

**ROD AND WIRE MILL GROUNDWATER
CORRECTIVE MEASURES STUDY
WORK PLAN**

TRADEPOINT ATLANTIC
SPARROWS POINT, MARYLAND

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Revision 1 – January 14, 2021

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1.0 INTRODUCTION

The Rod & Wire Mill (RWM) Area (the Site) is located in the northwestern portion of the Tradepoint Atlantic (TPA) Property and has also been given the designation of Parcel A3, as the entire property has been divided into several separate parcels.

In an email received on November 28, 2018, the United States Environmental Protection Agency (EPA) provided comments on the “Rod and Wire Mill Interim Measures Progress Report – August 2018”. The comments identified elevated zinc levels in some perimeter monitoring wells as a potential concern with respect to discharges to surface water. The most recent progress report, “Rod and Wire Mill Interim Measures Progress Report—December 2018” was submitted to the EPA and Maryland Department of the Environment (MDE) on February 15, 2019. In an email received on February 28, 2019, the MDE provided comments on this most recent report. The comments recommended additional well locations to address data gaps in the current monitoring network at the RWM.

The “Rod and Wire Mill Interim Measures Supplemental Investigation Report” (Revision 0 dated July 26, 2019) was completed to improve the understanding of groundwater conditions in the RWM, to address the concerns raised by MDE and EPA outlined in the comments mentioned above, and to support an evaluation of the most relevant and effective additional corrective actions for the groundwater conditions at the RWM. In addition to the supplemental onshore investigation activities, pore water and surface water samples were collected from locations in Bear Creek in the area just offshore (to the west) of the RWM to assess the current risk to offshore aquatic receptors.

Based on the results of the supplemental investigations, it was concluded that the remaining groundwater impacts do not present an imminent endangerment to human health or the environment that would necessitate additional interim measures prior to completion of a Corrective Measures Study (CMS) to determine an appropriate final remedy for the groundwater impacts at the Site. The investigation report recommended that a CMS be initiated.

2.0 CURRENT CONDITIONS

2.1 SITE SETTING AND USE

The TPA Property is located in Baltimore County, Maryland within the southeastern corner of the Baltimore metropolitan area, and approximately nine miles from downtown. The property encompasses approximately 3,100 acres of land located on a peninsula situated on the Patapsco River near its confluence with the Chesapeake Bay, and physically positioned in the mouth of the heavily industrialized and urbanized Baltimore Harbor / Patapsco River region. **Figure 1** shows the location and boundaries of the TPA Property.

From the late 1800s until 2012, the property was used for the production and manufacturing of steel. Iron and steel production operations and processes at the Site included raw material handling, coke production, sinter production, iron production, steel production, and semi-finished and finished product preparation. In 1970, Sparrows Point was the largest steel facility in the United States, producing hot and cold rolled sheets, coated materials, pipes, plates, and rod and wire. The steelmaking operations at the facility ceased in fall 2012 and the steel mill has been demolished. Current plans for the TPA Property include redevelopment over the next several years. Some portions of the TPA Property have already undergone remediation and/or redevelopment.

The RWM (the Site) is located in the northwestern portion of the TPA property, and is the location of the former mills that produced rods and wire products from the 1940's to the early 1980's. **Figure 2** shows the location and boundaries of the RWM.

A Response and Development Work Plan (RADWP) was approved for the remediation and development of Area A: Sub-Parcel A3-1 which includes the former Rod & Will Mill Special Study Area and encompasses essentially all the impacted groundwater plume. The Parcel is currently zoned Manufacturing Heavy-Industrial Major (MH-IM). The RADWP called for selective removal of contaminated soils followed by capping of impacted soils to prevent direct contact by future industrial workers and implementation of the following institutional controls:

- A restriction prohibiting the use of groundwater for any purpose at the Site and a requirement to characterize, containerize, and properly dispose of groundwater in the event of deep excavations encountering groundwater.
- Notice to MDE prior to any future soil disturbance activities at the Site below areas designated for engineering controls. This written notice will be required at least 15 days prior to any planned excavation activities at the Site that will penetrate through the cap.
- Requirement for a HASP in the event of any future excavations at the Site.

- Complete appropriate characterization and disposal of any future material excavated from beneath the cap in accordance with applicable local, state and federal requirements.
- Implementation of inspection procedures and maintenance of the containment remedies.

Subsequent to the approval of the RADWP, the Site was developed with the construction of a large industrial warehouse, which is the intended permanent site use.

2.2 INTERIM MEASURES

In 1986, a soil and groundwater remediation program was initiated to address groundwater that exhibited elevated concentrations of cadmium and residual soil contamination within the Sludge Bin Storage Area. Remediation initially consisted of a soil flushing program with associated pumping and treatment of groundwater from shallow and intermediate wells.

This pump and treat system was reconfigured in 2001 to provide groundwater recovery from two intermediate zone recovery wells (RW10-PZM020 and RW15-PZM020) that operated at a rate of between 5 and 12 gallons per minute (gpm). Recovered groundwater was transported via a pipeline to the HCWWTP for subsequent treatment and discharge in accordance with the National Pollutant Discharge Elimination System (NPDES) permit requirements for the Facility. The pump and treat system remained active until September 2016.

The “Interim Measure Work Plan – In-Situ Groundwater Treatment” (Advanced GeoServices Corp., August 2016) presented a Conceptual Site Model (CSM) that focused on a source of acidity to the local groundwater that lowered pH and increased the solubility of cadmium and zinc and mobilized these metals creating the groundwater plume containing these metals. The acidity is neutralized by alkaline slag in the shallow groundwater zone; however, slag is not present and neutralization does not occur in the intermediate zone aquifer where the elevated zinc and cadmium is observed in the groundwater plume.

The current remedial approach utilizes in-situ treatment trenches designed to reduce dissolved metal concentrations in the intermediate zone within the identified source areas. Specifically, alkaline reagents (TerrabondMG – 40% by weight in conjunction with limestone aggregate – 60% by weight) were added into the intermediate groundwater zone as permeable reactive barrier trenches designed to introduce alkalinity and raise pH in groundwater flowing to the west from select high concentration areas. The trenches were backfilled with reagent mix from a depth of 35 feet below ground surface (bgs) up to a depth approximately 12 feet bgs. The design and oversight of this remedial technique was completed by Advanced GeoServices (AGS) and is discussed in greater detail in the AGS Work Plan, Interim Measure Work Plan In-Situ Groundwater Treatment dated August 22, 2016. The construction of the trenches was completed in January 2017.

The soils and groundwater beneath the Former Sludge Bin Storage area contained the highest concentrations of cadmium in the RWM. A 130-foot by 130-foot section of this area was designated as the cadmium hot spot. To reduce the source of continuing cadmium contamination to groundwater in this area, approximately 1,252 cubic yards of soils were excavated from the top 2 feet of the cadmium hot spot and disposed of off-site. TerrabondMG powder was then mixed into the hot spot soils from a depth of 2 feet to 7 feet bgs. After the soils were mixed with the TerrabondMG, the cadmium hot spot was capped with a 12-inch layer of the smaller gradation of steel mill slag.

The interim groundwater treatment goals are to increase the pH in order to precipitate the dissolved metals and achieve a reduction in dissolved concentrations of cadmium and zinc within the source areas when compared to pretreatment conditions.

Since the completion of the trench installation, groundwater monitoring (monthly through 2017 and quarterly since that time) has been performed at upgradient, performance and perimeter wells to assess the performance of the installed interim measures. Interim Measures Progress Reports – have been submitted to the EPA as well as the MDE on a semi-annual basis. These progress reports summarize the results of the quarterly monitoring events.

2.3 NATURE AND EXTENT OF CONTAMINATION

The nature and extent of contamination is defined by overlapping plumes of two dissolved metal constituents of concern (COCs) – cadmium and zinc – in the shallow and intermediate groundwater zone. The source of the cadmium plume is the former Sludge Bin Storage Area. The zinc plume originates in the former East Pond. The limits of these source areas have been defined through historical plant documents and aerial photographs.

The lateral extent of the dissolved COC plumes in both the shallow and intermediate zones was defined in the Rod & Wire Mill Interim Measure Supplemental Investigation Report (Revision 0 dated 7/26/2019). To the west the plumes extend to the Bear Creek shoreline. While zinc is detected in several of the shallow wells outside the interim measure area, the elevated zinc plume is delineated to the northern portion of the former rod and wire mill footprint. There were no elevated levels of cadmium detected in the shallow zone outside the interim measure area. The lateral extent of the zinc plume in the intermediate zone has been generally defined by the lack of detections in the Greys Landfill wells to the north and the relatively low concentration observed in well RWG-MWI to the south and SW-082-MWI upgradient to the east.

Concentrations of dissolved zinc in sediment pore water were above the ambient water quality criteria for chronic exposure to aquatic life at three of the 16 offshore sediment sample locations.

Surface water samples confirmed the absence of concentrations of concern in Bear Creek as a result of the discharge of groundwater within the impacted area.

3.0 PURPOSE

3.1 OVERALL PURPOSE OF THE CORRECTIVE MEASURES STUDY

The scope of the CMS is to address groundwater impacts associated with the former Rod & Wire Mill Special Study Area. Soil impacts have been, or are being, addressed through a separate RADWP. Assessment and remediation of historical offshore impacts are being undertaken by the U.S. EPA, and is not within the scope of this CMS.

3.2 APPROACH FOR CORRECTIVE MEASURES STUDY

The groundwater concern is dissolved phase zinc and cadmium in the shallow and intermediate zone groundwater. The approach to addressing groundwater during the CMS is to:

- identify sources that need to be controlled to prevent cross-media transfer to groundwater (e.g., soil to groundwater),
- develop and evaluate alternatives to control continuing release of COCs to groundwater from identified source areas, and
- develop and evaluate alternatives to reduce levels of COCs in groundwater to the extent practicable and migration of contaminated groundwater across the shoreline/property boundary.

As noted, ecological risk associated with continuing groundwater discharges will be addressed in the CMS but existing impacts to offshore sediment will not be addressed. The CMS will also evaluate exposure control measures (e.g., institutional and engineering controls). These measures will be evaluated relative to their ability to control exposure in the short-term, while other measures work towards the reduction of contaminant levels and areal extent over the long-term.

4.0 CORRECTIVE MEASURES OBJECTIVES

4.1 CORRECTIVE ACTION OBJECTIVES (CAOs)

EPA expects final remedies to return usable groundwater to its maximum beneficial use, where practicable, within a timeframe that is reasonable. Where returning contaminated groundwater to its maximum beneficial use is not technically practicable, EPA generally expects facilities to prevent or minimize the further migration of a plume, prevent exposure to the contaminated groundwater, and evaluate further risk reduction. Technical impracticability (TI) for contaminated groundwater refers to a situation where achieving groundwater cleanup standards associated with final cleanup standards is not practicable from an engineering perspective. The term "engineering perspective" refers to factors such as feasibility, reliability, scale or magnitude of a project, and safety.

CAOs for the RWM Site are defined as follows:

- (1) control further releases of constituents of potential concern (COPCs) to the groundwater to the extent practicable,
- (2) control human exposure to the hazardous constituents remaining in the groundwater,
- (3) ensure that groundwater containing elevated concentrations of COPCs will not adversely impact ecological receptors nor adjacent surface water and pore water quality, and
- (4) return contaminated groundwater to cleanup levels based on its maximum beneficial use, to the extent practicable.

4.2 TARGET MEDIA CLEANUP LEVELS

Target Media Cleanup Levels and points of compliance will be developed during the CMS. The CMS will propose media cleanup levels appropriate for the proposed CAOs and prepare figures to identify the locations and extents of exceedances of the proposed media cleanup levels. Potentially applicable standards and relevant criteria, and preliminary target levels and points of compliance are discussed below.

EPA prepared a groundwater use determination memorandum dated April 13, 2018 (Appendix A). EPA concluded that drinking water use of groundwater in the shallow and intermediate aquifers at Sparrows Point can be excluded from consideration when developing groundwater cleanup levels. The memorandum indicated that maximum beneficial use is industrial, commercial or dewatering and that groundwater cleanup levels should be developed based on State surface water quality criteria. The memorandum also indicated that more stringent groundwater cleanup levels may be appropriate in specific areas of the Sparrows Point Site, based

on other potential exposures or pathways not associated with groundwater use (e.g., vapor intrusion or direct contact during construction excavation).

There is currently no direct exposure to groundwater for human receptors. The offsite human exposures have been determined to be negligible, while onsite workers may have short-term exposure to shallow groundwater during intrusive work. Offsite ecological receptors may have long-term exposure to pore water impacted by groundwater migration.

Therefore, with respect to potential human exposure, groundwater cleanup levels will be derived for constituents that might present an unacceptable risk due to direct contact during construction excavation or under a worst-case commercial/industrial exposure, such as the use of groundwater for equipment washing. The point of compliance for these cleanup levels would be Site-wide.

Soil cleanup levels will be developed to identify and delineate sources that need to be controlled to prevent cross-media transfer to groundwater (e.g., soil to groundwater).

With respect to potential industrial use and discharge of groundwater to surface water, groundwater cleanup levels will be developed based on State surface water quality criteria. These levels would apply Site-wide. The CMS will evaluate a surface water mixing zone in deriving these cleanup levels.

To protect ecological receptors, groundwater cleanup levels will be derived, based on State surface water quality criteria along with consideration of the quality and size of the potentially exposed habitat areas, with a point of compliance at the shoreline/property boundary. The CMS will evaluate an attenuation factor for groundwater to shallow pore water.

The CMS report will include figures presenting the distribution of contaminant concentrations exceeding these target media cleanup levels.

5.0 CORRECTIVE MEASURES TECHNOLOGIES

This section of the CMS Work Plan presents a description of the technologies planned for evaluation in the CMS. The technologies presented include those technologies considered applicable in addressing Facility contaminants, are likely to perform reliably and, will achieve the CAOs presented in Section 4.0 of this CMS Work Plan.

The potential groundwater remediation technologies to be evaluated include:

Institutional and Engineering Controls

- Restrictions on Groundwater Use
- Restrictions on Site Use
- Fencing/Warning Signs/Access Restrictions

Removal Technologies

- Excavation
- Groundwater Recovery (pump and treat)

Containment Technologies

- Hydraulic Containment
- Vertical Barrier Walls (sheet piling, soil-bentonite, etc.)

Treatment Technologies

- In-Situ Chemical Fixation (reagent injection, deep soil mixing)
- In-Situ Biological Treatment (EHC-M)
- Permeable Reactive Barriers
- Permeable Reactive Barriers with Groundwater Pumping

Disposal Technologies

- Off-Site Disposal/Landfilling
- On-Site Disposal (CAMU)
- Permitted Discharge

A screening of these technologies will be presented in a summary table describing each technology screened and the results of the screening to indicate which technologies are considered to be potentially applicable based on applicability to the target COCs and the implementability of the technology under the site conditions.

6.0 IDENTIFICATION AND EVALUATION OF ALTERNATIVES

This section of the CMS Work Plan presents a general description of the approach for identifying and evaluating potential corrective measure alternatives. Per applicable guidance, this section of the CMS will present a description of each alternative and a brief screening of the identified corrective measure alternatives against the Resource Conservation and Recovery Act (RCRA) threshold criteria.

6.1 IDENTIFICATION OF CORRECTIVE MEASURE ALTERNATIVES

Those technologies determined to be potentially applicable will be developed into Corrective Action Alternatives. Identified technologies may be used alone or in combination to form the overall corrective measure alternatives. The CMS may identify a current interim measure as, or as part of, a final corrective measure alternative.

The CMS will describe the components of each corrective measure alternative including an engineering description of each corrective measure alternative, a conceptual level design that will form the basis for the estimate of potential cost for that alternative, how the alternative may be expected to perform and, expectations regarding the time-frame for remediation.

These alternatives will be screened against RCRA's threshold criteria which are:

1. protection of human health and the environment;
2. attainment of media cleanup objectives; and
3. controlling the sources.

6.2 PILOT OR BENCH SCALE STUDIES

Based on the Progress Report for 2019 (dated February 14, 2020), a treatability study and field pilot test are proposed to evaluate direct injection of alkaline reagents as part of the CMS. A proposed treatability test plan will be developed and submitted by February 15, 2021 for review and approval.

6.3 EVALUATION OF CORRECTIVE MEASURE ALTERNATIVE(S)

This section will present a detailed evaluation of those alternatives determined to meet the threshold criteria. Pursuant to applicable CMS guidance, the evaluation will address each of the following evaluation/balancing criteria: long-term effectiveness; implementability; short-term effectiveness; toxicity, mobility and volume reduction; community acceptance; state acceptance; and cost.

6.3.1 Long-Term Effectiveness

This criterion refers to the expected effectiveness, reliability and risk of failure of the alternatives, including the effectiveness under analogous site conditions, the potential impact resulting from a failure of the alternative, and the projected useful life of the alternative.

6.3.2 Reduction in Toxicity, Mobility, or Volume of Wastes

This criterion generally refers to how much the corrective measures alternatives will reduce the waste toxicity, mobility and/or volume, primarily through treatment.

6.3.3 Short-Term Effectiveness

This criterion generally refers to potential short-term risks to on-site workers and the community in association with implementation of the corrective measure alternatives, such as might be associated with the excavation, handling, treatment, containment, and transportation of contaminated materials.

6.3.4 Implementability

This criterion refers to the relative ease of alternative implementation (construction), including duration, administrative and technical feasibility, and availability of the required services and materials.

6.3.5 Community Acceptance

This criterion refers to the known or anticipated community acceptance associated with the corrective measure alternatives. This criterion will be further evaluated through the 30-day public comment period that will be provided following remedy selection and issuance of a Statement of Basis by the USEPA.

6.3.6 State Acceptance

This criterion refers to how the corrective measure alternatives will comply with applicable State regulations (e.g., permit requirements).

6.3.7 Cost

This criterion addresses the anticipated short- and long-term costs associated with implementation of the corrective measure alternatives.

7.0 REPORT OUTLINE

The outline for the report is expected to be generally as follows:

- 1.0 INTRODUCTION
- 2.0 DESCRIPTION OF CURRENT SITUATION
 - 2.1 Summary of Previous Investigations
 - 2.2 Source Areas
 - 2.3 Nature and Extent of Groundwater Impacts
 - 2.4 Interim Measures
- 3.0 CORRECTIVE ACTION OBJECTIVES
 - 3.1 Corrective Action Goals
 - 3.2 Media Cleanup Levels and Point(s) of Compliance
- 4.0 IDENTIFICATION AND DEVELOPMENT OF THE CORRECTIVE MEASURES ALTERNATIVES
 - 4.1 Screening of Corrective Measures Technologies
 - 4.2 Identification of the Corrective Measures Alternatives
 - 4.3 Detailed Description of Each Alternative
 - 4.3.1 Protection of Human Health and the Environment
 - 4.3.2 Attainment of Media Cleanup Objectives
 - 4.3.3 Control of Sources of Releases
 - 4.4 Initial Screening of Alternatives
- 5.0 EVALUATION OF CORRECTIVE MEASURES ALTERNATIVES
 - 5.1 Detailed Evaluation of Alternative 1
 - 5.1.1 Long-Term Effectiveness
 - 5.1.2 Reduction in Toxicity, Mobility, or Volume of Wastes
 - 5.1.3 Short-Term Effectiveness
 - 5.1.4 Implementability
 - 5.1.5 Community Acceptance
 - 5.1.6 State Acceptance
 - 5.1.7 Cost
 - 5.2 Alternative 2
 - 5.3 Alternative 3, ...
- 6.0 COMPARATIVE ANALYSIS AND PREFERRED ALTERNATIVE
 - 6.1 Comparison of Alternatives
 - 6.2 Technical Impracticability Assessment
 - 6.3 Recommended Alternative

6.4 Preliminary Implementation Schedule

8.0 PROJECT ORGANIZATION AND RESPONSIBILITIES

8.1 PROJECT PERSONNEL

The Work Plan will be implemented by ARM Group Inc. (ARM) under a contract with Tradepoint Atlantic (TPA).

The TPA Project Manager is Mr. Peter Haid. Mr. Haid will be responsible for ensuring the availability of resources for the project and will be the primary point of contact with the regulatory agencies.

The ARM Project Manager, Mr. Neil Peters, P.E., is responsible for ensuring that all activities are conducted in accordance with this Work Plan and the contract requirements. Mr. Peters is a registered Professional Engineer in the State of Maryland and has served as Project Manager on numerous remediation projects. As Project Manager, Mr. Peters will be responsible for technical direction of ARM's team of engineers and geologists, directing daily project activities, tracking project schedule, and providing quality assurance. Mr. Peters will provide technical coordination with the MDE, EPA and TPA.

8.2 PROJECT SCHEDULE

Field treatability and pilot-scale testing of direct injection is proposed as part of the CMS. Due to the slow movement of groundwater at the Site, it is expected to take several quarters to see an effect. The anticipated schedule for completion of the CMS report is 12 weeks following completion of the field pilot testing.

FIGURES



 Property Boundary
 Rod & Wire Mill (RWM)

RWM

Trade Point Atlantic
 Location Map
 June 06, 2019

Figure
1



ARM Group LLC
 Engineers and Scientists

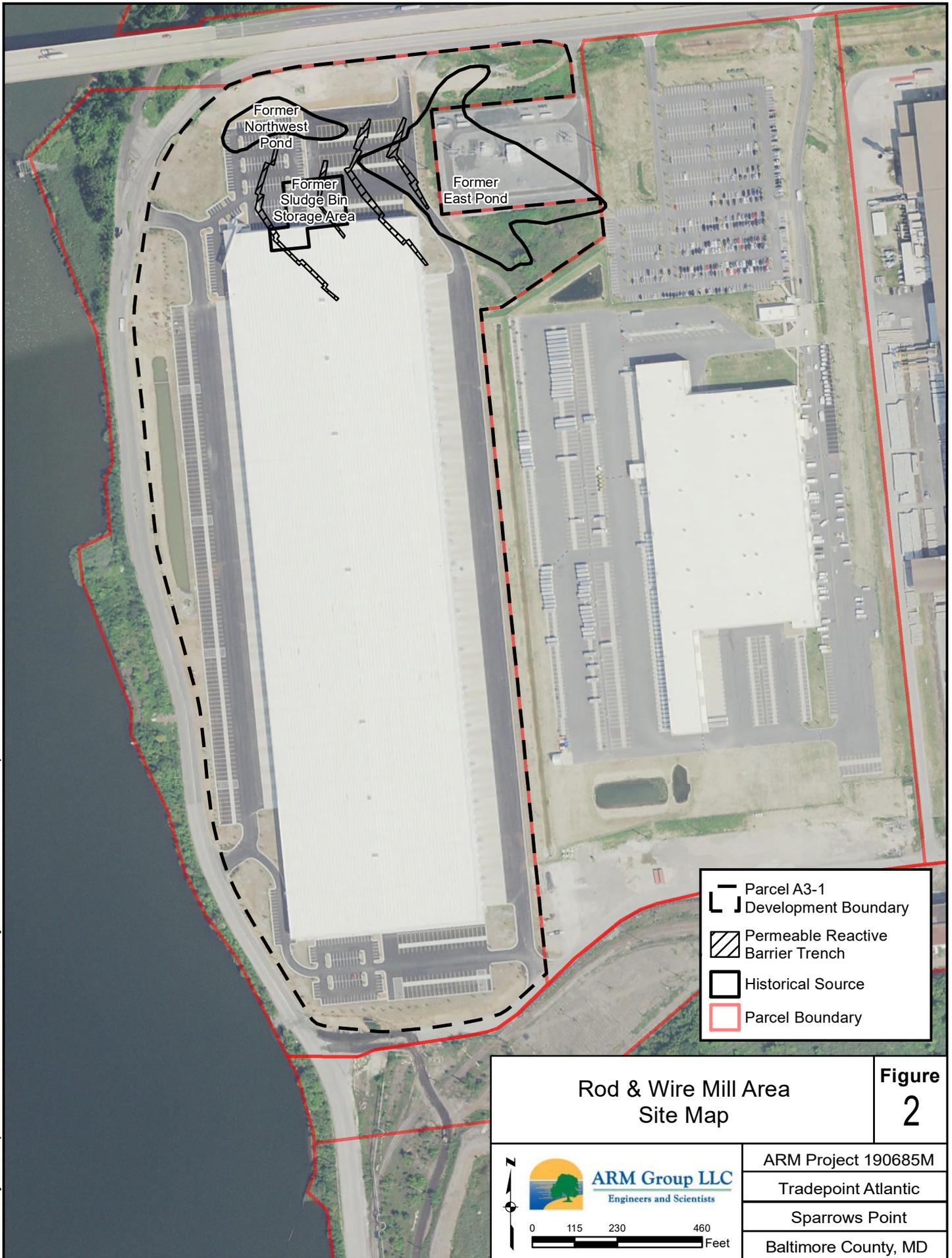
0 500 1,000 2,000
 Feet

Tradepoint Atlantic

Sparrows Point

Baltimore County, MD

ARM Project No. 190288M
 & No. 19034FM



Rod & Wire Mill Area
Site Map

Figure
2

ARM Project 190685M

Tradepoint Atlantic

Sparrows Point

Baltimore County, MD

APPENDIX A

**UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION III
1650 Arch Street
Philadelphia, Pennsylvania 19103-2029**

SUBJECT: Groundwater Use Determination April 13, 2018
Sparrows Point Site (Tradepoint Atlantic)
Sparrows Point, MD
MDD053945432

FROM: Erich Weissbart, P.G.
Project Manager
Office of Remediation

TO: Luis Pizarro
Associate Director
Office of Remediation

Introduction

The purpose of this memo is to establish the basis for determining the maximum beneficial use of groundwater at the Sparrows Point Site located in Sparrows Point, MD. This determination is necessary to select appropriate groundwater cleanup objectives for the facility under the Resource Conservation and Recovery Act (RCRA) Corrective Action program.

EPA policy for groundwater cleanup at RCRA Corrective Action facilities is to return usable groundwater to its maximum beneficial use in a timeframe that is reasonable given the circumstances of the site. A determination of maximum beneficial use is based on how groundwater is actually used or could be used, and should also be based on the hydrogeologic and geochemical characteristics of the groundwater aquifer. EPA prefers to rely on State groundwater use determinations, but can use its own in the absence of a State determination. The policy applies to impacted aquifers beneath a Corrective Action facility, however there are sites where it applies offsite as a result of migrating contaminant plumes. The majority of RCRA Corrective Action facilities are required to restore contaminated groundwater to levels acceptable for drinking, since drinking water is generally the most beneficial use of groundwater, requiring the lowest cleanup levels. However, groundwater cleanup levels can also be based on other uses and exposures, or to protect surface water to which groundwater discharges.

Without a formal aquifer use determination at the Sparrows Point facility, EPA's presumption is that the groundwater is usable as drinking water and must be restored to drinking water standards. Likewise, Maryland Department of the Environment Interim Final Guidance, Cleanup Standards for Soil and Groundwater (June 2008) defines aquifers of the State as Type I and Type II, which would also require the groundwater beneath Sparrows Point be restored to drinking

water standards. The remainder of this memorandum is to present the basis for excluding drinking water use from consideration at Sparrows Point and thereby establish alternative uses upon which to base groundwater cleanup levels. This groundwater use determination applies to impacted groundwater from immediately below the land surface at Sparrows Point, called “shallow” in historical reports, and groundwater immediately beneath the shallow called “intermediate” in historical reports. This document will define the depths of these two aquifers, the basis for the determination, and the basis for limiting the determination to the shallow and intermediate aquifers. Once this determination is made and accepted by stakeholders, groundwater cleanup levels will be proposed in a Statement of Basis (SB) proposing a remedy for sitewide groundwater. Once the usage determination and groundwater cleanup objectives are proposed, both will go through public participation as part of the proposed remedy decision for groundwater.

If groundwater use as drinking water is excluded as a basis for setting cleanup levels, an important component of final remedies is to establish institutional controls that prevent the usage of groundwater for potable use. Restrictions can be placed on the land using enforceable controls (e.g., with environmental covenants) preventing the installation of any types of wells other than monitoring wells, preventing the use of groundwater for anything other than monitoring and cleanup, or requiring treatment before use or discharge. However, the groundwater must still ultimately be restored to the cleanup objectives established for other potential uses and exposures, or attempts made to achieve the groundwater cleanup levels.

Background

Sparrows Point is a unique RCRA site in that that it is much larger than most, greater than 3,000 acres in areal extent, and it is surrounded by water on three sides. Sparrows Point is a peninsula, bounded to the east by Old Road Bay and Jones Creek; to the south and west by the Patapsco River; and to the northwest by Bear Creek, all of which directly or indirectly drain into the Chesapeake Bay. Throughout most of the peninsula, the elevation of the ground surface is between 10 and 20 feet above mean sea level (amsl). Surface water runoff is diverted and collected by a network of culverts, underground pipes, and drainage ditches within former process areas. Storm water is then discharged to Bear Creek, Jones Creek/Old Road Bay, and the Patapsco River under existing National Pollutant Discharge Elimination System (NPDES) discharge permits.

In 1887 Maryland Steel built an iron furnace on the Facility, and the first iron was cast in 1889. The Bethlehem Steel Corporation (BSC) purchased the property in 1916 and enlarged it, building mills to produce hot rolled sheet, cold rolled sheet, galvanized sheet tin mill products, and steel plate. During peak production in 1959, BSC operated 12 coke oven batteries, 10 blast furnaces, and four open hearth furnaces. The land no longer resembles that which was initially encountered prior to construction of the steel mill in the late 1800’s, nor does the Facility resemble that which terminated steel making in 2012.

Geology and Hydrogeology

The Sparrows Point Facility lies within the Atlantic Coastal Plain physiographic province. This province is characterized by a relatively thick wedge of alternating layers of sand, gravel, silt, and clay sediments. Near Baltimore, these unconsolidated sediments are primarily of Cretaceous age, but at Sparrows Point are overlain by up to 125 feet of later Pleistocene sediments. These complexly stratified deposits comprising the Atlantic Coastal Plain form an inter-layered sequence of aquifers and confining beds in a thickening wedge from the “fall line” to the southeast. The lithology, permeability, and structure of the sediments define the geologic setting and provide the framework for the groundwater-flow system. The geologic setting controls the occurrence, movement, and quality of groundwater. Predominantly sandy and gravelly layers, capable of yielding water, form aquifers, while fine-grained layers (silts and clays) impede the flow of groundwater and form confining units.

Stratigraphy at the site from deepest to shallow begins with crystalline basement rocks that are unconformably overlain by the Patuxent Formation, which is conformably overlain by the Arundel Formation. The Arundel Formation is disconformably overlain by the Patapsco Formation, which represents uppermost Cretaceous-age sediments. The Patuxent, Arundel, and Patapsco Formations are collectively called the Potomac Group. Pleistocene sediments of the Talbot Formation unconformably overlie the Cretaceous sediments. The thickness of the Atlantic Coastal Plain sediments vary across the site but notably, for the purpose of this memorandum, the shallow, intermediate, and deep aquifers investigated at Sparrows Point comprise sediments approximately 220 feet to 270 feet thick and are underlain by the Arundel Formation. The Arundel Formation, or Arundel Clay, is the middle unit of the Potomac Group. In the Baltimore area, it is a red to red-yellow, dense, plastic clay with thin lenses of silt. The Arundel Clay completely confines the Patuxent Formation and subsequent aquifers beneath.

Land reclamation and fill placement have occurred at the Facility since the early 1900s. In general, stream channels and estuaries that originally extended into the Sparrows Point peninsula were filled; the southern shoreline of the peninsula was expanded southward into the Patapsco River with fill; and fill was used to create level grades (Figure 1). The fill deposits are thickest (up to 40 feet) in the historic stream channels and estuaries, particularly Humphrey Creek, Greys Creek, Jones Creek, and Old Road Bay and in the two landfill areas, including Greys Landfill and Coke Point Landfill, where fill thickness may be as thick as 70 feet. More recent fill deposits are entirely manmade and were related to land reclamation associated with the expansion and development of the facility. The fill deposits consist primarily of iron- and steel-making slag. Because of its extensive presence across the Sparrows Point site, these manmade fill deposits are called the Slag-Fill Unit.

The Slag-Fill Unit is the uppermost hydrostratigraphic unit at the site. The shallow water table occurs within the Slag-Fill Unit, and groundwater within the Slag-Fill Unit is unconfined. In some areas the Slag-Fill Unit is directly underlain by and connected to the coarser grained beds or lenses within the Pleistocene Talbot Formation that comprise the Upper Talbot Channel Unit. In these areas, the Slag-Fill and Upper Talbot Channel Units form a single groundwater flow system. In much of the site, the Slag-Fill unit is underlain by finer-grained silts and clays that comprise the Talbot Clay Aquitard. In these areas, groundwater flow in the Slag-Fill Unit is separated from groundwater flow in any underlying coarse-grained beds or lenses. Wells

designated as shallow are screened within the slag/fill unit. The “shallow” bottom-of-screen elevations generally range from +5 to -20 feet amsl.

The thickness of the Talbot deposits (125 feet in the Sparrows Point area) may indicate an area of deeper paleo-channel erosion and subsequent backfill. The intermediate hydrogeologic zone includes the unconfined to partially confined groundwater in the Upper Talbot unit. The “intermediate” bottom-of-screen elevations generally range from -20 to -50 feet amsl. The presence of clay and silt layers within the intermediate hydrogeologic zone likely retard the vertical recharge of groundwater from the upper fill material.

The lower hydrogeologic zone includes the confined groundwater in the Lower Talbot or Upper Patapsco Sand unit. At Sparrows Point the Patapsco Formation has been interpreted to have a thickness of up to 255 feet. The “lower” bottom-of-screen elevations generally range from -50 to -141 feet amsl. Hydrogeologic zones at greater depth are known to exist based on a review of the regional geology; however, these deeper units are isolated from the upper three units by the Arundel Clay and impacts have not been identified from former operations.

Aquifers in the Patuxent and Patapsco Formations are the primary groundwater sources in the Baltimore area. Local water supplies can be produced from the Talbot Formation, however where the Talbot Formations outcrop close by to estuaries, nearby water supply wells are susceptible to chloride contamination. No municipal water supply wells are located on the Sparrows Point peninsula. Elevated chloride concentrations in the Talbot Formation are widespread along the Patapsco River and its estuaries, and salt-water encroachment is a significant factor limiting the development of water supplies in the Talbot Formation. Groundwater recharge to the Talbot Formation occurs primarily through the percolation of local precipitation to the water table. It is estimated that approximately 10 inches of rainwater per year recharges the surficial shallow water table aquifer. Discharge is primarily by natural means to springs and surface waters of local rivers, streams, and estuaries.

The Patapsco Formation is also a source of groundwater for the Baltimore area. A sand facies in the lower part of the Patapsco Formation is considered the principal source of water for the Patapsco aquifer. The Patapsco aquifer is confined at Sparrows Point by the overlying Pleistocene Talbot sediments that serve as the upper confining bed, and the Arundel Formation defines the lower confining bed.

The Patapsco aquifer was used as a source of groundwater prior to 1900 and during the early part of the 20th century. Because the Patapsco aquifer widely subsides beneath the brackish Patapsco River, elevated chloride concentrations became a major problem in areas near the Patapsco River estuary. By 1945, almost all water production from the Patapsco had ended due to excessive chloride near the Harbor, Canton, and Dundalk areas. The BSC plant was the only major user of the Patapsco aquifer in 1945. Water production totaled about 3 million gallons per day (Mgal/d); however, by the later 1940's and 1950's, many of the Sparrows Point wells were affected by elevated levels of chlorides and were abandoned. As of 1985, there were no major use of the Patapsco aquifer in the immediate vicinity of the Patapsco River estuary.

Usage

Current

There is no current ongoing usage of groundwater beneath the Facility, but there is groundwater extraction at an adjacent property as described below. Groundwater is monitored for various purposes on a regular frequency to assess remediation efforts at the former Rod and Wire Mill and Coke Oven Area.; regular groundwater monitoring also occurs at Greys Landfill. Across the entire Sparrows Point facility there are dozens to hundreds of monitoring wells constructed into the shallow aquifer and a lesser number into the intermediate aquifer. There are few monitoring wells constructed into the deeper aquifer. There are no monitoring wells into the Arundel Formation and none into the Patuxent below the Arundel. There are six deep production wells constructed into the Patuxent, but none are currently in use.

An adjacent property called Sparrows Point Shipyard (Shipyard) contains a "graving dock," used for the repair or scrapping of ships under dry conditions. Ships enter the graving dock when it is filled with water, via the Patapsco River, and then a gate is closed and water is removed. A central feature of the graving dock is the underdrain pumping system. The underdrain pumping system collects groundwater and pumps the water to the Patapsco River. The Shipyard's pumping system causes groundwater from the Coke Oven Area of Sparrow's Point to flow towards the graving dock. The discharge of the water from the underdrain pumps to the Patapsco River is regulated by the Clean Water Act; specifically by a NPDES discharge permit issued by MDE.

Because of sampling performed by MDE in 2005 where high concentrations of benzene were detected in the discharge, a 2006 permit renewal included a discharge limit of 0.51 mg/l on benzene in certain graving dock discharges that applied to dewatering/trim pumps, and not to the underdrain pumping system. In January 2009, MDE revised the permit to impose the same 0.51 mg/l limit to the underdrain pump discharge, and the revision went into effect in February 2010. To comply with the benzene limitation, the Shipyard installed a benzene treatment system that removes benzene from the groundwater.

The Shipyard operates the water treatment system to remain within the 0.51 mg/l benzene limit imposed by MDE, however the need for the treatment is caused by the operation of the graving dock. The Shipyard pump systems remove an average rate of 750 gallons per minute (i.e. roughly 1.08 Mgal/day). The influence from the dewatering system at the graving dock on water levels in the intermediate zone of groundwater in the Coke Oven Area is depicted on the potentiometric figures created from monitoring well water levels measured over time and submitted by the Facility in investigations and progress reports. Influence on the shallow zone of groundwater is not apparent. This condition is attributed to: location of the pumps at depths that correspond with the stratigraphy of the intermediate unit and decreased recharge from the Patapsco River, and the partially-confined condition of the intermediate zone in this area. The spread of a cone of depression from a pumping center under partially-confined conditions occurs more quickly than that under unconfined conditions. The influence of the graving dock pumping is observable over 2,000 feet away, where flow in the Coke Oven Area is shifted to the northwest in the intermediate zone, while flow in the shallow zone is to the southwest.

Potential Future Usage

Groundwater beneath the Sparrows Point Facility has value as a resource whether it is potable use or another use. How groundwater could be used depends upon multiple factors: vulnerability to contamination; hydrogeologic regimes (recharge and discharge areas); flow patterns; quantity and potential yield; ambient and/or background quality; and existing contamination are some¹. If each factor were addressed satisfactorily (e.g. sufficient quantity and yield and absence of contamination) then the groundwater could potentially be a potable source. However, if some factors were met successfully and others were not the groundwater could still have potential uses. The following list of groundwater uses was collected from the United States Geologic Survey and MDE:

1. **Public and domestic supply** - water used for indoor and outdoor household purposes—all the things you do at home: drinking, preparing food, bathing, washing clothes and dishes, brushing your teeth, watering the yard and garden.
2. **Aquaculture** water use is water associated with raising creatures that live in water—such as finfish and shellfish—for food, restoration, conservation, or sport.
3. **Industrial** water use includes water used for purposes such as fabricating, processing, washing, diluting, cooling, or transporting a product; incorporating water into a product; or for sanitation needs within the manufacturing facility. Some industries that use large amounts of water produce such commodities as food, paper, chemicals, refined petroleum, or primary metals.
4. **Irrigation** water is essential for keeping fruits, vegetables, and grains growing. Throughout the world, irrigation (water for agriculture, or growing crops) is probably the most important use of water. Estimates vary, but about 70 percent of all the world's freshwater withdrawals go towards irrigation uses (<http://www.globalagriculture.org/report-topics/water.html>). Large-scale farming could not provide food for the world's large populations without the irrigation of crop fields by water gotten from rivers, lakes, reservoirs, and wells.
5. **Livestock** water use is water associated with livestock watering, feedlots, dairy operations, and other on-farm needs. Livestock includes dairy cows and heifers, beef cattle and calves, sheep and lambs, goats, hogs and pigs, horses, and poultry. Other livestock water uses include cooling of facilities for the animals and animal products such as milk, dairy sanitation and wash down of facilities, animal waste-disposal systems, and incidental water losses.
6. **Mining** water use is water used for the extraction of minerals that may be in the form of solids, such as coal, iron, sand, and gravel; liquids, such as crude petroleum; and gases, such as natural gas. The category includes quarrying, milling (crushing, screening, washing, and flotation of mined materials), and other operations associated with mining activities.

¹ Factors to Assess Use, Value, and Vulnerability from: Handbook of Groundwater Protection and Cleanup Policies for RCRA Corrective Action; EPA 530-R-04-030; April 2004. Current use and exposures (including public water supply systems and private drinking water supply wells); Reasonably expected future uses (based on demographics, remoteness, and availability of alternative water supplies); Connections to surface waters; Impacts to ecological receptors; Value attributed to a groundwater resource, including public opinion; Governmental and legal boundary considerations (e.g., groundwater migrating across State boundaries).

Value

Because of the native unconsolidated sediments where groundwater is resident on the peninsula there is groundwater available for the typical uses described above. It is reported that BSC previously extracted 3 Mgal/d from the Patapsco Aquifer and the Shipyard currently extracts approximately 1 Mgal/d from the intermediate aquifer located in the Talbot Formation. Equally apparent from the former and current usage is that unconsolidated sediments possess the hydrogeologic characteristics necessary to extract groundwater at a sustainable rate. Aquifer characteristics are less important, as are most of the factors, than an assessment of the background quality of the groundwater. Groundwater background quality is the most important factor because the shallow aquifer resides in iron/manganese bearing slag fill and because the Sparrow's Point peninsula is surrounded by brackish water.

Background is the condition of groundwater including water quality indicators prior to the introduction of anthropogenic contamination. Water quality standards, i.e. pH, turbidity, temperature, etc. are typically collected from monitoring wells prior to groundwater sample collection. The purpose of collecting water quality indicators is to establish that a monitoring well groundwater sample reflects the conditions of an aquifer and not the well bore. The water quality indicators are recorded as evidence of proper sample collection.

In this effort to assess groundwater usage at the Sparrow's Point site, EPA requested an evaluation of site-wide groundwater, including an analysis of pH and total dissolved solids (TDS), from the current property owners. The Site-Wide Groundwater Study Report, (EnviroAnalytics Group (EAG) August 17, 2017), was submitted in response and included the requested groundwater data for both the shallow and intermediate aquifers as detailed below.

The EAG Report included an evaluation of boring logs and well construction logs constructed in the shallow aquifer that identified groundwater monitoring locations completed in the slag fill. The purpose was to determine and map the thickness of slag fill within the saturated zone. The conclusion presented was that most of the locations where groundwater is present in slag fill are located beyond the historical 1916 shoreline (Figures 1 and 2).

A Site-Wide Investigation (SWI) report completed in 2001 by CH2M-Hill provided hydrogeological and general water quality data across the entire Sparrow's Point Facility and addressed a number of objectives. Data collected to meet the objectives were used to develop a site-specific groundwater flow model with particle tracking simulating contaminant flow (MODFLOW). Water quality data collected to address the objectives were TDS and chloride concentrations from shallow and deep zones for comparing groundwater quality and determining surficial and groundwater connectivity.

The chloride and TDS data from the SWI report were combined with specific conductance (SC) data collected during the routine sampling of monitoring wells as part of current ongoing parcel investigations. The SC data that was collected during parcel investigations was converted to equivalent TDS values ($1000 \text{ uS/cm} = 534 \text{ mg/L TDS}$). These data points were used to develop TDS isoconcentration maps for the shallow and intermediate groundwater (Figures 3 and 4).

Groundwater associated with slag fill can exhibit extremely basic pH concentrations rendering it unusable. pH values collected from recent sampling events from each well or piezometer were contoured to create maps (shallow and intermediate) showing pH contours and delineating areas of the site where the pH exceeds 10 (Figures 5 and 6). These areas/zones are not usable as potable aquifers, both due to the high pH and the occurrence of the groundwater in non-natural slag fill which additionally contributes iron and manganese.

Iron and manganese (Fe/Mn) are common in shallow and intermediate groundwater at Sparrows Point. Manganese was detected in 95% of groundwater samples and iron was detected in 94% of groundwater samples. High levels of iron and manganese do not pose any known adverse health risks and EPA has not set MCLs for iron and manganese; however there are Project Action Levels (PALs) established as screening levels for the Facility. Secondary maximum contaminant levels (SMCL) recommended in the National Secondary Drinking Water Regulations are set for aesthetic reasons and are not enforceable by EPA, but are intended as guides to the States. The SMCL for iron is 0.3 mg/L (site-specific PAL is 14 mg/L) and the SMCL for manganese is 0.05 mg/L (site-specific PAL is 0.43 mg/L). High levels of these contaminants can result in discolored water, stained plumbing fixtures, and an unpleasant metallic taste to the water. For groundwater samples collected at Sparrows Point, 47% exceeded site-specific PALs for manganese and 30% exceeded PALs for iron.

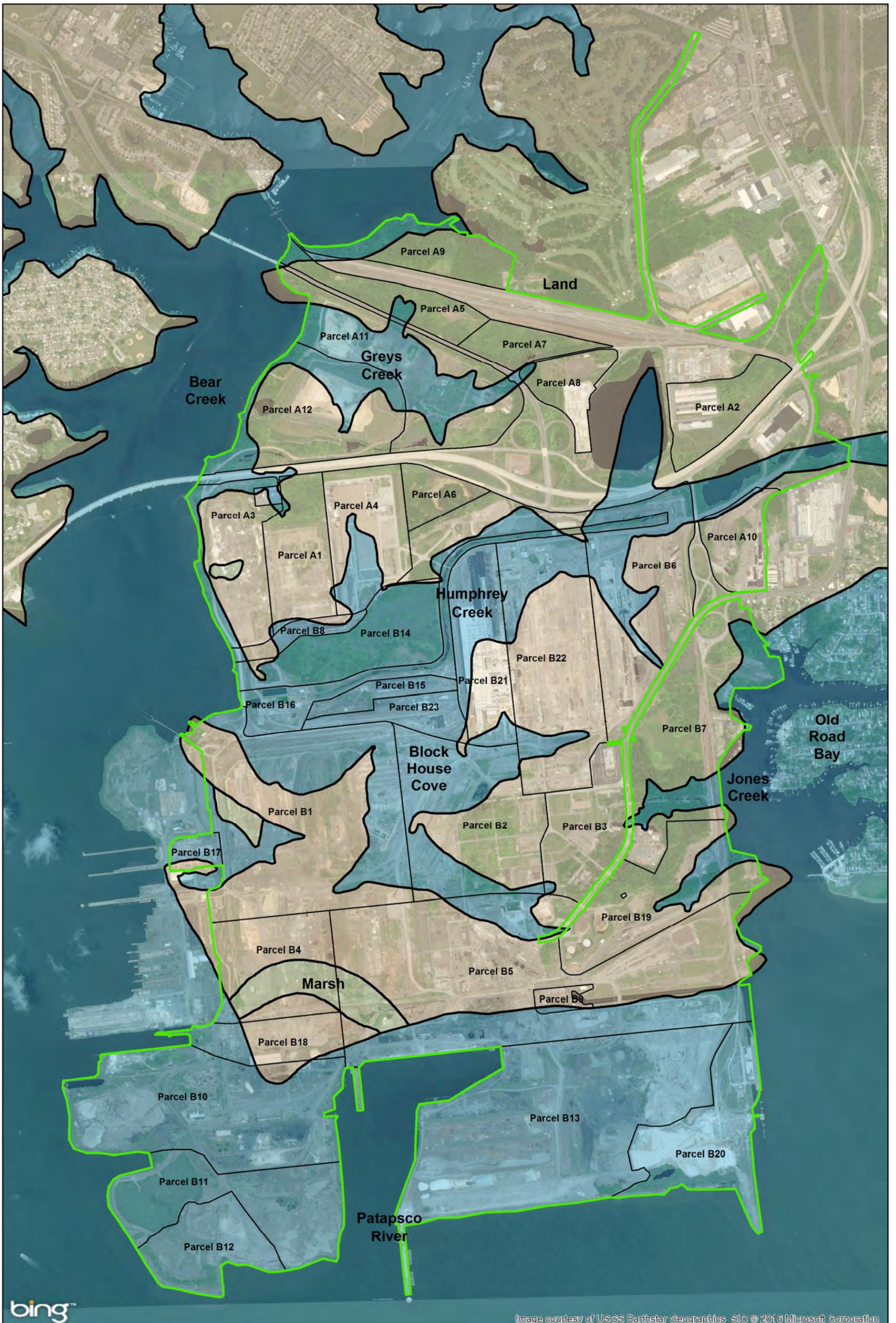
Saltwater intrusion was an issue at the Facility previously because of historical pumping for industrial water use. Data and analysis have been provided showing total dissolved solids and pH in groundwater across the site in the shallow and intermediate levels. Based on this data, (TDS and pH) shallow and intermediate groundwater is not suitable for potable use, primarily because of the largely man-made slag fill contributing elevated pH, Mn, and Fe, but also because of the connection to surface water and elevated chloride. The groundwater in these areas is not suitable for potable use. The table below summarizes the potential uses of groundwater in the shallow and intermediate zones, the potential cleanup standard that would have to be attained, and EPA's determination of usage.

Designation	Standard	Shallow Use	Intermediate Use
Domestic Potable Supply and Residential Irrigation	MCLs	No. Shallow groundwater contains excess TDS and elevated pH	No. Intermediate groundwater contains elevated TDS.
Farming (Livestock Watering and Agricultural Irrigation)	Ecological RBC or other risk based std.	No. Shallow groundwater contains excess TDS and both low and high pH	No. Intermediate groundwater contains elevated TDS.
Industrial, Commercial, Dewatering (Mining, aquaculture)	State Surface Water Quality Discharge Standards	Yes.	Yes. Current dewatering at Sparrows Point Shipyard.
Public Water Supply Well	MCLs	No. Shallow groundwater contains excess TDS and both low and high pH	No. Intermediate groundwater contains elevated TDS.
Test, Observation, Monitoring	None	Yes	Yes
Open Loop Geothermal ²	State Surface Water Quality Discharge Standards	yes	yes

Conclusion

Based on the above analysis, EPA has determined that drinking water use of groundwater in the shallow and intermediate aquifers at Sparrows Point can be excluded from consideration when developing groundwater cleanup levels. Maximum beneficial use should include the uses outlined in the above table, and groundwater cleanup levels should be developed based on State surface water quality discharge standards. More stringent groundwater cleanup levels may be appropriate in specific areas of the Sparrows Point Site, based on other potential exposures or pathways not associated with groundwater use (e.g., vapor intrusion or direct contact during construction excavation).

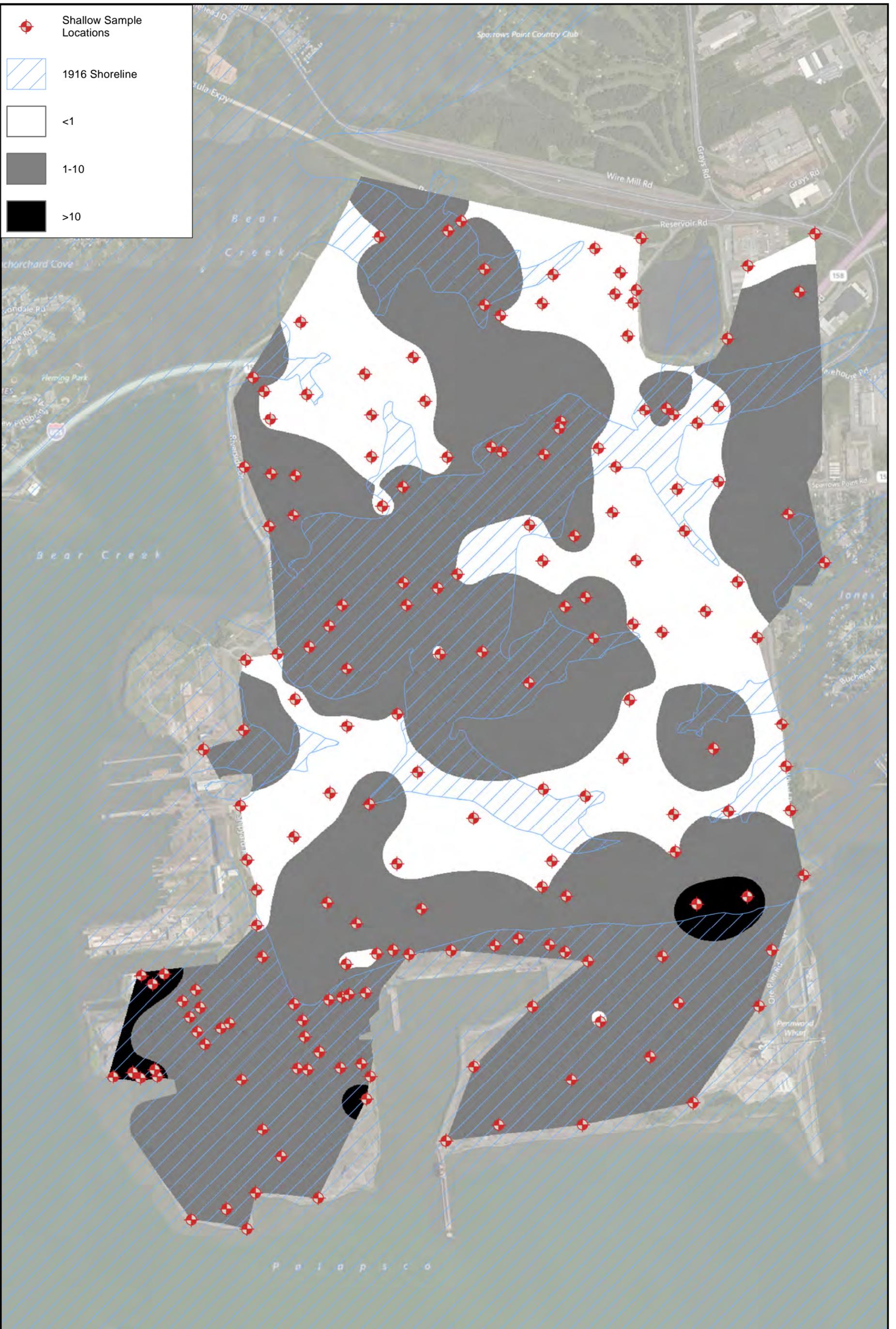
² The evaluation of geothermal systems is beyond the scope of this memorandum. In the case where the Facility or a Parcel owner/lessee proposes to use groundwater for geothermal heating or cooling EPA will then assess the viability of the proposal.



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Image courtesy of USGS Earthstar Geographics SIO © 2016 Microsoft Corporation

	<p>ARM Group Inc. Earth Resource Engineers and Consultants</p>	Site Boundary	Land	<h3>Approximate Shoreline 1916</h3> <p>July 19, 2017</p> <p><small>Adapted from Figure 2-5 of the Description of Current Conditions Report prepared by Rust Environmental and Infrastructure, dated January 1998</small></p>	EnviroAnalytics Group	Tradepoint Atlantic	Figure 1
		Area A Boundaries	Marsh		Area A: Project 150298M Area B: Project 150300M	Baltimore County, MD	



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ARM Group Inc.
Earth Resource Engineers and Consultants

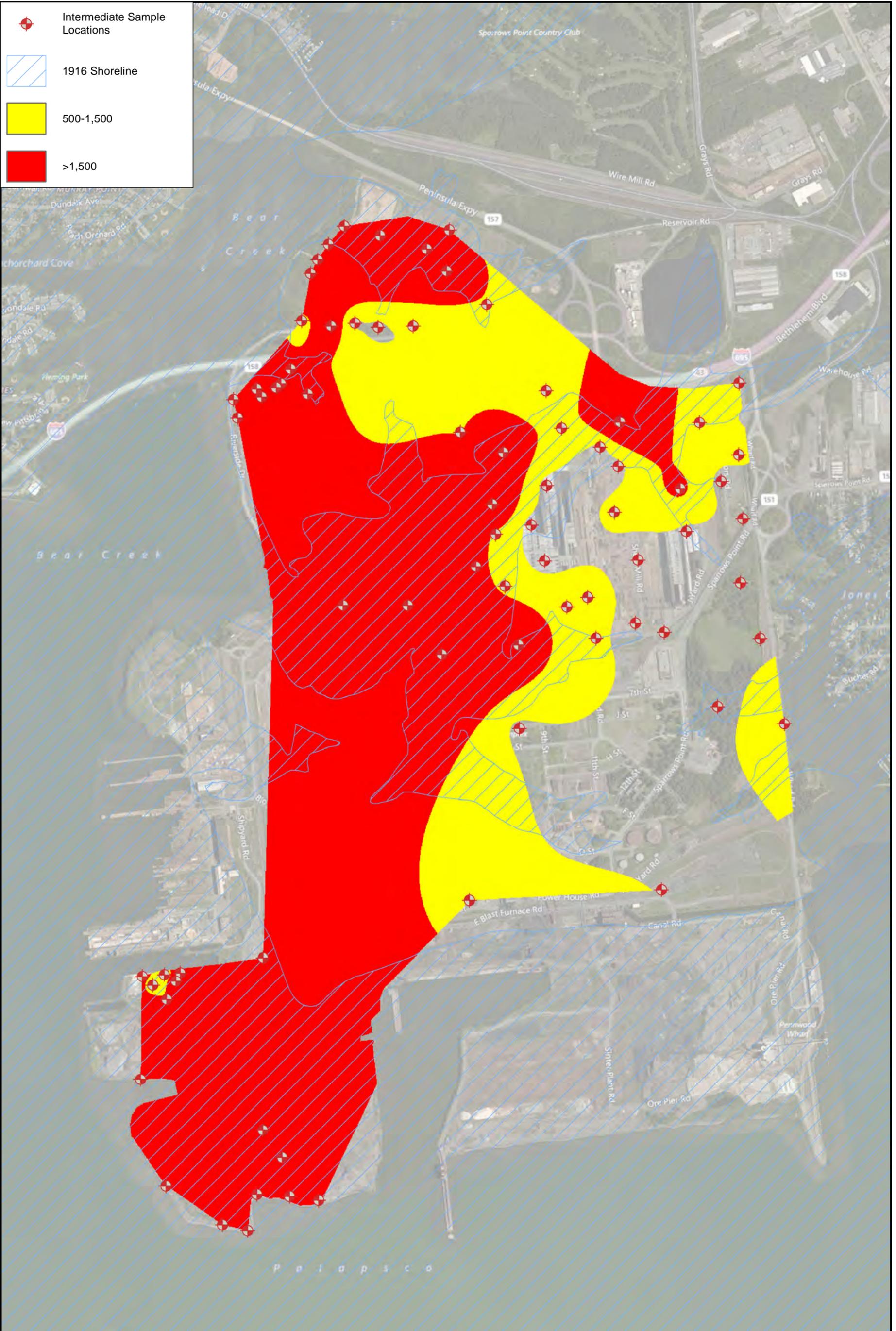
0 500 1,000 2,000
Feet

Site-Wide Groundwater Saturated Slag Thickness (ft)

March 16, 2018

EnviroAnalytics Group
Tradepoint Atlantic
Baltimore County, MD

Figure
2



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Earth Resource Engineers
and Consultants

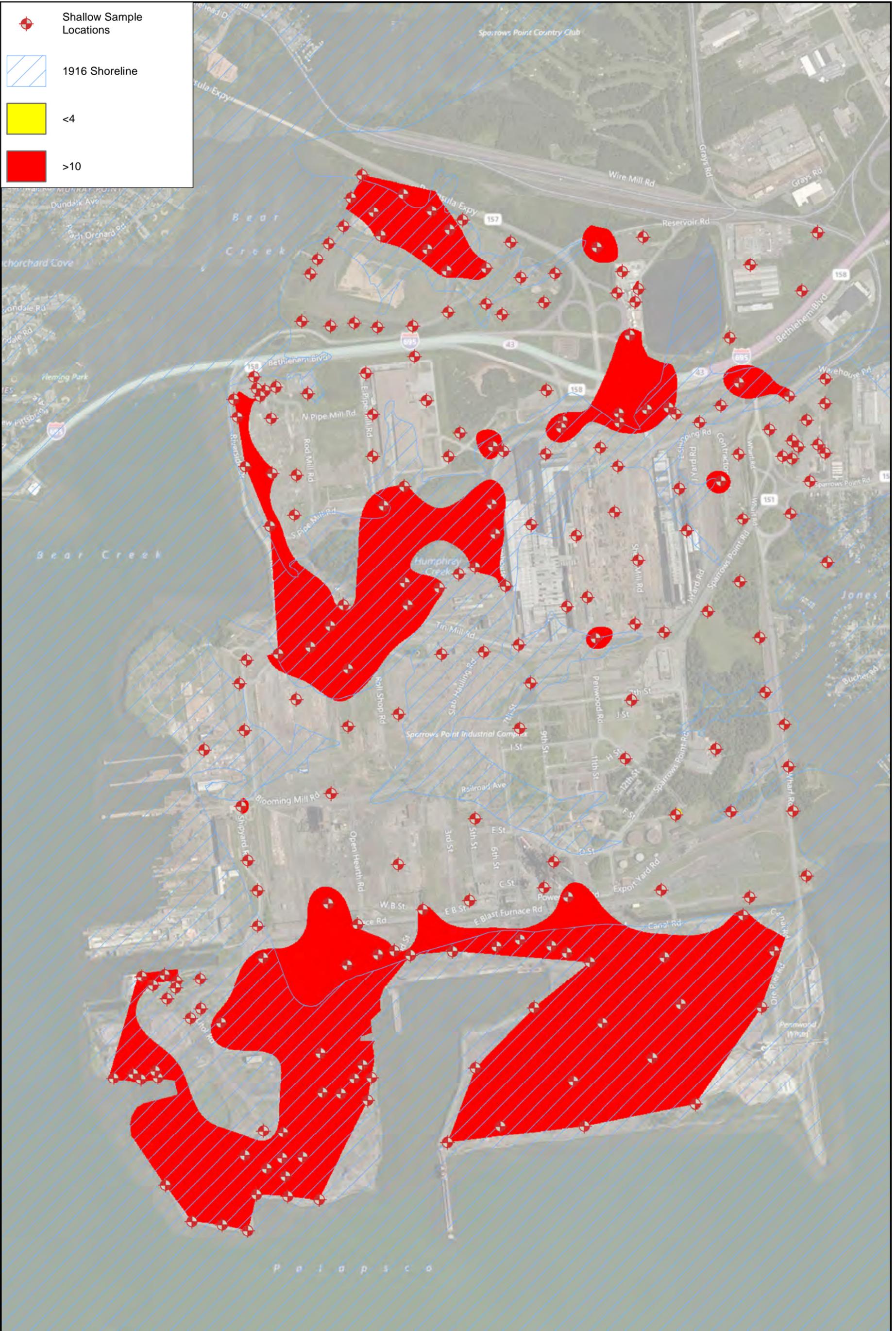
0 500 1,000 2,000
Feet

**Site-Wide Groundwater
Intermediate TDS Concentrations (mg/L)**

March 16, 2018

EnviroAnalytics Group
Tradepoint Atlantic
Baltimore County, MD

Figure
4



 Shallow Sample Locations
 1916 Shoreline
 <4
 >10

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 and Consultants


**Site-Wide Groundwater
 Shallow pH Concentrations**
 March 16, 2018

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 Tradepoint Atlantic
 Baltimore County, MD

Figure
5



Intermediate Sample Locations
 1916 Shoreline
 <4
 >10

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 Earth Resource Engineers
 and Consultants
 0 500 1,000 2,000
 Feet

Site-Wide Groundwater Intermediate pH Concentrations

March 16, 2018

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Figure
6