE GROUP SITES
JERSEY CITY, NEW JERSEY
60550261

DATE: 9/7/2021	DRAWN BY: DE	CHECKED BY: AC

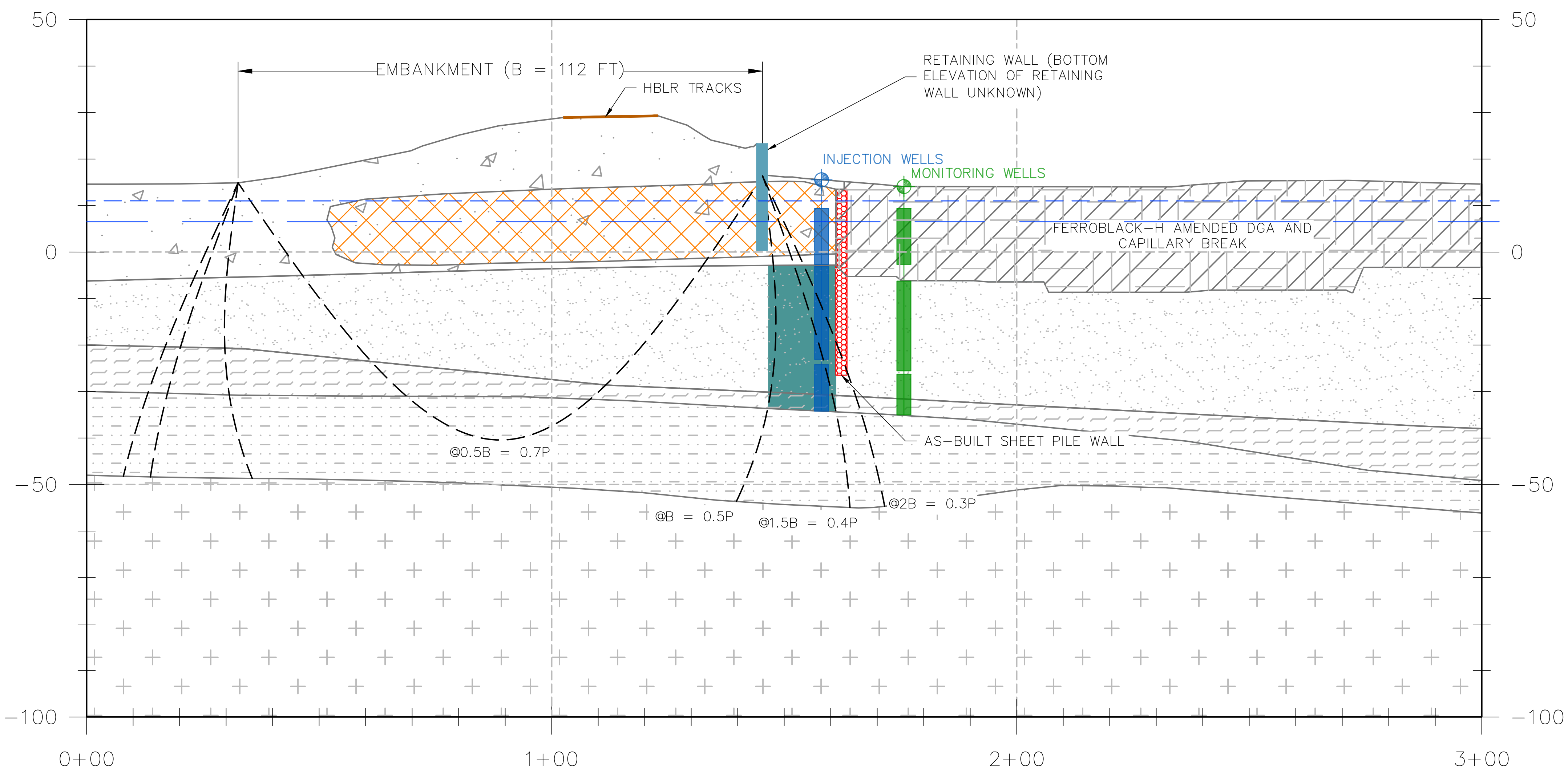
FIGURE 11
GROUNDWATER LEVEL INCREASE CONTOURS (FEET) SIMULATED IN MODFLOW MODEL SITE 199 (REDUCED PRESSURE), FORREST STREET, AND CARTERET INJECTIONS

LEGEND

- MINIMUM ALLOWABLE GROUNDWATER ELEVATION DURING INJECTION (EL. 6.5 NAVD88)
- MAXIMUM ALLOWABLE GROUNDWATER ELEVATION DURING INJECTION (EL 11 NAVD88)
- BOUSSINESQ STRESS CONTOUR
- EXISTING SHEETPILE
- FERROBLACK-H TREATMENT AREA
- INJECTION WELL
- WELL SCREEN INTERVAL
- MONITORING WELL
- WELL SCREEN INTERVAL

STRATIGRAPHY

SHALLOW WATER-BEARING ZONE	FILL: FINE TO COARSE SAND WITH SILT AND GRAVEL. MAY INCLUDE VARIOUS MATERIALS ASSOCIATED WITH HISTORICAL FILL SUCH AS: CONSTRUCTION SPOILS, DEMOLITION DEBRIS, GARBAGE, INCINERATOR ASH, COAL ASH, SHIP BALLAST, AND INDUSTRIAL WASTE
	DENSE-GRADED AGGREGATE (DGA) FILL: FINE TO COARSE SAND WITH FINE GRAVEL AND SILT
INTERMEDIATE WATER-BEARING ZONE	SAND AND SILTY SAND WITH LENSES OF GRAVEL, SILT, OR CLAY
DEEP WATER-BEARING ZONE	SAND WITH LENSES OF GRAVEL, SILT, OR CLAY
	BASAL TILL (LOWER FACIES OF RAHWAY TILL) REDDISH-BROWN 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. HARD, DENSE, COMPACT, AND TYPICALLY DRY.
	BEDROCK: STOCKTON FORMATION, LOCKATONG FORMATION, OR DIABASE
	AREA WITH VISUAL OBSERVATIONS OF CCPW, CONSISTING OF COPR, GREEN-GRAY MUD, OR FILL MIXED WITH COPR OR GREEN-GRAY MUD
	FERROBLACK-H AMENDED BACKFILL AREA



NOTES:

1. ELEVATIONS ARE SHOWN IN FT NAVD88.
2. APPROXIMATE ZONE OF INFLUENCE DETERMINED FROM BOUSSINESQ STRESS CONTOURS FOR AN INFINITELY LONG FOUNDATION. B = BASE WIDTH (WIDTH OF EMBANKMENT). P = PRESSURE.

DEFINITIONS:

CCPW	CHROMATE CHEMICAL PRODUCTION WASTE
COPR	CHROMITE ORE PROCESSING RESIDUE FT
DGA	DENSE-GRADED AGGREGATE
HBLR	HUDSON-BERGEN LIGHT RAIL
IRM	INTERIM REMEDIAL MEASURE
NAVD88	FEET IN NORTH AMERICAN VERTICAL DATUM OF 1988

15 0 30
SCALE 1"=30'

AECOM

PPG
GARFIELD AVENUE GROUP SITES
JERSEY CITY, HUDSON COUNTY NEW JERSEY

DATE: 09/15/2021 DRWN: FS/AC

HBLR EMBANKMENT STRESS DISTRIBUTION

FIGURE 12

File: C:\Users\china2\OneDrive\AECOM\PPG – GDS\910 CAD\20 SHEETS\GW\IRM Phase III Design\Site199\20210824 Fence Diagram_A–A'.dwg Layout: A–A' ANSI B (2) User: china2 Plotted: Sep 16, 2021 – 8:00am Xref's:

ATTACHMENT 1

GEOTECHNICAL BORING DATA

File: J:\Rem_Eng\Project Files\PPG Industries\Garfield Avenue\Shoring Alignment\CAD\Rail Shoring Clearance 01-26-11.dwg Layout: Fig 1 Geotech Boring Locations User: warrenr Plotted: Feb 16, 2011 - 10:08am

DESC	NORTHING	EASTING	DEPTH	CHEMISTRY SAMPLE
GT-1	683867.24	611079.64	50 FT. (OR TO BEDROCK)	GEOTECHNICAL BORING ONLY
GT-2	683921.94	611141.08	50 FT. (OR TO BEDROCK)	GEOTECHNICAL BORING ONLY
GT-3	683916.76	611247.28	50 FT. (OR TO BEDROCK)	SAMPLE 0-2, 5-7, 10-12, 15-17, (OR MEADOW MAT)
GT-4	683867.79	611333.72	50 FT. (OR TO BEDROCK)	GEOTECHNICAL BORING ONLY
GT-5	683869.88	611394.10	50 FT. (OR TO BEDROCK)	SAMPLE 0-2, 5-7, 10-12, 15-17, (OR MEADOW MAT)
GT-6	683780.37	611348.68	50 FT. (OR TO BEDROCK)	GEOTECHNICAL BORING ONLY
GT-7	683503.26	611209.67	50 FT. (OR TO BEDROCK)	GEOTECHNICAL BORING ONLY
GT-8A	683438.10	611111.34	50 FT. (OR TO BEDROCK)	GEOTECHNICAL BORING ONLY
GT-8B	683423.56	611144.66	50 FT. (OR TO BEDROCK)	GEOTECHNICAL BORING ONLY
GT-8C	683406.36	611176.03	50 FT. (OR TO BEDROCK)	GEOTECHNICAL BORING ONLY
GT-9A	683350.07	611068.49	50 FT. (OR TO BEDROCK)	GEOTECHNICAL BORING ONLY
GT-9B	683334.12	611098.40	50 FT. (OR TO BEDROCK)	GEOTECHNICAL BORING ONLY
GT-9C	683317.36	611129.51	50 FT. (OR TO BEDROCK)	GEOTECHNICAL BORING ONLY
GT-10A	683257.89	611023.04	50 FT. (OR TO BEDROCK)	GEOTECHNICAL BORING ONLY
GT-10B	683243.83	611056.10	50 FT. (OR TO BEDROCK)	GEOTECHNICAL BORING ONLY
GT-10C	683228.98	611087.27	50 FT. (OR TO BEDROCK)	GEOTECHNICAL BORING ONLY
GT-11	683138.79	611024.77	50 FT. (OR TO BEDROCK)	GEOTECHNICAL BORING ONLY
GT-12	683190.50	610946.63	50 FT. (OR TO BEDROCK)	GEOTECHNICAL BORING ONLY
GT-13	683257.18	610817.37	50 FT. (OR TO BEDROCK)	GEOTECHNICAL BORING ONLY
GT-14	683345.66	610731.51	50 FT. (OR TO BEDROCK)	GEOTECHNICAL BORING ONLY
GT-15	683454.83	610798.01	50 FT. (OR TO BEDROCK)	GEOTECHNICAL BORING ONLY
GT-16	683581.67	610871.09	50 FT. (OR TO BEDROCK)	GEOTECHNICAL BORING ONLY
GT-17	683608.54	610885.90	50 FT. (OR TO BEDROCK)	GEOTECHNICAL BORING ONLY
GT-18	683837.04	611488.55	50 FT. (OR TO BEDROCK)	SAMPLE 0-2, 5-7, 10-12, 15-17, (OR MEADOW MAT)
GT-19	683785.18	611568.77	50 FT. (OR TO BEDROCK)	SAMPLE 0-2, 5-7, 10-12, 15-17, (OR MEADOW MAT)

LEGEND

GEOTECHNICAL BORING

GEOTECHNICAL/CHEMISTRY BORING

PROPERTY LINE

IRM - INTERIM REMEDIAL MEASURE

75 0 150

GRAPHIC SCALE IN FEET

AECOM

PPG
SITE 114

PROPOSED GEOTECHNICAL BORING LOCATIONS
GARFIELD AVE, JERSEY CITY
HUDSON COUNTY, NEW JERSEY

DATE: 02/16/2011 | DRWN: RCW/WFD

FIGURE 1

GT - 03								
Soil Layer	Elevation	Depth Interval (Feet BGS)		USCS	N Value	N_{60}	ϕ' Degrees	Density (%)
Fill	16	0	1	Fill	NM	NM	NM	NM
		1	2	Fill	19	32	42	73
		2	4	Fill	9	15	35	50
		4	6	Fill	6	10	33	41
		6	8	Fill	24	41	45	82
		8	10	Fill	18	31	42	71
		10	12	No Recovery	14	24	39	63
	2	12	14	Fill	54	85	56	119
Meadow Mat		14	16	SM	80	118	63	140
		16	18	SM/ML/PT	25	35	43	76
		18	20	OL	4	5	29	30
	-6	20	22	OL	13	16	36	52
Silt/Sand/Sandy Silt		22	24	SP/GM	68	82	55	117
		24	26	SP/SW	7	8	31	37
		26	28	SP/SW	34	38	44	79
		28	30	move	41	44	46	86
		30	32	SP	16	17	36	53
		32	34	MH	21	21	38	59
		34	36	MH/SP	17	17	36	53
		36	38	SP	14	13	34	47
		38	40	SP	8	7	31	35
		40	42	ML	14	13	34	46
		42	44	ML	22	20	37	57
		44	46	MH	21	18	37	55
		46	48	CL	13	11	33	43
	-34	48	50	SW	14	NM	NM	NM

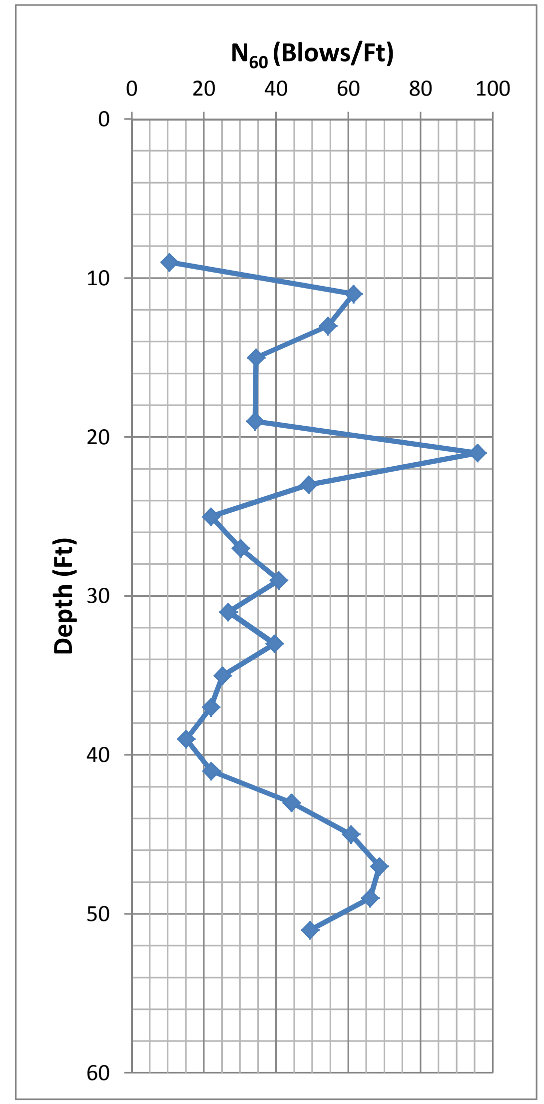
GT - 05								
Soil Layer	Elevation	Depth Interval (Feet BGS)		USCS	N Value	N_{60}	ϕ' Degrees	Density (%)
Fill	15	0	1	Fill	NM	NM	NM	NM
		1	2	Fill	20	34	43	75
		2	4	Fill	7	12	34	45
		4	6	Fill	9	15	35	50
		6	8	Fill	11	19	37	56
		8	10	Fill	13	22	38	61
		10	12	Fill	15	26	40	65
	1	12	14	No Recovery	17	27	40	67
Silt/Sand/Sandy Silt		14	16	SP/SM	19	28	41	68
		16	18	SW	21	29	41	70
		18	20	SP/GM	23	30	42	71
		20	22	SP/GM	25	31	42	72
		22	24	SW	39	47	47	88
		24	26	SP	5	6	29	31
		26	28	SP	17	19	37	56
		28	30	SP	9	10	32	40
		30	32	SP	18	19	37	56
		32	34	SP	7	7	30	34
		34	36	No Recovery		0	20	0
		36	38	CL/SM	9	9	32	38
		38	40	SM/C/SP/SM	20	19	37	56
		40	42	CL	8	7	31	35
		42	44	CL	10	9	32	38
		44	46	CL	4	3	27	24
		46	48	CL/SP	23	20	37	57
	-35	48	50	SP	55	NM	NM	NM

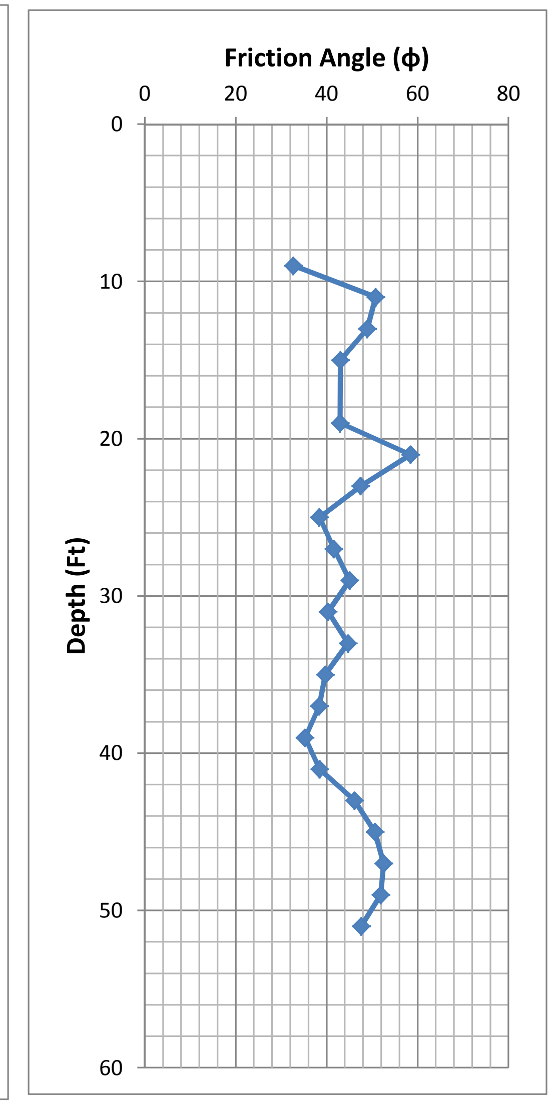
GT - 18								
Soil Layer	Elevation	Depth Interval (Feet BGS)		USCS	N Value	N_{60}	ϕ' Degrees	Density (%)
Fill	17	0	1	Fill	NM	NM	NM	NM
		1	2	Fill	19	32	42	73
		2	4	Fill	20	34	43	75
		4	6	Fill	22	37	44	79
		6	8	Fill	24	41	45	82
		8	10	No Recovery	26	44	46	86
	5	10	12	No Recovery	28	48	47	89
	2	13	15	SP	31	47	47	89
Silt/Sand/Sandy Silt		15	17	SP/PT	33	47	47	89
		17	18	No Recovery	35	49	47	90
		18	20	SM	36	47	47	89
		20	22	SW\GM	38	48	47	89
		22	24	GM	26	31	42	72
		24	26	GM	39	45	46	87
		26	28	GM/SP	20	22	39	61
		28	30	SP	18	19	37	57
		30	32	SP	19	20	37	57
		32	34	SP/SM	15	15	35	50
		34	36	SP	25	25	39	64
		36	38	SP	23	22	38	61
		38	40	SP	11	10	33	41
		40	42	SP	10	9	32	39
		42	44	SP	25	22	38	61
		44	46	SP/CL	15	13	34	47
		46	48	SP/CL	40	34	43	75
	-33	48	50	SP	53	44	46	86

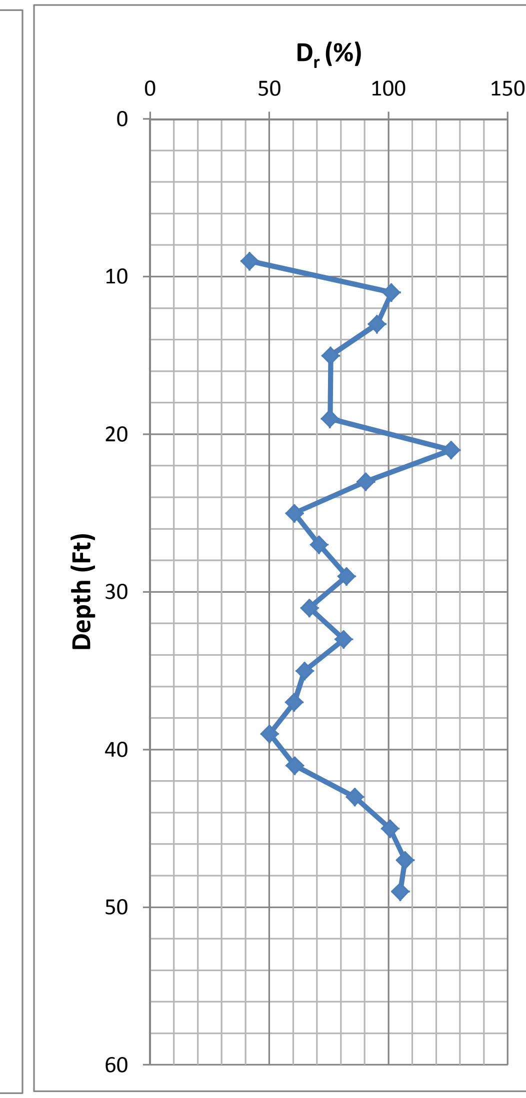
AECOM

PPG SITE 114	BORING LOCATIONS SITE LAYOUT GARFIELD AVE, JERSEY CITY HUDSON COUNTY, NEW JERSEY
DATE: 12/28/11 DRWN:	FIGURE 2

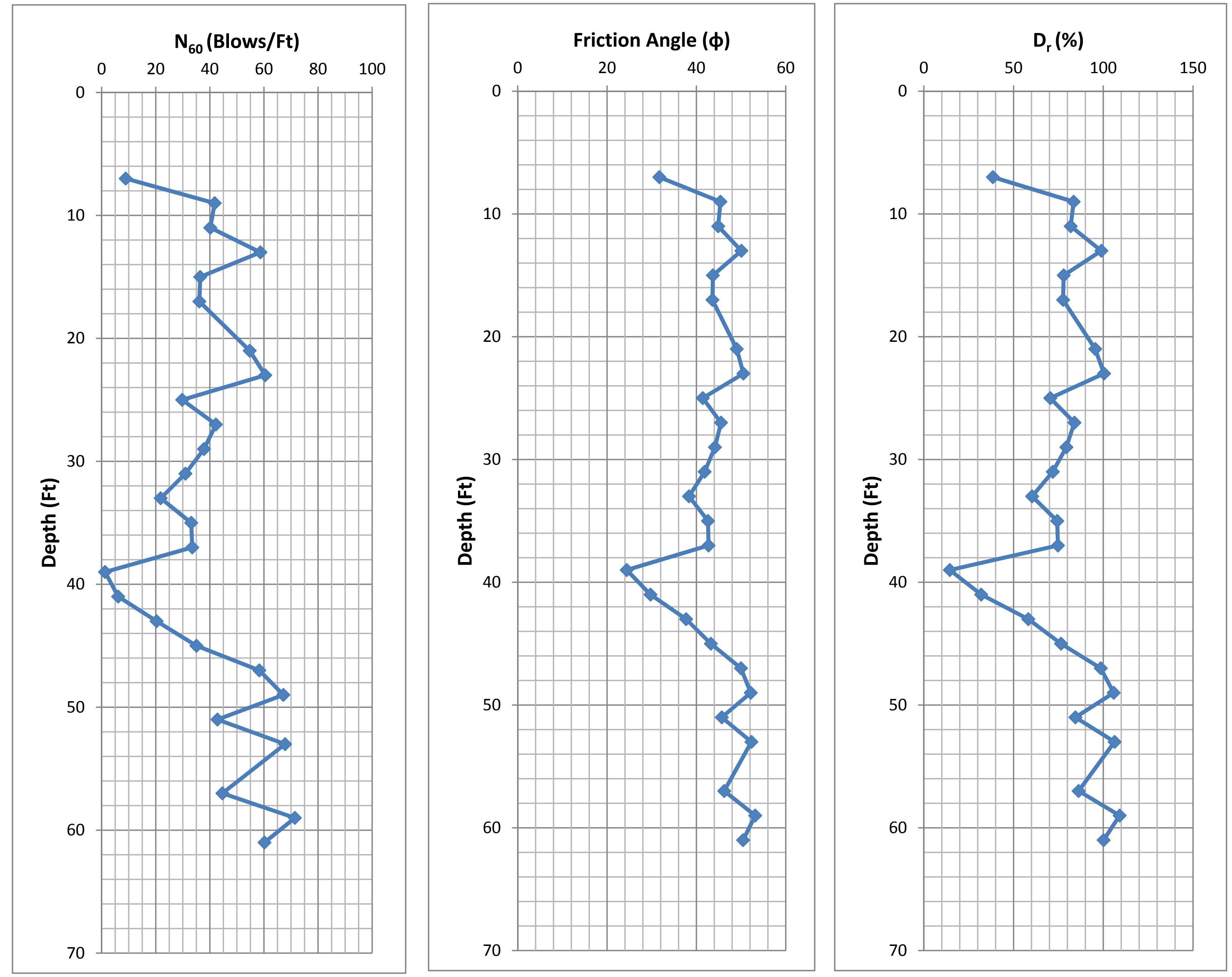
Boring ID # AE-1 Depth (ft)	Mid Point Depth (ft)	Blow Counts Blows/ft	N_{70} Blows/ft	N_{60} Blows/ft	D_r %	Friction Angle (ϕ) Degrees	
0-2	1	NA	NA	NA	NA	NA	
4-6	5	NA	NA	NA	NA	NA	
6-8	7	NA	NA	NA	NA	NA	Fill
8-10	9	4	9	10	42	33	Fill
10-12	11	26	53	61	101	51	Fill
12-14	13	25	47	54	95	49	Fill
14-16	15	17	29	34	76	43	Fill
16-18	17	NA	NA	NA	NA	NA	Fill - SM
18-20	19	19	29	34	75	43	SM - SW
20-22	21	56	82	96	126	58	SW
22-24	23	30	42	49	90	47	SW
24-26	25	14	19	22	60	38	SW - SP
26-28	27	20	26	30	71	42	SW
28-30	29	28	35	41	82	45	SW
30-32	31	19	23	27	67	40	SW
32-34	33	29	34	40	81	45	SW
34-36	35	19	22	25	65	40	SW
36-38	37	17	19	22	60	38	SP
38-40	39	12	13	15	50	35	SM
40-42	41	18	19	22	61	38	SM-SW
42-44	43	37	38	44	86	46	GW
44-46	45	52	52	61	101	51	GP
46-48	47	60	59	69	107	53	SP/GP
48-50	49	59	57	66	105	52	SP
50-52	51	45	42	49	91	48	SP/GP
52-54	53	Refusal	NA	NA	NA	NA	GC
54-56	55	Refusal	NA	NA	NA	NA	GC



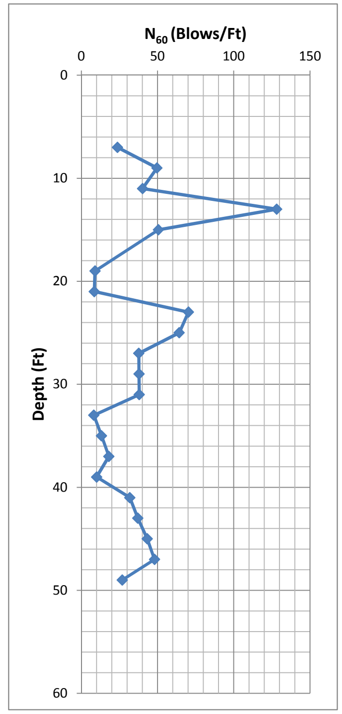


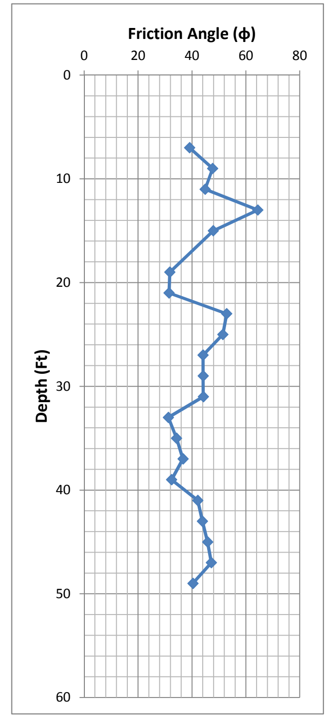


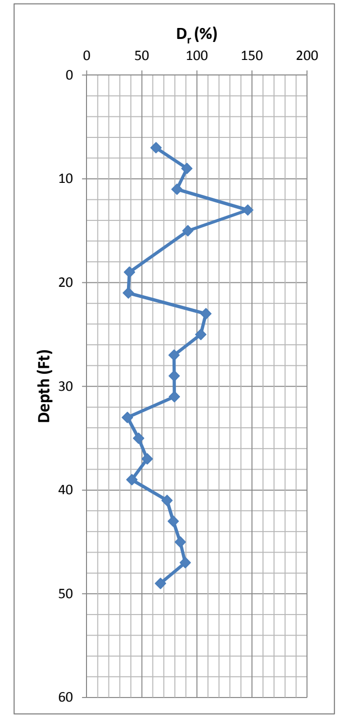
Boring ID # AE-2 Depth (ft)	Mid Point Depth (ft)	Blow Counts Blows/ft	N_{70} Blows/ft	N_{60} Blows/ft	D_r %	Friction Angle (ϕ) Degrees	
0-2	1	NA	NA	NA	NA	NA	
4-6	5	NA	NA	NA	NA	NA	
6-8	7	3	8	9	38	32	Fill
8-10	9	16	36	42	83	45	Fill
10-12	11	17	34	40	82	45	Fill
12-14	13	27	50	59	99	50	Fill
14-16	15	18	31	36	78	44	Fill
16-18	17	19	31	36	78	44	NR
18-20	19	NA	NA	NA	NA	NA	ST
20-22	21	32	47	55	96	49	SM-SM/GM
22-24	23	37	52	60	100	51	SW
24-26	25	19	26	30	70	41	SW/SM
26-28	27	28	36	42	84	46	SM
28-30	29	26	32	38	79	44	SM
30-32	31	22	27	31	72	42	SM
32-34	33	16	19	22	60	38	SM
34-36	35	25	28	33	74	43	SP
36-38	37	26	29	33	75	43	SP
38-40	39	1	1	1	14	24	NR
40-42	41	5	5	6	32	30	ML
42-44	43	17	17	20	58	38	ML
44-46	45	30	30	35	76	43	SW/GW
46-48	47	51	50	58	99	50	SW/GW-SP
48-50	49	60	58	67	106	52	SP
50-52	51	39	37	43	84	46	SP
52-54	53	63	58	68	106	52	SP
54-56	55	Refusal	NA	NA	NA	NA	SP
56-58	57	43	38	45	86	46	SP
58-60	59	70	61	71	109	53	SP/GP
60-62	61	60	52	60	100	50	GW
62-64	63	Refusal	NA	NA	NA	NA	GC



Boring ID # AE-3 Depth (ft)	Mid Point Depth (ft)	Blow Counts Blows/ft	N_{70} Blows/ft	N_{60} Blows/ft	D_r %	Friction Angle (ϕ) Degrees	
0-2	1	NA	NA	NA	NA	NA	
4-6	5	NA	NA	NA	NA	NA	
6-8	7	8	20	24	63	39	Fill
8-10	9	19	43	50	91	48	Fill
10-12	11	17	34	40	82	45	Fill
12-14	13	59	110	128	146	64	Fill
14-16	15	25	43	51	92	48	SM
16-18	17	NA	NA	NA	NA	NA	ST
18-20	19	5	8	9	39	32	OL
20-22	21	5	7	9	38	31	OL-SP
22-24	23	43	60	70	108	53	SP-SP/GP
24-26	25	41	55	64	103	51	SP/GP
26-28	27	25	32	38	79	44	SM
28-30	29	26	32	38	79	44	SM
30-32	31	27	33	38	80	44	SM
32-34	33	6	7	8	37	31	SM
34-36	35	10	11	13	47	34	SP/ML
36-38	37	14	15	18	55	37	SP
38-40	39	8	9	10	41	32	ML
40-42	41	26	27	32	73	42	ML-SP
42-44	43	31	32	37	79	44	ML/SM
44-46	45	37	37	43	85	46	SM
46-48	47	42	41	48	89	47	GM
48-50	49	24	23	27	67	40	GM/GC







Boring ID # AE-4 Depth (ft)	Mid Point Depth (ft)	Blow Counts Blows/ft	N_{70} Blows/ft	N_{60} Blows/ft	D_r %	Friction Angle (ϕ) Degrees	
0-2	1	NA	NA	NA	NA	NA	
4-6	5	NA	NA	NA	NA	NA	
6-8	7	3	8	9	38	32	Fill
8-10	9	3	7	8	36	31	Fill
10-12	11	33	67	78	114	55	Fill
12-14	13	49	91	107	133	60	Fill
14-16	15	12	21	24	64	39	GP-ML
16-18	17	42	68	80	115	55	GP
18-20	19	9	14	16	52	36	OL-SP
20-22	21	33	48	56	97	49	SP
22-24	23	37	52	60	100	51	SP
24-26	25	17	23	27	67	40	SP
26-28	27	6	8	9	39	32	SP
28-30	29	13	16	19	56	37	SP
30-32	31	4	5	6	31	29	SP
32-34	33	6	7	8	37	31	SP-SM
34-36	35	1	1	1	15	25	SP
36-38	37	NA	NA	NA	NA	NA	NR
38-40	39	10	11	13	46	34	ML
40-42	41	5	5	6	32	30	ML
42-44	43	10	10	12	45	34	ML-SP
44-46	45	11	11	13	46	34	SW
46-48	47	46	45	53	94	48	SP
48-50	49	32	31	36	77	43	SP
50-52	51	Refusal	NA	NA	NA	NA	SP/GP
52-54	53	32	30	34	76	43	SP/GP
54-56	55	42	38	44	86	46	SP/GP
56-58	57	33	29	34	76	43	SP/GP
58-60	59	Refusal	NA	NA	NA	NA	SP/GP