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December 22, 2020

Ms. Jessica LaClair
Project Manager
New York State Department of Environmental Conservation
Division of Environmental Remediation
625 Broadway, 12th Floor
Albany, New York 12233-7016

**RE: Basis of Design Submittal for Compensatory Wetland in OU-1
Former Anaconda Plant (a.k.a. Harbor at Hastings Site) Site No. 3-60-022
Hastings-On-Hudson, New York**

Dear Ms. LaClair:

Please find attached the following document prepared for New York State Department of Environmental Conservation (Department) to provide a basis of final remedial design for recently added components of the selected remedy for the Harbor at Hastings Site (former Anaconda Wire & Cable Plant site), NYSDEC Site #360022 located in Hastings-on-Hudson, New York:

- **BASIS OF DESIGN REPORT FOR COMPENSATORY WETLAND CONSTRUCTION**

This basis of design report (BODR) incorporates technical memoranda and conceptual presentations prepared by Arcadis of New York, Inc. and Sovereign Consulting, Inc., as discussed with the Department. It is a follow-up to the Preliminary Design (PD) submitted to the Department on November 29, 2017 pursuant to the NYSDEC's OU1 Amended Record of Decision (ROD) and OU2 ROD; (NYSDEC 2012a 2012b), as well as the Amended Order on Consent dated November 6, 2013 (AOC) with additional data that was conditionally approved in a NYSDEC letter dated July 21, 2017.

The BODR for the Compensatory Wetland incorporates and expands upon concepts regarding wetland separation and protection technology screening, and wetland habitat platform elevation,

approved by the Department in letters issued October 5, 2020 and December 8, 2020, respectively.

This BODR has been prepared in substantial conformance with the NYSDEC Department of Environmental Remediation Technical Guidance for Site Investigation and Remediation (DER-10).

We appreciate your time in this matter and look forward to your review. If you have any questions or comments on this submittal, please feel free to contact me at 832-619-5825.

Sincerely,



Paul G. Johnson
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BASIS OF DESIGN REPORT FOR COMPENSATORY WETLAND CONSTRUCTION

Harbor at Hastings Site
(Former Anaconda Wire & Cable Plant Site)
Hastings-On-Hudson, New York
NYSDEC Site #3-60-022

December 2020

A large, solid orange geometric shape, resembling a stylized triangle or a section of a larger triangle, is positioned in the bottom right corner of the page. It is composed of two overlapping triangles, creating a diagonal line across its surface. A thin white horizontal line runs across the page, intersecting the orange shape.

BASIS OF DESIGN REPORT FOR COMPENSATORY WETLAND CONSTRUCTION
HARBOR AT HASTINGS SITE

Certification Statement:

I, Mark O. Gravelding, certify that I am currently a New York State registered Professional Engineer and that this Basis of Design Report was prepared in accordance with all applicable statutes and regulations and in substantial conformance with the Division of Environmental Remediation Technical Guidance for Site Investigation and Remediation (DER-10).



12/22/2020

Mark O. Gravelding, P.E. Date
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**BASIS OF DESIGN REPORT
FOR COMPENSATORY
WETLAND CONSTRUCTION**

Harbor at Hastings Site
(Former Anaconda Wire & Cable Plant Site)
Hastings-On-Hudson, New York
NYSDEC Site #3-60-022

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December 2020

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Appendix A. NYSDEC Correspondence

Appendix B. Construction Methods Related to In-Water Work (Arcadis, June 2020)

Appendix C. Marsh Elevation Evaluation and Determination for Compensatory Wetland Design (Arcadis, November 2020)

Appendix D. Technology Screening Decision Document for Compensatory Wetland Separation and Protection (Arcadis, August 2020)

ACRONYMS AND ABBREVIATIONS

2D	two-dimensional
3D	three-dimensional
Arcadis	Arcadis of New York, Inc.
ASCE	American Society of Civil Engineers
bgs	below ground surface
BOD	Basis of Design
CAMP	Community Air Monitoring Plan
CERP	Community and Environmental Response Plan
CIRIA	Construction Industry Research and Information Association
cm/s	centimeters per second
CPP	Citizen's Participation Plan
CQAPP	Construction Quality Assurance Project Plan
deg	degree
fps	feet per second
ft/ac	feet per acre
ft/sf	foot per square foot
GCL	Geosynthetic Clay Liner
H&A	Haley & Aldrich
HASP	Health and Safety Plan
HEC-RAS	Hydrologic Engineering Center River Analysis System
Marsh	a compensatory wetland
MHTL	mean high tide level
MLTL	mean low tide level
mm	millimeter
mm/yr	millimeters per year
MTL	mean tide level
NAVD88	North American Vertical Datum of 1988
NEA	Northwest Extension Area
NYCDPR	New York City Department of Parks & Recreation

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NYSDEC	New York State Department of Environmental Conservation
OM	organic matter
OU1	Operable Unit 1
OU2	Operable Unit 2
%	percent
PCB	polychlorinated biphenyl
pcf	pounds per cubic foot
psf	pounds per square foot
RAMP	Remedial Action Monitoring Plan
Riverkeeper	Riverkeeper, Inc.
ROD	Record of Decision
SBT	Systems Based Tool
Site	Harbor at Hastings Site (former Anaconda Wire & Cable Plant site), NYSDEC Site #360022
SLAMM	Sea-Level Affecting Marshes Model
Sovereign	Sovereign Consulting, Inc.
SMP	Site Management Plan
TBD	to be determined
TSCA	Toxic Substances Control Act
TSDD	Technology Screening Decision Document
USACE	U.S. Army Corps of Engineers
USEPA	United States Environmental Protection Agency
WLR	water-level rise
WSE	water surface elevation

1 INTRODUCTION

On behalf of Atlantic Richfield Company (AR), Arcadis of New York, Inc. (Arcadis) has prepared this Basis of Design Report (BODR) for review pursuant to New York State Department of Environmental Conservation (NYSDEC) requirements for Remedial Design (6NYCRR Part 375). This Report provides a summary of guidance and assumptions for design and construction of a compensatory tidal wetland (the Marsh) within Operable Unit 1 (OU1) at the Harbor at Hastings Site (former Anaconda Wire & Cable Plant Site), NYSDEC Site #360022 located in Hastings-on-Hudson, New York (Site) that compensates for the approved remedy which includes unavoidable displacement of aquatic habitat in the Hudson River to construct the Northwest Extension Area (NEA) as a key component of the remedy, in accordance with the 2012 Record of Decision (ROD) for OU2 (NYSDEC 2012b).

Prior to the submittal of this BODR, AR and NYSDEC have collaborated on certain aspects of the Marsh construction and NYSDEC has reviewed and approved certain design concepts for the Marsh (**Appendix A**) and continues to review additional interim submittals. Each stage of design (design memoranda, 95% Design and Final Design) will be subject to NYSDEC approval. The current document will form the basis for the 95% Design of the Marsh. Principal additional stakeholders involved in this component of the 95% Design review include United States Army Corp of Engineers (ACOE), as well as the Village of Hastings-On-Hudson and the Hudson Riverkeeper Fund, Inc., now known as Riverkeeper, Inc. (Riverkeeper) pursuant to a Consent Decree v. Atlantic Richfield Company (Consent Decree 2016). For simplicity, the term Final Design used throughout this BODR includes the 95% Design submittal for stakeholder review, complete with all design elements and drawings, as well as the Final Design submittal that will be certified in accordance with DER-10 and prepared for public distribution, following any revisions to the 95% Design based on stakeholder review.

In consultation with NYSDEC, the siting and extent of the Marsh were agreed upon in September 2018. Design assumptions are based on existing remedial investigation and pre-design reports, laboratory data, and in-situ testing data. A summary of existing site conditions is available in the 2017 Preliminary Design Report (Arcadis 2017). Additional data collected from the Marsh area include soil and groundwater analytical results, subsurface light non-aqueous phase liquid observations, and void observations (Sovereign 2018). Geotechnical data were also collected during the Pre-Design Investigation (PDI) adjacent to the Marsh within the Northwest Extension Area (NEA) (Sovereign 2018). Additional groundwater monitoring data were presented in the 2019 Supplement to PDI Data Summary Report (Sovereign 2019).

Conceptual Marsh plans have been presented to NYSDEC by AR, Sovereign Consulting, Inc. (Sovereign), and Arcadis on numerous occasions, including June 27, 2019 at the Site (AR and Sovereign) and September 26, 2019 in Albany (AR, Arcadis and Sovereign). During these discussions, NYSDEC requested a separation layer be included in the wetland design, and Arcadis and Sovereign evaluated neighboring marshes and regional tidal data in order to establish a target Marsh elevation and means of protecting the marsh from River energy. Follow up concept slide presentations and memoranda have included:

- Slide Presentation via Online Meeting on June 23, 2020 - Discussion of Low Marsh Design and Separation

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- Memorandum for Discussion - Technology Screening Decision Document for Compensatory Wetland Separation and Protection, August 20, 2020
- Memorandum for Discussion - Marsh Elevation Evaluation and Determination for Compensatory Wetland Design, November 6, 2020

NYSDEC provided comments on the draft Technology Screening Decision Document (TSDD) in an October 5, 2020 letter (Appendix A). The Department found the draft TSDD to be acceptable and approved the use of a geosynthetic clay liner (GCL) or equivalent barrier layer of the intertidal wetland to be constructed. The letter also included the following comments, some of which are addressed in this document and some of which will be addressed in the Final Design:

- The Department has previously specified that a 2-foot minimum separation layer is required between the historic fill containing residual PCBs and the habitat layer of the Marsh.
- The Department verbally accepted a habitat layer of 3 feet, had questions regarding how compaction and erosion will be addressed, and noted a potential concern over phragmites due to their long root structure.
- The following is a list of items the Department would like addressed in future design and monitoring submittals:
 1. If necessary, to achieve the proper elevations for the new wetland, the Department is not opposed to removing additional soils beyond those described in the ROD.
 2. Effectiveness monitoring for the wetland must also include a way to determine if the underlying residual PCBs have impacted the newly created wetland.

NYSDEC also approved the November 26, 2020 technical memorandum entitled "Marsh Elevation Evaluation and Determination for Compensatory Wetland" in a December 8, 2020 letter (**Appendix A**).

2 KEY DESIGN ELEMENTS AND OBJECTIVES

The key elements and considerations anticipated in the Marsh design include:

- Construction sequence and methodology, including soil excavation
- Marsh platform elevations and morphology
- Marsh isolation, separation, and habitat layers
- Marsh channel morphology
- Marsh Inlet/Outlet
- Vegetation
- Ecological performance criteria, monitoring and management
- River Barrier, with ability to accommodate a potential river access point for future development
- Stormwater diversion.

BASIS OF DESIGN REPORT FOR COMPENSATORY WETLAND CONSTRUCTION HARBOR AT HASTINGS SITE

The overall design objective is creation of a sustainable intertidal low-marsh habitat to mitigate the river habitat loss associated with the NEA. The 2012 ROD for OU1 (NYSDEC 2012a) specified green remediation principles to be considered and outlined overall project objectives. Additional intermediate design objectives to be satisfied in the design of the Marsh include the following:

- Resilience to expected sea level rise for at least 50 years
- Promote a dominant culture of smooth cordgrass (*Spartina alterniflora*) on the Marsh platform, while also including species diversity in planting plans to target long-term stability (including a diverse plant community along slopes from low marsh into upland areas)
- Discourage establishment of common reed (*Phragmites australis*)
- Protect the Marsh from potential impact by residual PCBs at the Site
- Protect against deleterious erosion of the Marsh platform, channels, slopes, and barrier structures
- Account for water level rise, natural accretion, and stream channel migration within the Marsh
- Establishment of Marsh within 5 years based upon defined performance criteria

These key design elements and objectives are further discussed in the sections below.

2.1 Construction Sequence and Methodology

Construction of the Marsh will be influenced by logistical considerations and administrative requirements. Logistical considerations during construction include approaches to address construction personnel health and safety, groundwater management, wave and current energy, geotechnical requirements, sustainable practices, and resource usage. The administrative requirements discussed here are related to ecological protection measures as described in the June 22, 2020 memorandum titled *Construction Methods Related to In-Water Work* (Construction Sequencing Memorandum) (**Appendix B**).

2.1.1 Construction Sequencing

Construction sequencing and in-water remedial construction work activities were discussed with NYSDEC on May 15, 2020 and summarized in the Construction Sequencing Memorandum, which was approved by NYSDEC in a letter dated September 24, 2020. The memorandum and approval specified when in-water work outside of turbidity curtains would be allowed, and that work within turbidity curtains may be performed year-round. Turbidity curtains will be installed to isolate the Nearshore and Backwater areas from the Hudson River prior to performing specific activities. The specific activities related to Marsh construction include shoreline demolition, construction of a River Barrier on the western side of the Marsh, and other construction tasks performed in the water. For periods when turbidity curtains are to be used to control turbidity within the Hudson River, a Turbidity Mitigation and Control Plan and a Monitoring and Maintenance Plan for the turbidity curtain will be implemented as described in the Construction Sequencing Memorandum. In addition to the administrative sequencing requirements discussed in the Construction Sequencing Memorandum, the work will be sequenced/phased based on the Contractor's approach, design constraints, weather/climatic conditions, and permit requirements for other regulatory conditions.

2.1.2 Anticipated Methods

Construction methods will be proposed by the construction contractor during bidding. Construction methods will address the following construction elements:

- Remedial/Marsh excavation, including additional excavation to establish target Marsh platform elevation (prior to Marsh construction)
- Shoreline demolition (prior to Marsh construction)
- River Barrier
- Inlet/Outlet
- Isolation layer
- Separation layer
- Demarcation layer between habitat separation layer and habitat substrate
- Habitat substrate layers (Marsh and transitional slope)
- Marsh channels
- Marsh and slope plantings
- Project construction elements.

Excavation limits will be generally consistent with those presented in the 2018 PDI DSR Amendment (Sovereign 2018), except where the Marsh construction requires additional excavation to accommodate the areal extents and depths required for construction of the Marsh layers, as approved by NYSDEC (Appendix A). See **Figures 2A and 2B** for a comparison of the proposed remedial excavation and Marsh extents.

Regarding the change in methodology for OU1 remedial excavation approach (slurry wall or sheeting), the Marsh was not identified nor included in design considerations originally outlined in the Preliminary Design Report (Arcadis 2017). Additionally, construction of the River Barrier adds a new consideration to water control during the excavation and backfill approach. For these reasons, the Contractor may be allowed to choose to excavate the entire Marsh and River Barrier in the dry, in the wet or in some combination of these approaches. The feasibility of each approach will be evaluated during Final Design, considering the following general objectives and considerations:

- Avoid downstream release of impacted sediments
- Avoid or minimize cross-contamination of non-impacted soils and fills
- Confirm achievement of required excavation depths
- Maintain excavation stability, as needed to protect personnel, equipment, and adjacent structures
- Construction access
- Water management and treatment
- Permit restrictions.

Potential approaches to excavation in the wet include the following mechanical dredging techniques:

- Long reach excavators and/or amphibious excavators operating from locations above the high tide elevation
- Barge or crane/swamp mat-mounted excavators
- Environmental bucket mounted on a wireline crane.

If dredging is performed in hydraulic connection with the Hudson River, then turbidity curtains will be required (the turbidity curtains around the Nearshore may be used). Environmental buckets will be used for any dredging within the turbidity curtain unless debris or sediment conditions prevent their effective use. The Final Design specifications will require that the contractor provide alternative methods in a Turbidity Mitigation and Control Plan. Acceptable alternatives include removal of obstructions with excavator or crane fitted with grapple and shear cutting or vibratory removal of existing wood piles. A digging bucket (aka a hinged clamshell bucket with teeth) will be used in difficult conditions and will be replaced by an environmental bucket as soon as practicable.

Excavation in the dry will be performed using excavators and standard excavation techniques. Dewatering and material management (excavated soil and sediment) will be performed in accordance with methods defined for the remaining OU1 excavation areas, as outlined in the Preliminary Design and to be refined in the Final Design.

Due to the challenges and costs associated with dewatering the Marsh to target subgrade elevations as low as -4 feet North American Vertical Datum of 1988 (NAVD88), the Marsh layers may be placed in the wet and as such will be comprised of materials that consolidate quickly under their own weight (e.g., clean sands or fine gravel). It is also anticipated that the isolation layer itself may be placed in the wet (according to manufacturer's recommendations for underwater installations), as well as any overlying soils that will consolidate over time and under such conditions, or that can ultimately tolerate limited differential settlement. The bidding contractor will be responsible for providing a plan for sequencing the Nearshore dredging and shoreline demolition adjacent to the Marsh, Marsh/remedial excavation, barrier construction, and other components related to Marsh construction to meet the required performance objectives.

2.2 Marsh Platform Elevations and Morphology

2.2.1 Marsh Elevation Range

The targeted design elevation range for the Marsh will be based on (1) expected salinity ranges; (2) expected estimates of water-level rise (WLR); (3) expected tidal elevation range; and (4) biological benchmark data for both smooth cordgrass and common reed. Based on the evaluation presented in *Marsh Elevation Evaluation and Determination for Compensatory Wetland Design*, included as **Appendix C**, the Final Design for the Marsh platform elevation will be based on:

- Expected rate of WLR of 0.0175 foot per year (0.210 inch per year), representative of regional conditions

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- Projected tidal range at an assumed future completion time frame for wetland construction (i.e., ~June 2026) from a mean tide level (MTL) of +0.460 foot to a mean high tide level (MHTL) of +2.296 feet
- Targeted upper 25 percent (%) of the tidal range projected for the assumed future wetland completion time frame, estimated at +1.361 feet to 2.296 feet
- Mechanism to adjust the final elevation closer to the actual completion date based on updated WLR analysis.

Arcadis considered the lower threshold elevation of +1.36 feet for the Marsh platform and added a safety factor of 0.2 foot, which accounts for the anticipated accuracy of final grading as defined by construction specifications, to propose a targeted Marsh platform elevation of approximately +1.56 feet.

NYSDEC has reviewed and approved this basis for the marsh elevation design in a December 8, 2020 letter (**Appendix A**).

2.2.2 Natural Accretion Estimate

Arcadis evaluated this lower threshold elevation to confirm that the design elevation will continue to provide “elevation capital” following Marsh construction. Using a constant rate of WLR through the life of the project, a proposed tidal marsh habitat elevation of +1.56 feet at the assumed wetland construction completion time frame provides the necessary elevation capital to sustain a low marsh habitat for at least 50 years after completion of restoration activities¹. To incorporate accretion into the projection of wetland design life, a review was completed of existing studies that predict wetland response to long-term sea level rise. These studies, as referenced below, typically focused on the Sea-Level Affecting Marshes Model (SLAMM) that has been completed for the Hudson Estuary, as well as other large estuaries on the north Atlantic Ocean coast. A SLAMM simulates the dominant processes that affect shoreline modifications during long-term sea level rise scenarios. It was one of the first landscape-scale models to incorporate the effects of vertical marsh accretion rates on predicting marsh resiliency.

Piermont Marsh, which was the most prominent wetland in the southern Hudson River, has been studied extensively (Wong and Peteet 1999). Wong and Peteet (1999) performed detailed analysis indicating that this approximately 5,700-year-old marsh experienced a rate of deposition of 2.6 millimeters per year (mm/yr.) over its lifetime. Evaluating the rate of sedimentation only since European settlement in the area (i.e., 1697), the rate slightly increased to 2.9 mm/year (Dee Cabaniss Pederson et al. 2005).

The New York SLAMM (Warren Pinnacle Consulting 2014) simulated salt-marsh accretion rates for the Hudson study area (inclusive of the project area).² For wetlands below or near MHTL, the model estimates accretion rates to be approximately 4 mm/yr. The model also evaluated the variability of data and uncertainty of accretion rate estimates. By calibrating the model only with minimum and maximum accretion rates, the model provided likely ranges for the accretion rate within the Hudson River study

¹ Assumes restored marsh platform will remain higher than the estimated MTL elevation.

² It is noted that the accretion rate projections are not based on site specific data for regularly flooded marshes in the Hudson study area (due to limited acreage), and that projections may be skewed higher due to high total suspended solids in the Hudson River.

area. Specifically, the model identified a minimum “most-likely” accretion rate of 1.5 mm/year compared to a maximum “most-likely” accretion rate of 10.9 mm/yr.

To provide an additional regional reference, the vulnerability of marshes in the Delaware Estuary and Barnegat Bay was also evaluated (Haaf et al. 2015). The study provided the following ranges of accretion rates:

- Delaware Estuary, saltwater: 3.19 to 10.1 mm/yr
- Barnegat Bay, saltwater: 1.91 to 6.7 mm/yr.

If conservatively assuming an accretion rate of 3.0 mm/yr. that aligns with historic Piermont Marsh data and falls within modeled ranges in the Hudson River, Delaware Estuary, and Barnegat Bay, the Marsh platform can be assumed to rise by approximately 0.44 foot (or 134.1 mm) over a 50-year period.³ While WLR over a 50-year period will be greater than accretion rates, a Marsh platform elevation of approximately 2.0 feet will remain above the MTL after a 50-year period and in turn can be assumed to continue to support a low marsh community.

2.2.3 Marsh Platform Morphology

The Final Design will provide a primarily flat restored Marsh platform, with the potential for slopes up to approximately 0.5 percent (at time of construction) towards the tidal channel network to promote micro-channeling as the Marsh becomes established. As discussed further in Section 2.4.2, a general rule of thumb that applies to coastal salt marsh restoration is that no area within the Marsh platform should be located more than 100 feet from a tidal channel (New York City Department of Parks & Recreation [NYCDPR] 2018). While NYCDPR recognizes this is more of a rule of thumb, it provides a framework that targets a sinuous channel construction within the Marsh platform to minimize the distances of low marsh plantings to the tidal channel. The slope of the platform will also take into consideration:

- The upper threshold for a low marsh habitat at the assumed time for wetland construction (i.e., ~2026) is 2.296 feet (NAVD88)
- The threat of common reed establishment increases as the marsh platform gets closer to the MHTL (2.296 feet).

It is anticipated that the restored Marsh platform will be generally flat throughout the Marsh as discussed above. It is anticipated that the transitional slopes from the low marsh platform to uplands will have steeper slopes, and which will be further refined during Final Design.

2.3 Marsh Layers

2.3.1 Purpose

The Marsh will comprise several specialized layers of soils and geosynthetics to promote long-term productivity and protection against residual impacts. Residual PCBs will be left in place under the Marsh

³ This estimate conservatively assumes maturation at 5 years for a low marsh and no accretion during the first 5 years after planting.

due to the maximum prescribed excavation depths of 9 feet near the Hudson River (described as the Northern Shoreline in the 2012 OU1 ROD) and to depths of 12 feet farther inland (NYSDEC 2012a). A summary of PCB analytical results is presented in the 2018 PDI DSR Amendment (Sovereign 2018). Figures 1 and 2 of the attached Technology Screening Decision Document (**Appendix D**) plot the available data regarding soil and groundwater PCB concentrations to be left in place beneath the Marsh. Additional excavation to be performed beyond the remedial excavation extents shown on the 2018 drawings will be presented on the Final Design drawings. The general Marsh layering is depicted in the cross section on **Figure 2B**. Final Design specifications will provide performance-based criteria for Marsh construction materials, allowing the contractor to propose functionally equivalent substitutions pending the design engineer's review.

2.3.2 General Layers

An isolation layer will be installed at the base of the wetland excavation to mitigate the potential for migration of PCBs from the underlying fill to the Marsh habitat as described in the approved TSDD (**Appendix D**). The proposed isolation layer includes a geosynthetic clay liner (GCL) with an approximate 6-inch sand cushion layer underneath. Alternative products are also being considered that have similar performance (e.g., AquaBlok). Above the isolation layer, a 2-foot separation layer is prescribed to meet NYSDEC separation layer requirements, followed by a geotextile demarcation layer and the Marsh habitat layer. A geotextile demarcation layer will be installed between the separation layer and the Marsh habitat. The general layering is depicted on **Figure 2B**.

2.3.3 Isolation and Separation Layers

A sand cushion layer (~6" sand) will be installed on the final excavation surface to provide a smooth, uniform surface for placement of the isolation layer and to protect the isolation layer from underlying debris, large rocks, etc.

The isolation layer will be installed to address residual PCB impacts beneath and within the vicinity of the Marsh, as required by the governing documents for remediation of the Site. As described in the TSDD, a geosynthetic clay liner (GCL) has been identified as a likely option for the isolation layer. The material-performance specifications for the isolation layer will target a minimum low hydraulic conductivity and allow for materials substitution (e.g., installation of AquaBlok instead of GCL, as described in the TSDD), provided the minimum design criteria are met. Additional information related to the selection and criteria for the isolation layer is provided in Appendix D.

NYSDEC also requires a 2-foot minimum separation between the historical fill containing residual PCBs and the created Marsh habitat layer. This separation layer will be composed of granular fill placed on top of the isolation layer.

The groundwater model for the Site (Arcadis 2019) will be updated to reflect the effects of proposed Marsh conditions on groundwater flow in the vicinity of the Marsh. A component of the planned analysis includes assessing design height of the isolation layer around the periphery of the Marsh to control groundwater overtopping of the isolation layer and entering the Marsh.

2.3.4 Demarcation Layer

A geotextile or similar product will be placed between the separation layer and the habitat layer to provide a visual indication of the contact between the separation layer and habitat layer. This demarcation layer will serve to alert personnel performing construction tasks that they have reached the separation layer and will alert personnel performing Marsh inspection tasks of significant erosion issues. Additional properties for the geotextile will be determined during Final Design, such as the need for retention of fines within the overlying habitat substrate and the need for supplemental support of overlying materials.

2.3.5 Habitat Layer

The habitat layer will be placed above the demarcation layer to a nominal thickness of 3 feet and will be designed to promote growth of target plant species. Physical and chemical characteristics of habitat-layer soils will be specified to accommodate target vegetation, anticipated faunal usage, constructability and availability considerations, and erosion resistance. It should be noted that the habitat-layer thickness of 3 feet is conservatively greater than anticipated Marsh vegetation rooting depths (i.e., generally 12 inches) to allow for natural headcutting of smaller feeder channels, primary tidal-channel construction, natural erosion, accretion processes, and to promote favorable moisture retention and nutrient cycling.

The vegetated wetland habitat substrate will likely consist of sand amended with spent mushroom compost or similar material to obtain a target organic matter (OM) content ranging from approximately 5 to 10%. The final determination for composition of habitat substrate will balance ecological value of higher organics and structural stability provided by sand. For reference purposes, a total organic matter content of 6% would require a ratio of 82% sand and 18% mushroom spent compost.⁴

The design also considers the fact that nutrient rich silt, clay, and organic sediments will be deposited on the Marsh surface very quickly after introducing tidal flushing to the marsh platform and which will provide additional nutrients to support early successional intertidal plant community development. While NYCDPR (2018) does not recommend amendments with organics, they have been included herein based upon ongoing communication with NYSDEC and to ensure appropriate nutrients for plants during the early successional development stages.

While particle size and chemical properties of the sand will be refined as part of Final Design, NYCDPR (2018) outlines the following as design targets:

- Dominant particle size (>70%) 0.05 mm to 0.25 mm in diameter
- Limited fines (<10%) silt or clay particles, 0.05 mm to 0.0002 mm in diameter
- pH of 4 to 8.

2.4 Marsh Channel Morphology

The success of this tidal-marsh construction project is predicated on the ability to effectively promote tidal flushing through all portions of the marsh habitat, as necessary to support the targeted plant community. A successful restoration design must provide a channel network that is able to distribute tidal waters and

⁴ This is based upon percent organic matter of spent mushroom compost of 28% as provided by vendor analyses.

nutrients throughout all portions of the Marsh, while also providing sufficient drainage during the ebb tide. In natural, coastal wetland systems, a tidal channel network often consists of an intricate system of bifurcating channels within a shallow coastal environment that provides a critical exchange of sediment and water between the estuary and its coastal wetlands. The dominant factors that influence tidal flushing in a coastal wetland include marsh platform elevation, vegetation, shape of channel cross section (i.e., width, depth), and plan view of channel (i.e., sinuosity, length, dendritic pattern). Marsh platform elevation is addressed in Section 2.2 and directly ties to channel morphology and ability to effectively promote tidal flushing. This section provides the basis for the following tidal-channel design elements:

- Shape of Channel Cross Section(s)
- Plan View of Channel
- Size and Configuration of Channel Connection (Inlet/Outlet) to the Hudson River.

2.4.1 Shape of Channel Cross Sections

Typically, channel dimensions can be estimated from reference sites with similar drainage areas and tidal prisms (NYCDPR 2018). Quality reference sites facilitate the ability to quantify channel dimensions in ideal habitat conditions, which then can be utilized for design metrics and goals. Anthropogenic disturbances (e.g., mosquito ditching, *Phragmites* invasion, shoreline hardening) throughout the Hudson River Estuary have made it difficult to identify an appropriate reference site for this project. A native low marsh habitat along the river's edge is uncommon in this portion of the Hudson River watershed. Additional information pertaining to evaluation of similar habitats in this reach of river can be referenced in the *Marsh Elevation Evaluation and Determination for Compensatory Wetland Design* (**Attachment C**). Channel cross sections will be designed as triangular or trapezoidal to facilitate ease of construction. Shape selection (i.e., triangular or trapezoidal) will depend on anticipated flow energy, upgradient tidal prism, and/or desired channel width and flow depth.

2.4.1.1 Channel Width near Inlet/Outlet

To determine the design channel width near the inlet/outlet end (i.e., where it connects to the Hudson River), the Final Design will be supported by (1) a Systems Based Tool (SBT) developed to support ecological restoration projects in the Delaware River watershed, (2) reference to similar salt marsh restoration projects in New York City and New Jersey, and (3) reference to natural tidal channel networks within Jamaica Bay.

To support marsh restoration and enhancement within the Cape May and Supawna Meadows National Wildlife Refuges, New Jersey, Sovereign developed an SBT that provides a regional reference set based on 21 wetland reference sites located along the banks of the Delaware Estuary and which had no significant observable anthropogenic disturbance (e.g., mosquito ditching, salt hay farming, construction, etc.). Sovereign provided Arcadis a summary of this SBT in the form of a draft internal communication. Given the absence of other strong reference sites for this project area, this tool provides one of the most comprehensive data sets for undisturbed marshes along the North Atlantic coastline of North America. A brief summary of the SBT follows:

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For each reference site located within either the Delaware Bay or Delaware Inland Bays estuaries, the channel width at the confluence with the larger marsh unit or water body was compared to the overall low marsh acreage. Wetland sizes ranged from 0.98 acre to more than 1,881 acres. The channel width ranged from slightly over 2 feet to more than 370 feet. The acreage of the low marsh footprint was plotted against the channel opening at their confluence or “outlet” to the larger water body. A power-slope relationship was identified from a data plot, with an r^2 value of 0.9216 (see Figure A below). The formula for this relationship is as follows:

$$\text{Marsh Channel Width (ft)} = 4.6866 \text{ (ft/ac)} \times \text{MA (ac)}^{0.5857},$$

where MA = marsh acreage.

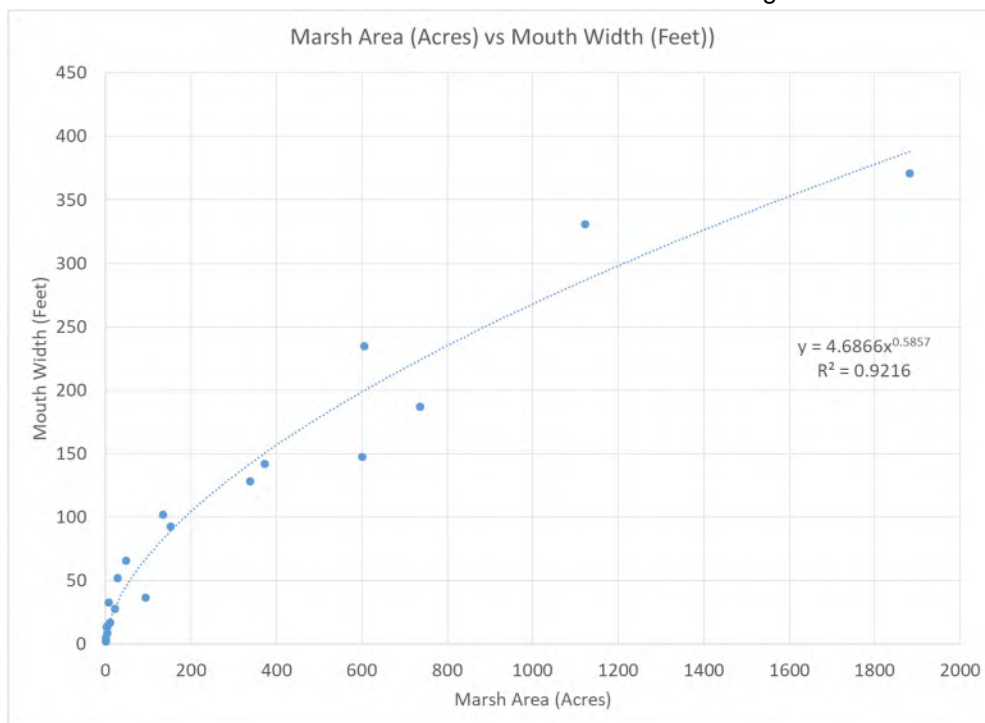


Figure A. Relationship Developed by Sovereign for Tidal Marshes within the Delaware Bay and Delaware Inland Bays Estuaries

Applying this calculation to the proposed 1.32-acre Marsh, the recommended width of the channel at the Marsh outlet to the Hudson River would be approximately 6 feet wide⁵. This approximate width provides a starting point that will be further refined through hydrodynamic modeling of the proposed marsh habitat (see Section 2.4.4) to optimize wetland inundation and flushing.

This SBT was also compared to a recently completed tidal marsh project at Sunset Park in Jamaica Bay. The project restored 5 acres of coastal salt marsh habitat and created a channel width of approximate 12 to 15 feet (based on aerial imagery) at the outlet to Jamaica Bay. Using the formula presented above, a

⁵ It is also noted that this approach has been successfully applied to two coastal marsh restoration projects in the Delaware Estuary.

5-acre wetland design would require a channel width of 12 feet. A similar analysis of other regional salt marsh projects, or natural channel networks within Jamaica Bay, could be further evaluated if determined necessary as part of the final restoration design.

2.4.1.2 Channel Depth and Side Slopes

In general, when an appropriate channel width and shape are provided to a restored marsh plain, tidal flows will naturally adjust the channel depth to produce optimum hydrodynamic conditions during peak flood tide and ebb tide. However, in the design of the proposed Marsh platform, the channel depth at the outlet to the Hudson River is limited by (1) design of tidal-channel slope through the marsh, (2) maximum allowable marsh-platform elevations to avoid ingress of undesirable plant species, and (3) establishment of a minimum channel invert elevation at the downgradient extent to maintain proper tidal drainage and flushing. For the purposes of this design, the platform elevation will target a relatively flat surface with an elevation of +1.56 feet (NAVD88). The channel depth at the outlet will be approximately 1.5 feet, with a channel-invert elevation range between -0.5 and 0.5 feet (NAVD88) (mean tide line) to ensure that the channel runs dry before mean low tide (-1.445 feet). Due to these limitations, the longitudinal profile of the restored channel network will have a very subtle slope (i.e., <1%) that will be designed to promote generally unrestricted floodtide flow into the marsh while also promoting adequate flushing action during ebb tide (i.e., primarily to promote the removal of undesirable detritus and invasive plant seeds, and to promote proper nutrient and sediment cycling).

Side slopes for restored tidal channels generally range from approximately 3:1 to 6:1 (Coats et al. 1995). Hydrodynamic modeling will be used to evaluate various side slopes, with an emphasis on maintaining desired flow energies during ebb tide to promote tidal flushing.

2.4.2 Plan View of Channel

The plan view of a restored tidal channel will be designed for length, sinuosity, and dendritic pattern (i.e., channel network). As noted above, a general rule of thumb provided by NYCDPR (2018) recommends that no areas within the marsh plain be more than 100 feet from a tidal channel. This rule will be used as a framework to establish the channel network, in addition to hydrodynamic modeling. As this is a relatively small acreage wetland, the network will likely not exceed a 2nd or 3rd order channel design.

A summary of existing guidelines for distinct channel parameters in a plan view is provided below. However, it is noted that the Final Design will rely heavily on the proposed layout of the wetlands, the required location of the inlet and outlet structure, and the design of a channel network that effectively delivers and drains tidal waters throughout the restored marsh platform. A conceptual plan for the tidal channel network within the restored marsh platform is provided on **Figure 1**.

Drainage Density

Drainage density is one of the most important design parameters for the plan view of a channel network as it provides the arterial network for inundation and drainage of the marsh platform. Coates et al. (1995) recommends drainage density⁶ of 0.01 to 0.02 foot per square foot (ft/sf) as a general guideline (Coats et

⁶ Drainage density = length of all channels divided by the marsh area

al. 1995). This is equivalent to approximately 435.6 to 871.2 feet of channel for every acre of restored marsh. Appreciating this density is only a recommended guideline, the final design will aim to restore a sinuous channel that minimizes distances of low marsh platform to the tidal channels where possible. The design will also recognize that additional 2nd or 3rd order channels will likely develop in response to the hydrodynamics on the restored marsh platform.

Bifurcation Ratio

Bifurcation is the process of single channel segments branching in repeated patterns. Coats et al. (1995) recommends a bifurcation ratio of 3.5⁷. For a wetland of this size, a relatively simple bifurcation network will likely be restored (i.e., 2 to 3 orders of channel segments) with the understanding that smaller feeder channels will develop in response to the hydrodynamics on the restored marsh platform. This is based on past professional experience and a process that does not significantly decrease the aerial coverage of proposed plant communities.

Sinuosity

First order channels are generally considered to have the lowest sinuosity, with sinuosity increasing with channel order. Channel sinuosity will be defined by both the location and the angle of approach of the mouth of the channel to the Hudson River, as well as the framework that no portion of the marsh platform exceed 100 feet from a tidal channel.

2.4.3 Inlet / Outlet Design

The main-channel inlet/outlet will be designed to promote long-term stability, resistance to floodtide and ebb-tide velocities, wave action, and flow energies from the Hudson River. The currently envisioned configuration is illustrated on **Figures 1** and **2C** and places the inlet/outlet in the North Boat Slip at the southern boundary of the marsh platform. Preliminarily, the design process will assume a trapezoidal inlet/outlet geometry, rock-lined, with a target invert elevation between approximately -0.5 to 0.5 feet (NAVD88).

2.5 Vegetation

As described in Ecological Communities of New York State (Edinger et al. 2014), “the vegetation of the low salt marsh is a monospecific stand of cordgrass (*Spartina alterniflora*).” As such, smooth cordgrass will be the dominant species within this created low marsh habitat. To provide additional diversity as recommended by NYSDEC, the following native species provide potential minor plant associates that will be considered in the final wetland design: saltgrass (*Distichlis spicata*), saltmeadow cordgrass, American saltmarsh bulrush (*Bolboschoenus maritimus* ssp. *pauldosus*), and high tide bush (*Iva frutescens*).

Dominant plant species that may be included in the planting design along the perimeter of the marsh as it transitions to uplands include saltgrass, saltmeadow cordgrass, black grass (*Juncus gerardii*), perennial saltmarsh aster (*Symphyotrichum tenuifolium* var. *tenuifolium*), switchgrass (*Panicum virgatum*), and high tide bush. Additional native grasses and flowering forbs will be considered for this transition area as part

⁷ Bifurcation ratio = number of channels in a given channel order divided by the number of channel segments in the next highest order.

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of a native seed mix. Additional woody species to be planted here could include bayberry (*Myrica pensylvanica*), groundsel-tree (*Baccharis halimifolia*), beach plum (*Prunus maritima*), eastern red cedar (*Juniperus virginiana*), and rose species (*Rosa* spp.).

The salt marsh community will be planted with 2-inch plugs at a plant spacing between 12 to 18 inches on center. If high tide bush is included in the planting plan, then the native shrub (a minimum size of 1-gallon container) will be planted in clusters of three at a minimum of 10 feet on center. A typical Marsh platform planting table is included in **Table 1**. The table is provided to illustrate plant spacing, diversity, and potential species to be considered in Final Design. All plants will be obtained from a native plant nursery within the region (i.e., within approximately 250 miles of the Site). All plant stock will be healthy, vigorous stock and free from disease, infestation, or significant structural damage. All plantings will strategically target the spring (i.e., March through May) and will be acclimated to local salinities by the nursery prior to shipment.

Table 1. Typical Marsh Platform Planting Table.

Scientific Name	Common Name	Size	Density (stems/acre)	On-Center Spacing (feet)	Total Number
<i>Spartina alterniflora</i>	Smooth cordgrass	2-inch plug	19,360	1.5	TBD
<i>Spartina patens</i>	Saltmeadow cordgrass	2-inch plug	4,840	3.0	TBD
<i>Distichlis spicata</i>	Saltgrass	2-inch plug	4,840	3.0	TBD
<i>Iva frutescens</i>	Jesuit's bark/High-tide bush	Minimum 1-gallon container	436	10	TBD

Note: TBD = to be determined (in Final Design).

The transitional community will depend on a final grading plan and expected hydrologic gradient along the perimeter of the restoration site. A conceptual cross section through the restored marsh platform is provided on **Figure 2B**. Herbaceous species will utilize either 2-inch plugs and/or seeding as appropriate. The density and size of trees and shrubs will be evaluated to provide native ecological value while also adding aesthetic value to the waterfront community and visitors. Size of trees and shrubs will likely include nursery container stock from 1 to 7 gallons.

2.5.1 Herbivory Control

Herbivory controls to protect plantings and seedings from wildlife (e.g., Canada geese) will be installed immediately following all planting and seeding. While the final determination of herbivory controls is the responsibility of the selected Contractor, the following is a framework for what will be expected at a minimum from the Contractor.

- Herbivory exclusion fencing (i.e., orange, grid construction fence or similar) will be used to address avian wildlife. Fencing will remain in place and be maintained for at least 1 to 3 years. Within the interior of the restored Marsh, all plants will be protected with a grid pattern of 6- to 10-foot wooden

stakes that allow heavy nylon or mason line to be strung between the stakes. Along the line, reflective flagging should be attached at 2- to 5-foot intervals.

2.5.2 Post-Planting Maintenance

It is assumed that wetland plantings in tidal wetlands will not require watering due to normal tidal cycles. Over the first year of growth, the selected Contractor will be required to evaluate the need for maintenance of herbivory controls.

Mortality rate of planted stock will be evaluated within the first growing season by the selected Contractor. The survival assessment and resulting planting specifications will be formally recorded at the conclusion of the first year.

The selected Contractor will maintain herbivory control for 1 year following planting. The project team responsible for the 5-year compliance monitoring and adaptive management program will take over responsibility to maintain these controls as needed, and which will remain in place for at least 3 years from planting.

Implementation of an exotic/invasive species control plan, focused on common reed, will be an essential component of this restoration project. Control of exotic/invasive species will be accomplished through spot spraying of a glyphosate herbicide, as necessary. The frequency of control events will be established through data collected during monitoring events. However, herbicide control is anticipated to occur every September following the initial planting activities. Herbicide application as part of the exotic/invasive species control program will be conducted by a certified herbicide applicator.

2.6 Ecological Performance Criteria, Monitoring, and Maintenance

2.6.1 Performance Criteria

Monitoring activities will be designed to evaluate the status of the compensatory project relative to its objectives and identify the need for additional maintenance or corrective action (e.g., seeding, planting, exotic/invasive species control). Monitoring activities will be designed to evaluate the status of the compensatory project relative to its objectives and identify the need for additional maintenance or corrective action (e.g., seeding, planting, exotic/invasive species control). Qualitative and quantitative data will be reviewed to evaluate project conditions and identify circumstances that would warrant corrective action.

The following performance criteria will be used to evaluate project success:

- Total vegetative cover of 90% of created vegetated marsh habitats
- Less than 10% ground cover of invasive plant species
- Maintenance of channel morphological dimensions at the inlet/outlet to Hudson River.

2.6.2 Monitoring

An “as built” plan will be completed following completion of all marsh construction activities and submitted to the USACE and NYSDEC as part of a construction completion report. These as-built plans will be used as the baseline for the compliance monitoring program and all adaptive management. Boundaries of vegetation community types present in the new Marsh area will be identified and mapped on the plan, as well as a complete final accounting of plants installed within each planting area. Representative cross sections of the constructed tidal channel will be surveyed, as well as a complete longitudinal profile of the channel, and will be added to the plan.

Compliance monitoring will be completed for a 5-year period following Marsh construction activities. If performance standards as defined below are met after 5 years, no further action will be taken. If performance standards are not met after 5 years, then the need for continued compliance monitoring will be coordinated with the agencies.

Compliance monitoring will consist of two site visits per year (spring and fall) by a qualified Wetland Scientist. Quantitative and qualitative data regarding hydrology, vegetative species composition, invasive species presence, wildlife use, and effectiveness of the bank stabilization techniques will be collected during the fall monitoring event. A final monitoring and adaptive management plan will outline the methods required to effectively evaluate progress toward defined performance criteria.

Qualitative and quantitative monitoring data collected during routine monitoring events will be the basis of appropriate recommendations for the restoration project. Monitoring data and recommendations will be included in an annual monitoring report produced following completion of the fall monitoring event each year. The report will be submitted to USACE and NYSDEC by December 31.

2.6.3 Adaptive Management

The process of adaptive management will be used to monitor and maintain the Marsh. This proactive management strategy uses information gathered over time to identify successful management practices and opportunities for improvement that will help guide the Marsh project toward achieving its objectives. As such, routine monitoring is an important component of adaptive management. Information collected during monitoring events will provide a means to identify and build on effective management practices and to develop recommendations to modify ineffective practices and implement corrective actions.

Maintenance activities and corrective actions will be implemented as appropriate through the duration of the required monitoring period to address recommendations made through the adaptive management process. Recommended maintenance activities or corrective actions may include installation of additional stabilization structures, planting and/or seeding, additional soil amendment, or control of invasive/exotic species.

As discussed in Section 2.5.2, implementation of an exotic/invasive species control plan is an essential component of this newly created Marsh maintenance. Control of exotic/invasive species will be accomplished through spot spraying of a glyphosate herbicide, as necessary.

2.7 River Barrier Design and Construction

The River Barrier will be constructed between the Hudson River and the Marsh to protect the Marsh from anticipated wave action, flow energies from the river, ice, debris and to aid in controlling tidal flows into and out of the Marsh. The key design considerations for the Barrier will include wave protection and geotechnical stability. Design consideration will also be given to the proposed alignment, constructability, and footprint of disturbance. The Barrier will also be designed with consideration for the Village of Hasting's expressed desire to see it as a potential river access point for future development.

2.7.1 Hydraulic Design, Materials of Construction, and Geometry

The River Barrier will be evaluated as a rubble-mound breakwater that consists of stone bedding material, riprap armor, and the potential for future river access. The River Barrier (the Barrier) design will be based on USACE (1993, 1995), CIRIA (2007), or similar guidance. The side slopes of the Barrier are not expected to be steeper than 1.5 horizontal foot to 1 vertical foot. The Barrier crest width is anticipated to be approximately 10 feet to accommodate potential future development for access. No vehicular traffic loading will be considered for the design. To minimize consumption of developable land, Barrier slopes will be as steep as practicable while maintaining minimum factors of safety for stability requirements. The anticipated design crest of the Barrier is currently estimated as +8 feet NAVD88. The ultimate crest elevation will be designed to protect against erosion based on estimated wave heights, wave runup, and wave overtopping potential, with consideration given to natural energy dissipation within the wetland during high-water/flooding conditions.

Consolidation of a Marine Silt layer is expected to cause a significant amount Barrier settlement after installation. The Barrier will be constructed to achieve and maintain the minimum required top of berm elevation after primary consolidation is complete (i.e., the Barrier will likely be constructed with an initial crest height greater than the desired final crest height).

Cushion and isolation layers may extend up the Marsh side of the Barrier for groundwater control as shown on **Figures 2B** and **2C**. Barrier construction (i.e., materials of construction and/or geometry) may vary along the length of the Barrier to accommodate marsh inlet/outlet function, constructability, future accessibility, and/or aesthetic considerations.

2.7.2 River Barrier Design Assumptions

Design criteria for the River Barrier evaluations include existing and post-construction bathymetry, geotechnical properties of native and imported material, water levels, wave climate (height, length, and angle), allowable overtopping of the Barrier, ice thickness, and surcharge loads. These design assumptions will be used to model potential forces on the rubble-mound breakwater design to achieve overall stability.

The River Barrier is just south of the proposed NEA bulkhead extension, which was evaluated in the Preliminary Design Report by Arcadis (Arcadis 2017). Due to the proximity of the River Barrier to the NEA bulkhead extension, the geotechnical properties established for the NEA bulkhead extension will be adopted for this design. Arcadis intends to also use the data collected from historical soil borings PDGEO-17 to PDGEO-22, which are very close to the proposed alignment of the River Barrier, to further

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refine our understanding of the site lithology and geotechnical properties. **Table 2** presents the preliminary soil profile that will be used for the design of the River Barrier.

Table 2. Soil Properties along the Northwest Extension Area (Arcadis 2017)

Layer	Elevation	(N ₁) ₆₀	Y (moist)	Y (sat)	Φ	Su
	(feet NAVD88)		(pcf)	(pcf)	(deg)	(psf)
Existing Fill	+4 to -17	8	120	125	29	--
Marine Silt (1)	Mudline to -40	WOR	--	105	28	300
Marine Silt (2)	-40 to -60	WOR	--	105	30	600
Marine Silt (3)	-60 to -70	WOR	--	105	31	900
Basal Sand	-70 to -130	18	--	125	34	--

Notes:

bgs – below ground surface

γ - Unit weight

pcf – pounds per cubic foot

Φ - Angle of internal friction

deg – degrees

Su – Shear Strength

psf – pounds per square foot

(N₁)₆₀ – Corrected Standard Penetration Test blow count

Design criteria for water levels and wave heights will consider the probable modes of failure associated with rubble mound breakwaters. The design criteria will account for average conditions and conditions that have a 50% probability of being exceeded during the assumed design life (USACE 1995). MHTL and MLTL are projected to be at elevations of 2.296 feet NAVD88 and -1.445 feet NAVD, respectively, at the time of anticipated construction completion in approximately 2026 (sea level rise analysis included is included in Attachment A of Appendix C).

The most recent Preliminary Flood Hazard Data available for the Site from the Federal Emergency Management Agency (FEMA) and analyses of storm-tide impacts in the lower Hudson River prepared by the United States Geological Survey (USGS) will be considered in design for overtopping and overall barrier resilience.

Design for surface erosion will also consider river velocities and ice flows within the river. Typical river velocities in the offshore areas vary from approximately 2.2 feet per second (fps) on the flood tide (flowing upstream) to approximately 2.9 fps on the ebb tide (flowing downstream) (H&A 2015). During the winter, ice pack flows in the Hudson River build up along the proposed Barrier location due to westerly winds (Haley & Aldrich [H&A] 2008).

In response to a request by the Village of Hastings, the River Barrier will be designed with consideration for potential future conversion to river access. A uniform vertical pedestrian surcharge load of 100 pounds per square foot (American Society of Civil Engineers [ASCE] 2010) will be applied to the Barrier crest for design purposes. No vehicular traffic will be considered for the design. The surface material of the crest will be finalized in coordination with the Village of Hastings.

2.7.3 River Wave Barrier Evaluations

For rubble-mound breakwaters, failures are generally caused by wave action or geotechnical factors, such as erosion, slope failure, and bearing failure. These failure mechanisms are often exacerbated by subsurface water loads. In consideration of these failure modes, the following evaluations will be performed for River Barrier:

- Riprap armor size and thickness calculations
- Material selection for the Barrier bedding, based on:
 - internal erosion assessment
 - filter layer design
- Slope stability of the Barrier, including:
 - global stability of side slopes
 - veneer stability (sliding) between the bedding material and isolation layers, as needed
- Bearing stability considerations, including:
 - potential for toe erosion
 - settlement of the bearing materials

Additional details for the design evaluations are provided below. In accordance with USACE guidance for breakwaters and levees, seismic loading will not be considered (USACE 1993, 2000).

2.7.3.1 Riprap Armor Design

Riprap armor material size will be designed to withstand wave action using two calculation methods, the most conservative of which will be used for construction. These methods include the Hudson formula and the Van der Meer equations (USACE 1993). The riprap armor thickness will be at least twice the nominal diameter of the stone's D_{50} (the average stone size by weight) and at least 25% larger than the largest stone size (USACE 1995).

2.7.3.2 River Barrier Bedding Material Selection

The bedding layer below the riprap armor is designed to prevent excessive settlement of the Barrier due to armor stone sinking into the underlying sediment. The River Barrier bedding will consist of locally sourced gravel or stone that is small enough to minimize sinking and large enough to withstand internal erosion (migration of material through riprap voids). The gradation requirements of the bedding material will be determined based on USACE filter criteria calculations (USACE 1993, 1995). The interaction between the bedding material and existing sediment/fill will similarly be evaluated using filter criteria calculations (USACE 1993, 1995).

The hydraulic conductivity of materials used for the bedding material will be estimated using the Excel-based program, HydrogeoSieveXL (Devlin 2015) for use in hydrodynamic models (Section 2.4.4). HydrogeoSieveXL uses 15 standard equations to estimate hydraulic conductivity based on grain-size distribution (Devlin 2015). The specific equation(s) used to evaluate a soil sample will be determined

based on the material description. For example, Terzaghi's equation is only applicable to sandy soils and coarse sand (Devlin 2015). Arcadis will contact local quarries to obtain the grain size distributions of readily available material for Barrier construction. Alternative sustainable and green materials will also be researched during final design in accordance with DER-10. Site concrete rubble that can be determined to meet the Site-specific backfill requirements will be considered. This effort will provide a more sustainable remedy by conserving natural resources, reducing waste, and providing a reduction in carbon dioxide emissions.

2.7.3.3 Slope Stability Analyses

Slope stability analyses to be completed by Arcadis during Final Design, will determine the maximum allowable slope inclination of the River Wave Barrier. Global stability evaluations will be completed using the SLOPE/W® software program developed by Geo-Slope International, Ltd. (Geostudio 2019). These analyses will consider the geotechnical properties of native and imported material, water levels, wave climate, ice thickness, flood elevations, and surcharge loads. Minimum required factors of safety will be based on slope stability criteria from the USACE Design and Construction of Levees (USACE 2000). Applicable factors of safety include:

- 1.4 for long-term (steady seepage) conditions
- 1.3 directly after construction
- 1.1 during a rapid drawdown condition (if required based on hydrodynamic modeling).

In addition to global stability, veneer stability analyses will be performed to prevent sliding of bedding material over isolation layers on River Wave Barrier slopes. These calculations will be performed using limit equilibrium methods outlined by Koerner and Soong (Koerner and Soong 2005).

2.7.3.4 Bearing Stability

The toe stability at the base of the River Wave Barrier will be evaluated in accordance with CIRIA guidelines (CIRIA 2007). Generally, riprap should extend outward from the toe of slope by a factor of three times the nominal diameter of the riprap's D_{50} . If the riprap armor at the toe is the same size as the riprap armor of the cover layer, the toe is more likely to be stable.

Settlement will be a critical aspect for the design and construction of the River Wave Barrier. Results of the Arcadis 2017 preliminary design indicate that the Marine Silt stratum is highly compressible when subjected to increased overburden pressures (Arcadis 2017). In the 2017 calculations, the modeled settlement in the NEA ranged from 1.9 to 4.1 feet for a site elevation increase of 5 to 9 feet using a low-density fill material (Arcadis 2017). Future settlement evaluations of the River Wave Barrier will use the calculation methods outlined in the 2017 preliminary design but with project-specific inputs including the River Wave Barrier height, width, and unit weight. These calculations may consider the presence of existing piers below the Barrier alignment, which could reduce predicted settlement. Construction methodologies to mitigation settlement will also be developed during the design.

2.8 Stormwater Diversion

To reduce the input of freshwater and debris into the Marsh, overland run-on flow will, to the extent practicable, be diverted around the Marsh via surface swales, permanent diversion berms, or similar cover system feature. Overland run-on diversion features will be identified and detailed in the Final Design. Storm sewers that currently transect the proposed Marsh area will also be redirected to outfalls located to the south of the Marsh inlet, in the North Boat Slip.

The storm sewer relocation plan was presented in the Preliminary Design Report (Arcadis 2017) drawings C-7 and C-7A. Four outfalls from sewer lines transecting the proposed Marsh area will be decommissioned and relocated into a cluster of outfalls within the North Boat Slip (noted as Relocated Storm Sewers on **Figure 2A**). The final outfall elevations will be determined during Final Design.

- An 18-inch Westchester County sewer overflow currently transects the proposed Marsh. This outfall will be relocated to a new 18-inch outfall in the North Boat Slip. The current outfall invert elevation is +0.13 feet NAVD88. This outfall ties into a pump station at the eastern property boundary.
- Two additional outfalls located immediately adjacent to the proposed Marsh area, in the northeastern corner of the North Boat Slip, will be relocated to new 18-inch and 30-inch outfalls farther south within the North Boat Slip. These sewers also tie into the pump station.
- A 48-inch outfall for Hastings Creek will be relocated farther north within the North Boat Slip, to a new 48-inch outfall. The current outfall is not visible. The current invert elevation at the outfall is lower than -3.00 feet NAVD88, based on available survey data at a manhole located approximately 130 feet east of the assumed outfall location. Approximately 95 feet upstream from this location, the pipe invert is -1.96 feet NAVD88.

The potential for freshwater intrusion into the Marsh as a result of freshwater discharges from these outfalls is limited and not likely to have a material negative impact on the survival of the marsh habitat. This determination is based upon the following considerations:

- Volume of the pipe flows is negligible relative to the Hudson River, and is anticipated that the salinity of the river water will dominate over waters discharged from these outfalls.
- Discharged stormwater from these pipes can only enter the wetland for a small proportion of the tidal cycle (i.e., top portion of the incoming tide).
- Salinities within the Hudson River naturally fluctuate on a daily (e.g., storm events), seasonal (e.g., spring flows), and episodic (e.g., droughts, wet periods) scale. Anticipated native species to be planted in the Marsh have demonstrated regional tolerance of these salinity fluctuations.
- The volume of stormwater discharge will likely be greatest during precipitation events. At the same time, the salinity in the Hudson River will likely be lower due to freshwater inputs. As such, during these periods of greatest potential for freshwater inputs, the natural salinity within the river will already be naturally low.

As such, no additional freshwater flow mitigation related to these onsite outfalls is necessary for protection of the Marsh habitat.

3 PATH FORWARD – FINAL DESIGN

Following NYSDEC approval of this BODR, the Marsh will be designed and incorporated into the 95% and Final Site Remedial Design with a set of bid quality plans and specifications. Submittals will include:

- A 95% design submission of the design plans and specifications for stakeholder review
- A final design submission of the plans and specifications signed and stamped by a professional engineer licensed to practice in New York State and including the required certification set forth in DER-10, Subdivision 1.5(b).

Table 3 (attached) lists drawings from the Preliminary Design Report (Arcadis 2017) to be modified to depict design changes related to Marsh construction and lists new drawings to be produced to depict the design changes. Anticipated related specifications to the Marsh construction are listed in Section 3.2.

3.1 Remedial Design/Remedial Action Supporting Plans

The 95% design submittal will also include the compensatory wetland elements in the following:

- Community Air Monitoring Plan (CAMP)
- Community and Environmental Response Plan (CERP)
- Remedial Action Monitoring Plan (RAMP)
- Construction Health and Safety Plan (HASP) requirements
- Construction Marine Assurance Plan requirements
- Construction Quality Assurance Project Plan (CQAPP)
- Site Management Plan (SMP):
 - Institutional/Engineering Control Plan
 - Habitat Monitoring Plan
 - Operations & Maintenance Plan
 - Contingency Plan
- Applicable permits and permit equivalencies for remedial construction
- Updated Remedial Cost Estimate
- Construction Schedule.

3.2 Technical Specifications

The following list of technical specifications will be included in the 95% Design. Other specifications will be included as identified during design.

BASIS OF DESIGN REPORT FOR COMPENSATORY WETLAND CONSTRUCTION
HARBOR AT HASTINGS SITE

Table 4. Technical Specifications

Section	Specification Title
Division 01 - General Requirements	
01 12 13 (01 11 00)	Summary of Work, Multiple Prime/Single Prime (Summary of Work)
011400	Work Restrictions
01 30 53 (01 30 00)	Site Security
01 31 19.13 & 01 31 19.23 (01 31 19)	Project Meetings
013300	Submittal Procedures
013529	Contractors Health and Safety Plan (Health, Safety and Emergency Response Procedures)
014100	Regulatory Requirements
014500	Quality Control
01 51 05 (01 51 00)	Temporary Utilities
015211	Engineer's Field Office
015213	Contractor's Field Offices and Sheds
015513	Access Roads and Parking Areas
015526	Maintenance and Protection of Traffic (Traffic Control)
015705	Temporary Controls
017123	Field Engineering
017133	Protection of Adjacent Construction
017419	Construction Waste Management and Disposal
017719	Closeout Requirements
Division 02 - Existing Conditions	
024100	Demolition and GIB for Demolition (Demolition)
025129	Surface Cleaning Decontamination
026000	Handling, Transportation, and Disposal of Impacted Material (OU1)
027100	Water Treatment (Temporary Water Management System)
Division 31 - Earthwork	
310519	Geosynthetics for Earthwork
312200	Grading
312316	Excavation
312319	Dewatering
312323	Fill Materials (includes Compaction)
312500	Erosion and Sedimentation Controls
315000	Excavation Support and Protection
315600	Slurry Walls
Division 32 – Exterior Improvements	
327200	Wetland Restoration
32 91 19.13 (32 92 00)	Topsoil Placement and Grading (Lawns and Meadows)

Section	Specification Title
Division 33 – Utilities	
330505	Buried Piping Installation

3.3 Regulatory/Permitting and Access Requirements

Marsh construction will require consultation and coordination with the United States Army Corps of Engineers (USACE) and NYSDEC to obtain applicable permits prior to construction activities. It is assumed that implementation of the overall site remedy will require a USACE Nationwide 38 (NW38) permit and the NYSDEC Section 401 Water Quality Certification (WQC) and will include the following:

- Joint Permit application submittal (USACE NW38 permit and NYSDEC WQC)
- Consultation with National Oceanic Atmospheric Administration
- Biological Assessment and Essential Fish Habitat assessment
- Section 7 Endangered Species Act consultation from the U.S. Fish and Wildlife Service
- New York Natural Heritage Program project screening
- New York State Historic Preservation Office project review
- New York State Office of General Services request and review of the Water Index Grant
- New York State Department of State review of Coastal Zone Management forms
- Federal Consistency Assessment
- State Environmental Quality Review form.

4 REFERENCES

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BASIS OF DESIGN REPORT FOR COMPENSATORY WETLAND CONSTRUCTION
HARBOR AT HASTINGS SITE

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TABLES

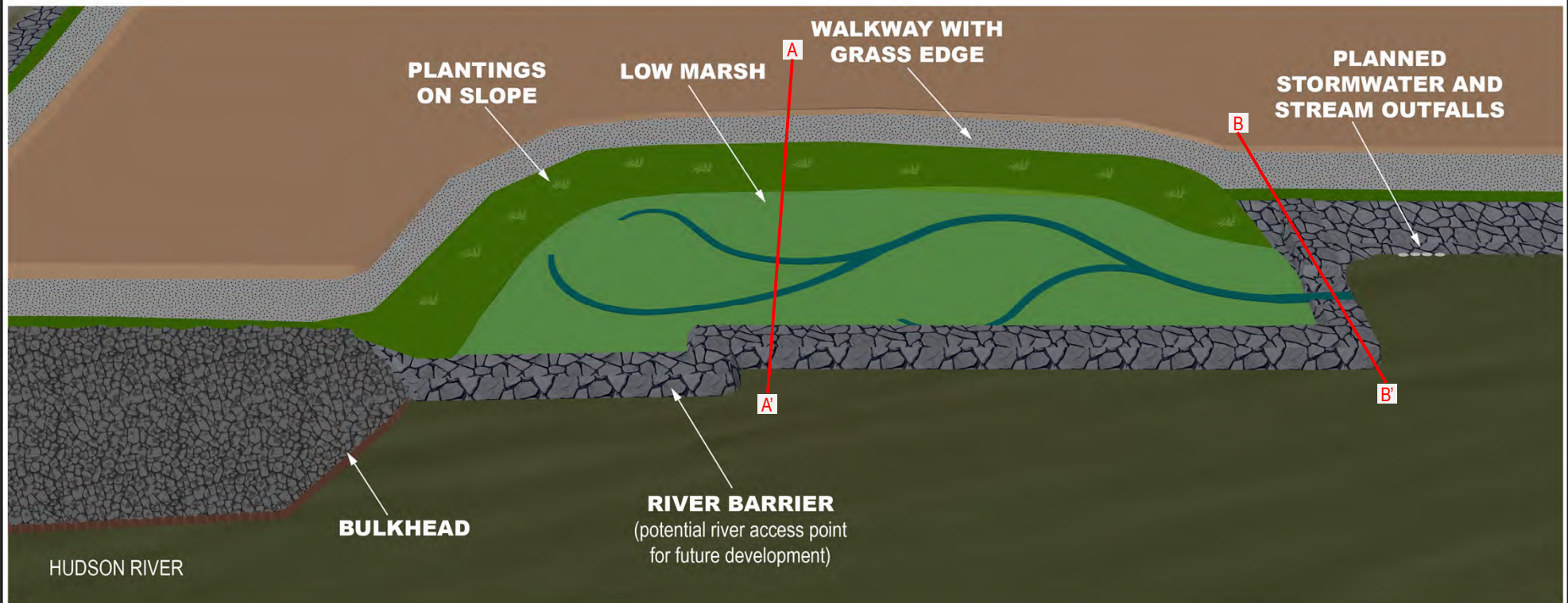


Table 3
New and Modified Drawings for Final Design and Specifications
Harbor at Hastings Site
Hastings-On-Hudson, New York
NYSDEC Site #3-60-022

New Drawings to be Created	
1	Overall plan view of Marsh depicting final grades and features for Marsh and surrounding areas, including Marsh platform and slopes, River Wave Barrier, sloped shoreline, drainage channels, and surface materials.
2	Overall Marsh Demolition Plan
3	Details for stormwater control features to route overland stormwater flow away from Marsh
4	Marsh layers tie-in details (geotextile, GCL, and other layers tie-in with surrounding berms and upland materials)
5	River Wave Barrier details
6	North-south cross section(s) through Marsh and into North Boat Slip
7	East-west cross section(s), extending from upland east of Marsh into river west of Marsh.
8	Plan view of North Boat Slip depicting outfalls (sizes and invert elevations), cutout into shoreline for outfalls, and diversion structure (berm, bulkhead, or boulders, as discussed in basis of design report).
9	Scaled view face of shoreline in North Boat Slip depicting outfalls, shoreline armoring around outfalls, and diversion structure
10	Marsh vegetation planting plan (depict plant types and spacing across habitat platform and habitat slopes)
11	Marsh vegetation planting details (plant sizes, root depths relative to Marsh layers, etc.)
Drawings from the Preliminary Design Report to be Modified	
C-1 SITE LOGISTICS AND TRAFFIC CONTROL PLAN	Update to reflect revised layout due to Marsh construction.
C-3 EROSION AND SEDIMENT CONTROL PLAN - NORTH	Update with new Marsh erosion and sediment control requirements, such to include silt curtain around proposed Marsh.
C-5 GENERAL DEMOLITION PLAN	Update with new Marsh demolition requirements.
C-5D SHORELINE DEMOLITION PLAN - STATION 15+00 TO	Update with new Marsh demolition requirements.
C-5E SHORELINE DEMOLITION PLAN - STATION 21+75 TO	Update with new Marsh demolition requirements.
C-16A CROSS SECTION	Update with Marsh grading plan.
C-16A CROSS SECTION	Update with Marsh grading plan.
C-17A CROSS SECTION	Update with Marsh grading plan.
D-9 RESTORATION ELEVATIONS	Update with Marsh grading plan.
D-13 RESTORATION ELEVATIONS - NEAR SHORE NORTH	Update with Marsh grading plan.
D-14 RESTORATION ELEVATIONS - NEAR SHORE NORTH,	Update with Marsh grading plan.
D-16 NEAR SHORE CROSS SECTIONS	Update with Marsh grading plan.
D-17 NEAR SHORE CROSS SECTIONS	Update with Marsh grading plan.

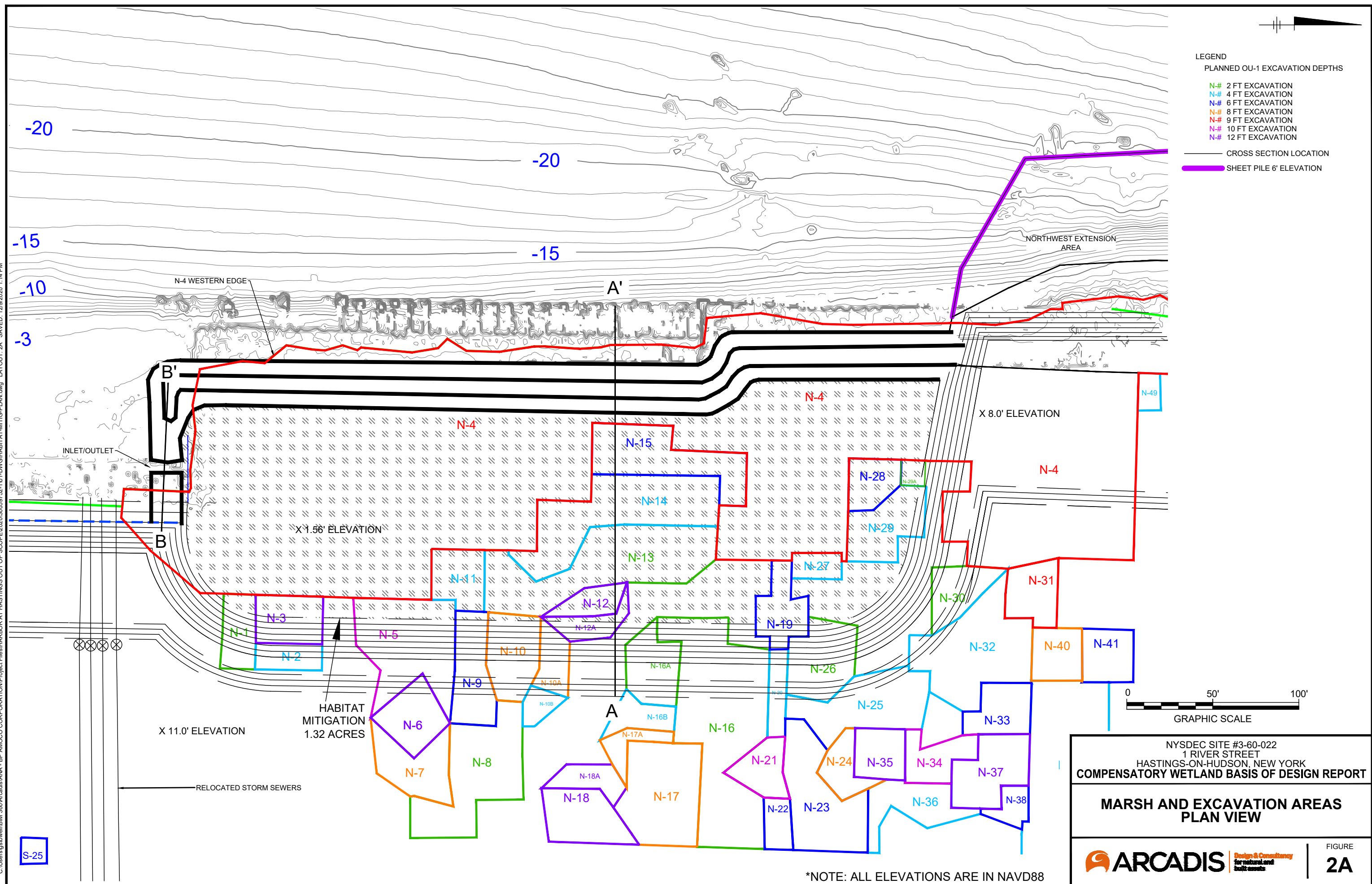
FIGURES





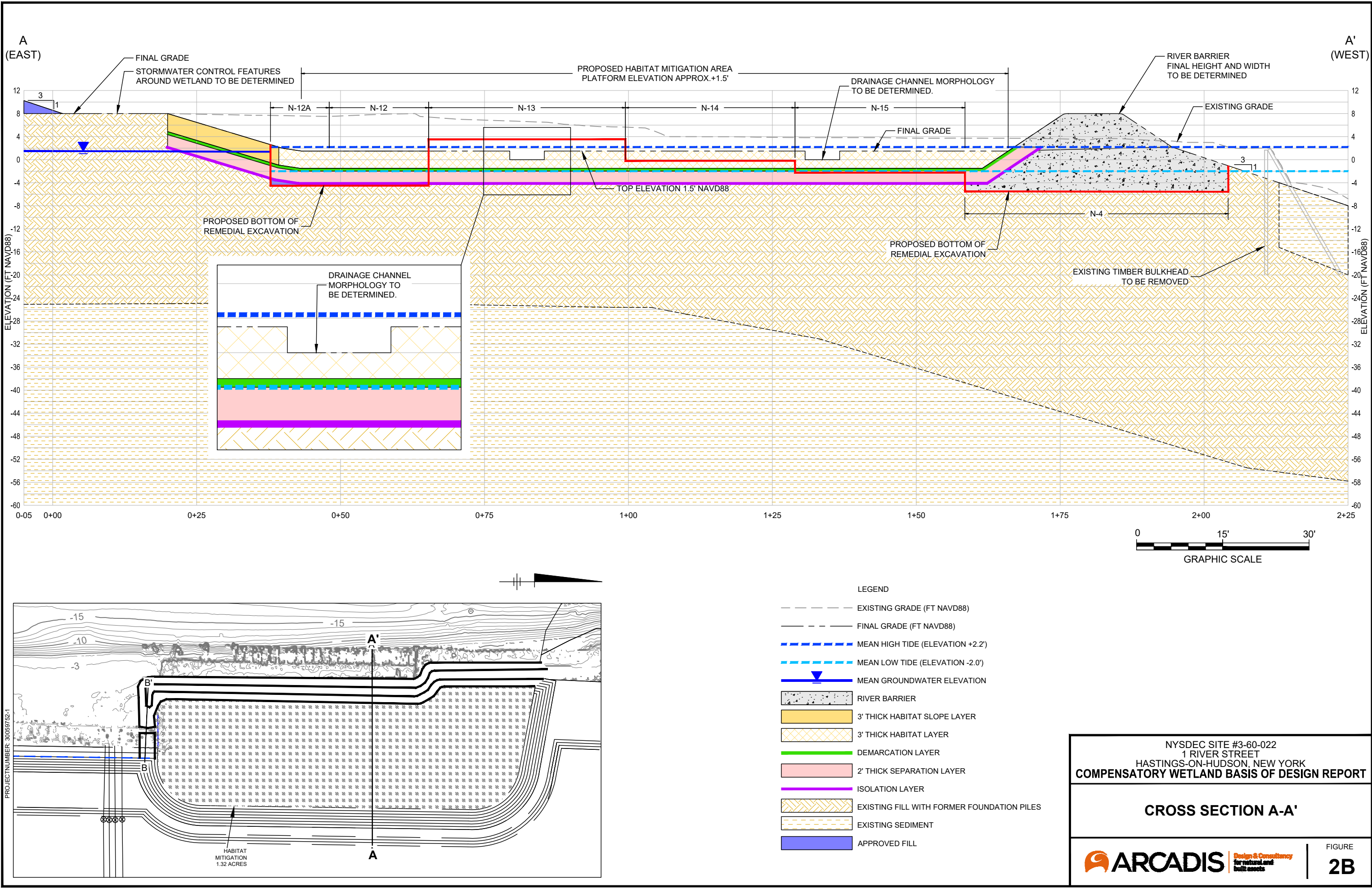
NYSDEC SITE #3-60-022 1 RIVER STREET HASTINGS-ON-HUDSON, NEW YORK COMPENSATORY WETLAND BASIS OF DESIGN REPORT	
CONCEPTUAL SHORELINE IMPROVEMENTS	
 ARCADIS <small>Design & Consultancy for natural and built assets</small>	FIGURE 1

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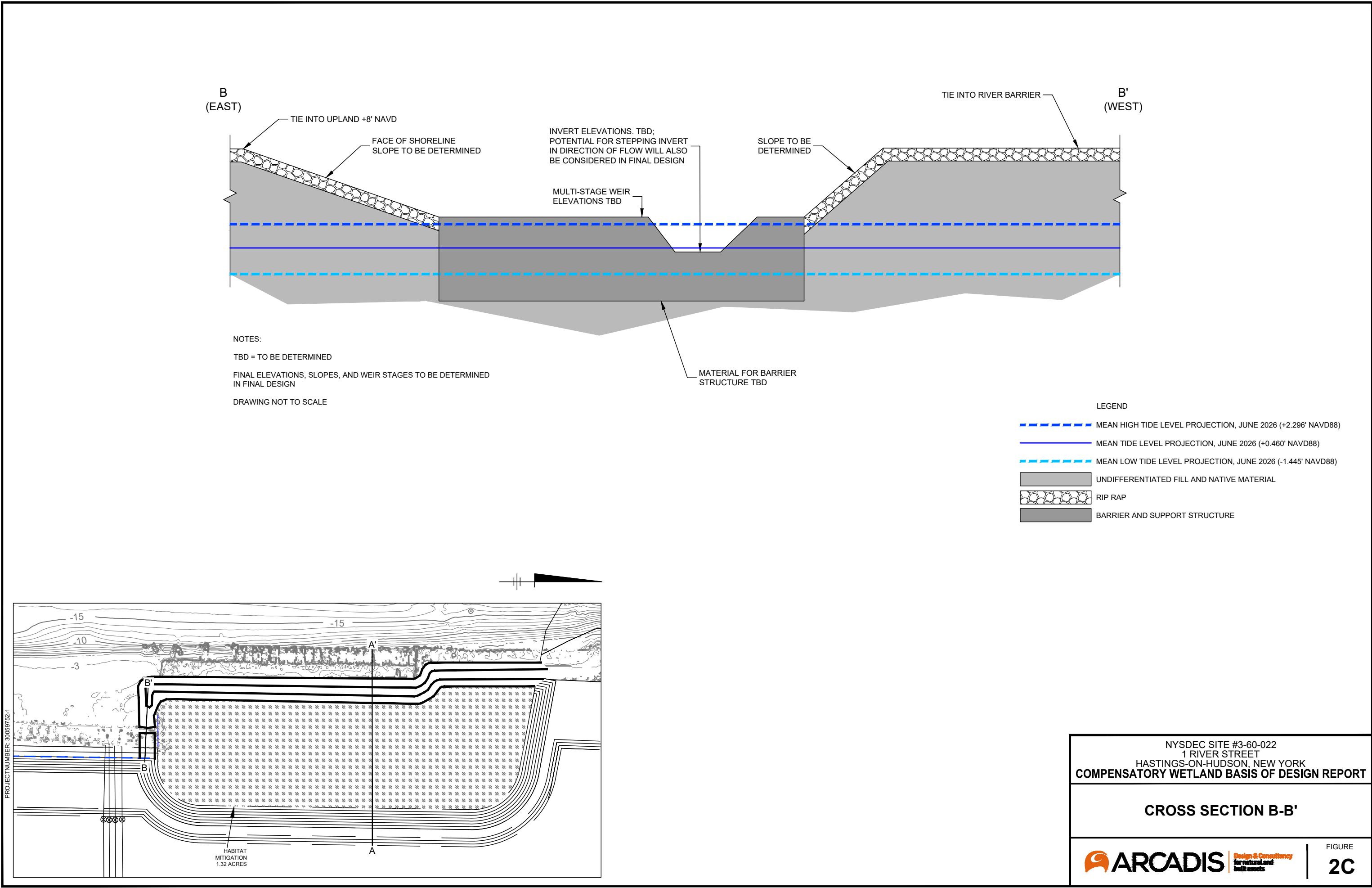


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APPENDIX A

NYSDEC Correspondence



NEW YORK STATE DEPARTMENT OF ENVIRONMENTAL CONSERVATION

Division of Environmental Remediation, Remedial Bureau D

625 Broadway, 12th Floor, Albany, NY 12233-7013

P: (518) 402-9676 | F: (518) 402-9773

www.dec.ny.gov

September 24, 2020

Mr. Paul Johnson
Operations Project Manager
Atlantic Richfield Company
Remediation Management
150 W. Warrenton Road
MC 200 1E

Re: Construction Methods Related to In-Water Work
Harbor at Hastings, NYSDEC Site #360022

Dear Mr. Johnson:

The Department of Environmental Conservation has reviewed the draft memo dated June 22, 2020 regarding the proposed construction sequencing and methods of in-water remedial construction work activities at the Harbor at Hastings site. The following is a list of items the Department would like addressed in future design and monitoring submittals:

1. Please use an environmental bucket that can be closed completely to minimize resuspension of sediments and decanting of water whenever possible.
2. The turbidity curtains will not sufficiently contain dissolved PCBs, therefore initial water quality monitoring must be conducted to determine whether or not the site PCBs are in the dissolved form and have potential to leave the work enclosure at levels of concern.
3. For work in the Old Marina and Kinnally Cove strong consideration should be given to having a double turbidity curtain system.
4. A Total Suspended Solid (TSS) action level outside the main turbidity curtain should be 100ppm over ambient and a PCB action level of 0.2ppb per Aroclor.
5. Water quality monitoring for metals will also be required.
6. For areas of dredging without a turbidity curtain, water quality monitoring will be required at the edge of the 500-foot mixing zone. Concentrations of PCB, metals and TSS must meet water quality standards at this location. Attached is guidance to use during design and while drafting the water quality monitoring program.
7. Decanting of barges outside of the turbidity curtain will not be allowed without adhering to specific requirements. The Department will provide these requirements if needed.

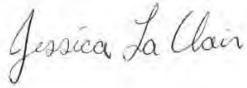


Department of
Environmental
Conservation



The Department finds the construction methods acceptable. The Department approves a work window for in-water work outside of a turbidity curtain to begin September 1st and ending January 15th. If you have any questions, please feel free to contact me at (518)402-9821.

Sincerely,

A handwritten signature in cursive script that reads "Jessica LaClair".

Jessica LaClair
Project Manager
Bureau D, Section A
Division of Environmental Remediation

Attachment

cc: J. Armitage, DEC
B. Conlon, DEC
S. Edwards, DEC
H. Gierloff, DEC Region 3
A. Schimizzi, DEC Region 3
K. Woodfield, DEC
J. Nealon, DOH
M. Schuck, DOH
M. Gopal, Sovereign Consulting Inc.

NEW YORK STATE DEPARTMENT OF ENVIRONMENTAL CONSERVATION

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625 Broadway, 12th Floor, Albany, NY 12233-7013

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October 5, 2020

Mr. Paul Johnson
Operations Project Manager
Atlantic Richfield Company
Remediation Management
150 W. Warrenton Road
MC 200 1E

Re: Draft Technology Screening Decision Document for Compensatory Wetland
Separation and Protection
Harbor at Hastings, NYSDEC Site #360022

Dear Mr. Johnson:

The Department of Environmental Conservation has reviewed the draft memo dated August 20, 2020 regarding the Technology Screening Decision Document (TSDD) for the separation layer for the wetland at the Harbor at Hastings site. The Department has previously specified that a 2-foot minimum separation layer is required between the historic fill containing residual PCBs and the habitat layer of the intertidal wetland. The Department verbally accepted a habitat layer of 3 feet but had questions regarding how compaction and erosion will be address and noted a concern over phragmites due to their long root structure.

The following is a list of items the Department would like addressed in future design and monitoring submittals:

1. If necessary, to achieve the proper elevations for the new wetland, the Department is not opposed to removing additional soils beyond those described in the Record of Decision.
2. Effectiveness monitoring for the wetland must also include a way to determine if the underlying residual PCBs have impacted the newly created wetland.

The Department finds the draft Technology Screening Decision Document acceptable. The Department approves the use of a geosynthetic clay liner (GCL) as the barrier layer for the intertidal wetland to be constructed onsite. If you have any questions, please feel free to contact me at (518) 402-9821.

Sincerely,



Jessica LaClair
Project Manager
Bureau D, Section A
Division of Environmental Remediation



Department of
Environmental
Conservation



ec: J. Armitage, DEC
S. Edwards, DEC
B. Conlon, DEC - OGC
A. Guglielmi, DEC - OGC
H. Gierloff, DEC Region 3
A. Schimizzi, DEC Region 3
K. Woodfield, DEC
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M. Gopal, Sovereign Consulting Inc.

NEW YORK STATE DEPARTMENT OF ENVIRONMENTAL CONSERVATION

Division of Environmental Remediation, Remedial Bureau D

625 Broadway, 12th Floor, Albany, NY 12233-7013

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www.dec.ny.gov

December 8, 2020

Mr. Paul Johnson
Operations Project Manager
Atlantic Richfield Company
Remediation Management
150 W. Warrenville Road
MC 200 1E
Naperville, IL 60563

RE: Technical Memo – Marsh Elevation Evaluation and Determination for
Compensatory Wetland Design
Harbor at Hastings Site #360022

Dear Mr. Johnson:

The Department of Environmental Conservation has reviewed the Marsh Elevation Evaluation and Determination for Compensatory Wetland Design technical memo dated November 6, 2020 for the Harbor at Hastings site. This memo summarized the evaluation for expected salinity ranges, expected estimates of sea level rise, expected tidal elevation range and biological benchmark data for both smooth cordgrass and common reed. All of these factors will be used in determining a final targeted design elevation range. This memo also addressed comments the Department made in a letter dated October 28, 2020.

The targeted lower threshold elevation will be reevaluated based on additional regional tidal data available closer to the year of marsh construction to account for updated sea level rise. The technical memo for Marsh Elevation Evaluation and Determination for Compensatory Wetland is approved. If you have any questions, please feel free to contact me at (518)402-9821.

Sincerely,



Jessica LaClair
Project Manager
Bureau D, Section A
Division of Environmental Remediation

ec: J. Armitage, DEC



Department of
Environmental
Conservation



B. Conlon, DEC
S. Edwards, DEC
A. Guglielmi, DEC
H. Gierloff, DEC Region 3
A. Schimizzi, DEC Region 3
J. Nealon, DOH
M. Schuck, DOH
M. Gopal, Sovereign Consulting Inc.

APPENDIX B

Construction Methods Related to In-Water Work (Arcadis, June 2020)



MEMO

To:
Paul Johnson,
Remediation Management (RM)

Copies:
L. Littrell
M. Gopal, Sovereign
M. Gravelding, Arcadis

Arcadis of New York, Inc.
One Lincoln Center
110 West Fayette Street
Suite 300
Syracuse
New York 13202
Tel 315 446 9120
Fax 315 449 0017

From:
Lance Ketcham,
Raymond Kapp,
Arcadis of New York, Inc.

Date:
June 22, 2020

Arcadis Project No.:
30039767

Subject:

DRAFT FOR DISCUSSION PURPOSES ONLY

Construction Methods Related to In-Water Work,
Harbor at Hastings Site, NYSDEC Site# 3-60-022
Hastings-on-Hudson, New York

INTRODUCTION

This memorandum is being presented to summarize discussions and document the agreements that were clarified during our WebEx meeting with the New York State Department of Environmental Conservation (NYSDEC) on May 15, 2020 regarding proposed construction sequencing and methods of in-water remedial construction work activities at the Hastings-on-Hudson site. Prior to the May 15, 2020 meeting with NYSDEC, we provided them with a draft memorandum for discussion dated February 20, 2020 which outlined the activities, including the allowable work window during which certain site remediation activities in the Hudson River will be permitted to be performed, and measures to be performed to protect fish and wildlife during in-water work activities (Arcadis 2020). NYSDEC provided comments to the discussion memorandum via email on March 30, 2020 (NYSDEC 2020). The subject matter of the memorandum and the comments from NYSDEC were discussed during the May 15th meeting, and the conclusions are presented here for concurrence by NYSDEC. In response to a request made by NYSDEC, additional detail is presented regarding the sequencing of the Northwest Extension Area (NEA) construction and how that construction timeline affects the in-water work sequencing, and the potential methods for dredging and other remediation work within the Old Marina and Kinnally Cove (OM/KC) Area.

OUTCOME OF MAY 15, 2020 MEETING WITH NYSDEC

Several figures were presented to NYSDEC in our February 20th memorandum to generally outline the level of work that could be completed in water during several work window scenarios. Figure 2A (attached) shows the expected in-water work sequence that can be undertaken based on the amount of time agreed to in this meeting. The following is a summary of the work window clarification that was agreed to in the meeting, and details are further clarified in this memo:

- The work window will be from September 1st through January 15th. Activities subject to the work window (allowed only during the work window) are:
 - Deepwater Area dredging and backfilling, without a turbidity curtain.
 - Installation of the NEA sheet pile wall, without a turbidity curtain.
 - Any activities that could disturb the river bottom outside of the installed nearshore and Old Marina/Kinnally Cove turbidity curtains, with the following exceptions:
 - Staging and installation of turbidity curtain piles can be performed between August 1 through August 31.
 - Barges can be mobilized to the site and spudded in at offshore locations at any time. However, pre-dredging to provide additional draft for barges will not be permitted outside the work window.
 - Temporary floating docks can be spudded in, to prepare for the dredging and upland work at any time.
 - Barge transport and loading/offloading of materials and waste at any time.
 - Depth sounding for survey.
 - Demobilization of barges and temporary floating docks.
- Once the turbidity curtains are installed in Construction Season 1 and managed, all work within the turbidity enclosures can proceed independent of the work window, year-round. Such activities include:
 - Removal of existing dock piles and other obstructions to remedial dredging.
 - Demolition and removal of bulkheads, piles, foundations, and platforms along the Site shoreline.
 - Installation of measures to temporarily stabilize shorelines adjacent to targeted dredging in OM/KC, such as temporary sheeting and/or pre-excavation, as necessary.
 - Dredging and backfilling of the Nearshore and OM/KC remedial areas,
 - Completion of the NEA sheet pile wall and tiebacks within the shoreline (land-based components).
 - Construction of the intertidal marsh, including protective wave barrier.
 - Construction of the sloped shoreline, including rip-rap placement, shoreline plantings and in-river habitat enhancements such as boulders in the South Boat Slip Area.
 - All upland work.

- The turbidity curtain layout line will be as shown in the Preliminary Design (PD) at a water depth of approximately 15 feet.
- A turbidity curtain monitoring and maintenance program will be developed and implemented, as discussed in this memorandum.
- Decanting of dredge water will not be allowed outside of a turbidity curtain. Decanting may be performed within a turbidity curtain, subject to turbidity limits with necessary controls and contingency measures, as discussed in this memorandum.

NEA CONSTRUCTION SEQUENCING

Per the preliminary design plan as outlined in Appendix B of the November 2017 Preliminary Design Report (Arcadis 2017), Deepwater Area dredging adjacent to the NEA (this adjacent area is defined as the Northwest Area in Pre-Design Investigation reports) should not take place until the NEA bulkhead is installed. In developing a construction sequencing strategy for work window restrictions in the Hudson River for this project, Arcadis determined that completion of the NEA construction will require more than one work window to complete. As such, the sequencing of pile installation for the NEA sheet wall and adjacent dredging requires partial installation of the NEA wall during Construction Season 1 followed by dredging on the river side during Construction Season 2. Specifically, the river will continue to equilibrate through the open ends of the NEA wall to maintain similar water column levels on either side of the bulkhead during the Construction Season 2 dredging. This will be accomplished by leaving the ends near the existing land open after Season 1. The final NEA bulkhead sheet piles at each end of the wall would not be installed until after the adjacent Deepwater Area dredging is completed and the required excavation, backfilling and tie-back installation on the land side is ready to be begin.

Following isolation of the NEA from the river, OU1 backfill and tie-back installation is proposed to be performed, followed by three lifts of backfill placement and consolidation periods, installation of tiebacks, and construction of the groundwater treatment funnel and gate systems. Details will be included in the Final Design; however, the concept is that consolidation of each lift will be achieved by application of a surcharge load. Due in large part to the extended period of consolidation specified for each lift, at approximately 1.2 to 1.4 years each, NEA construction activities will require a minimum of approximately 4 years to complete using this technique. Below is a summary of the installation steps:

1. Install upland isolation slurry wall.
2. Install cantilever steel sheet pile wall along the bulkhead alignment, except for those areas left uninstalled to allow water to freely travel on either side of the bulkhead.
3. Install monitoring points along the NEA for survey monitoring of sheet pile positioning and allowable deflection during construction.
4. Dredge down to 6 ft below sediment surface (bss) in areas with impacted sediment on the riverside of the bulkhead.
5. Backfill dredged areas in front of the NEA.
6. Install remaining sheet piles to isolate NEA from the Hudson River.
7. Fill behind sheet pile wall with lightweight aggregate lifts and allow for monitored consolidation.
8. Monitor consolidation to determine the timing of the next lift of backfill.

9. Add additional fill to account for settlements and to reach elevations to facilitate tieback installation.
10. Install tie-rods connected to anchor wall on existing upland portion of the site.
11. Fill behind bulkhead to proposed final elevation with lightweight aggregate.

The turbidity curtains for the Nearshore and OM/KC areas will terminate near the NEA bulkhead walls. Upon completion of step 2 (above) and installation of the turbidity curtains, the open ends of the bulkhead will be isolated from the Hudson River by the turbidity curtains.

OM/KC DREDGING AND WORK ACTIVITIES

A variety of potential methods or combination thereof could be used to remove sediments from the OM/KC Area. The objective in all cases is to safely remove material while controlling disturbance of this area below the target elevations and maintaining turbidity levels outside the main turbidity curtain in the river.

Due to the shallow mudline in the OM/KC Area, if a traditional dredge and scow operation was selected, it would need to work its way into the shoreline from the Hudson River before offloading any material from OM/KC Area onto the Old Marina shoreline, resulting in reduced process efficiency. This could also result in over-dredging of the OM/KC sediments already designated for remedial dredging due to the clearance required for boat draft. Other concerns include disturbance of sediment by operations.

Measures will be considered in the final design and incorporated into the contractor specifications to minimize disturbance of sediment within the OM/KC Area, including dredging accessible areas from the shoreline, establishing temporary structures to dewater select areas for removal with conventional equipment and/or use of contractor specific alternative construction methods to be reviewed. Turbidity controls will be maintained, and additional methods may include but may not be limited to more turbidity curtains to meet the turbidity limits established in the final design. A second offloading structure will be considered within the OM/KC Area to limit disturbance and travel times from the removal areas.

MONITORING CONTROL MEASURES

Construction activities will be monitored in accordance with the Final Design specifications, agency permitting requirements, supplemental plans, and contractor work plans. Additional detail regarding monitoring and control measures, as discussed during the May 15th meeting, are presented below:

- Piles will be driven with a vibratory hammer to the extent practical to reduce underwater sound energy. It is anticipated that limited use of an impact hammer may be necessary to drive piles to design depth to overcome obstructions or refusal to vibratory methods. Mitigation measures for hammer driving may include limiting the hours-per-day of hammering.
- Monitoring for deflection along the NEA bulkhead shall be performed. Bulkhead monitoring requirements will be specified during Final Design and included in the Remedial Action Monitoring Plan.
- Deepwater Area dredging and backfilling will be performed without a turbidity curtain but with best management practices (BMPs) implemented, including but not limited to an environmental bucket, no decanting, and control of the bucket position passing through the water column.
- In the design specifications, the construction contractor will be required to provide:

- A Turbidity Mitigation and Control Plan for the Deepwater Area consisting of specific BMPs to be implemented to mitigate turbidity during dredging.
- A Turbidity Mitigation and Control Plan for the shoreline and OM/KC areas. The Plan shall include turbidity curtain and temporary pile types and design, materials list, installation methods, navigational safety devices, and BMPs. Turbidity curtains shall at a minimum comply with Type 3 curtain specifications for deployment in tidal rivers.
- A Monitoring and Maintenance Plan for the turbidity curtains. The plan shall include regular inspection for damage or potential compromise due to impacts such as debris, wake damage, and storm surge. The turbidity curtain system shall be inspected at the start of the workday and a minimum of once per shift, and material removed whenever debris appears to have fouled the curtain. Inspection shall include but not limited to the fabric, floats, seams, and anchors for integrity. Dredging and related turbidity generating work shall stop until repairs are completed.
- Contingency measures shall be implemented if elevated turbidity readings are noted at a monitoring location. All monitoring locations will be outside the main turbidity curtain in the river. Typical actions could include reduced production rate, addition of engineering controls or stoppage of work until the readings are complying. If decanting is occurring in the OM/KC area, contingency measures may include installation of additional turbidity curtain(s). General contingency measures could include options to modify to dredge operation, such as fall height, cycle time, bucket handling procedures, or use of a rinse tank. Contractor will be required to have contingency measures on-site and be prepared to implement additional engineering controls immediately.
- Environmental buckets shall be used for dredging within and outside of the turbidity curtain unless debris or sediment conditions prevent their effective use. Alternative methods shall be included in the contractor's Turbidity Mitigation and Control Plan. Acceptable alternatives include removal of rock obstructions with excavator or crane fitted with grapple and shear cutting or vibratory removal of existing wood piles. Use of a digging bucket or clamshell will only be used in difficult conditions and will be replaced by an environmental bucket as soon as practicable.
- In general, BMPs consistent with NYSDEC Division of Water Technical and Operational Guidance Series (TOGS) 5.1.9 (NYSDEC 2004), as well as applicable USEPA and US Army Corps of Engineers' guidelines and manuals, will be employed to mitigate environmental impacts from construction activities. Examples of BMPs include:
 - Dredge buckets (where applicable):
 - Must be equipped with monitoring capabilities to inform the dredge operator if the bucket is not completely closed.
 - Shall be designed to maintain enclosure of sediments when the bucket is being raised through the water column; minimize, to the maximum extent practical, the generation of suspended sediments during bucket lowering, closing, and raising in the water column; and minimize the amount of water contained in the dredge bucket as it is closed. The bucket shall include features designed by the bucket's manufacturer that allow sediment to be removed at near in-situ densities and to allow free water overlying the sediment in the bucket to drain once the dredge bucket has been raised above the water surface.

- Collection and on-site treatment of water from scows supporting dredging operations outside the turbidity curtain, as well as water from dredge spoil piles staged and processed on land within the site.
 - Maintaining pollution prevention and waste minimization programs from initiation of mobilization activities to project close out.
 - Maintaining good site housekeeping practices.
 - Utilization of low emission diesel equipment and fuel.
 - Reducing project emissions by minimizing idle time for equipment by shutting down equipment not being actively used.
 - Using environmentally acceptable lubricants for oil-water interfaces, to the extent practicable.
- The Remedial Action Monitoring Plan will include the required turbidity action levels outside the main turbidity curtain and at appropriate distances from active Deepwater Area dredging. Response actions will be developed by the Engineer for review by NYSDEC and inclusion in the Final Design.

REFERENCES

- NYSDEC 2004. NYSDEC Division of Water Technical and Operational Guidance Series (TOGS) 5.1.9, In-water and Riparian Management of Sediment and Dredged Material, November 29, 2004.
- Arcadis. 2017. Preliminary Design Report; Harbor at Hastings Site (Former Anaconda Wire & Cable Plant Site) Hastings-On-Hudson, New York; NYSDEC Site #3-60-022. Prepared for Atlantic Richfield. November.
- Arcadis. 2020. Construction Sequencing Related to Work Window Time Restrictions. Memorandum to Paul Johnson, Remediation Management from Lance Ketcham and Raymond Kapp, Arcadis of New York, Inc., DRAFT FOR DISCUSSION PURPOSES ONLY, February 20, 2020.
- NYSDEC. 2020. Email from Angela E. Schimizzi (NYSDEC) to Paul Johnson (BP), Jess LaClair (NYSDEC), and Martha Gopal (Sovereign) re: Hastings Final Natural Deposition Memo. March 30.

ATTACHMENTS

Figure 2A. Preliminary In-Water Construction Sequencing Layout, 4.5-Month Work Window Scenario

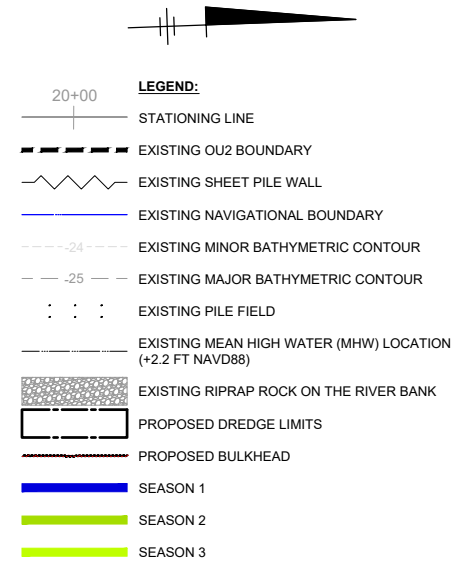
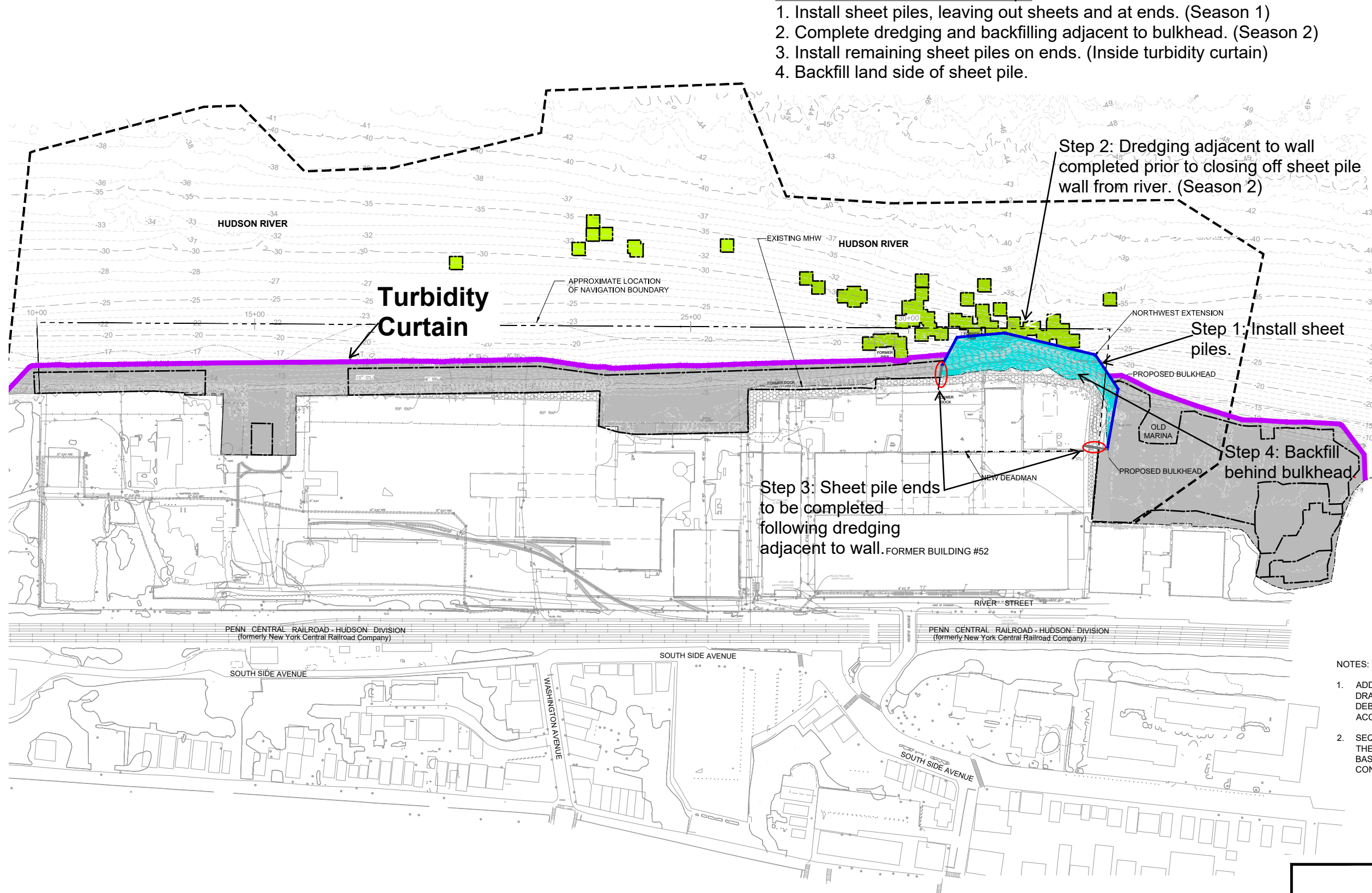
DIV\GROUP\IMDV DB: G. STOWELL PM: R. KAPP LYRON="OFF=REF" ACADVER: 23.1S (LMS TECH) PAGES: 21 OF 21 PLOTTED: 2/12/2020 7:17 PM BY: STOWELL, GARY
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XREFS: IMAGES: 30039767

X-BORDER-DL
X-BASE-1
X-BASE-BATHY
X-BASE-CURAGE
X-BASE-DESIGN
X-BASE-SURF-DREDGE

NEA bulkhead construction steps

1. Install sheet piles, leaving out sheets and at ends. (Season 1)
2. Complete dredging and backfilling adjacent to bulkhead. (Season 2)
3. Install remaining sheet piles on ends. (Inside turbidity curtain)
4. Backfill land side of sheet pile.



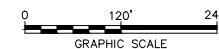
SEASONS 1 THROUGH 8 (TURBIDITY CURTAIN INSTALLATION AND REMOVAL, RESPECTIVELY)

AREA BEHIND TURBIDITY CURTAIN TO BE COMPLETED YEAR ROUND UPON INSTALLATION OF THE TURBIDITY CURTAIN (OU-1 SHORELINE AND PROPOSED WETLAND NOT SHOWN)

WORK BEHIND NORTHWEST EXTENSION AREA BULKHEAD TO BE COMPLETED YEAR ROUND UPON COMPLETION OF BULKHEAD.

NOTES:

1. ADDITIONAL DEBRIS IS PRESENT BEYOND THAT SHOWN ON THE DRAWINGS. IN ADDITION TO MAPPED DEBRIS, HISTORICAL DEBRIS SHOULD BE EXPECTED AND WILL BE REMOVED IN ACCORDANCE WITH THE TECHNICAL SPECIFICATIONS.
2. SEQUENCING PRESENTED FOR ILLUSTRATION PURPOSES ONLY. THE ORDER OF OPERATIONS IS ANTICIPATED BE REFINED BASED ON CONTRACTOR INPUT DURING CONSTRUCTION CONTRACTING AND REMEDIAL IMPLEMENTATION.



ATLANTIC RICHFIELD CO.
HASTINGS-ON-HUDSON, NEW YORK
CONSTRUCTION SEQUENCING OU2

PRELIMINARY IN-WATER CONSTRUCTION
SEQUENCING LAYOUT
4.5-MONTH WORK WINDOW SCENARIO



FIGURE

2A

APPENDIX C

Marsh Elevation Evaluation and Determination for Compensatory
Wetland Design (Arcadis, November 2020)



MEMO

To:

Paul Johnson,
Remediation Management (RM)

Copies:

L. Littrell
D. Tsao
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L. Ketcham, Arcadis
M. Gopal, Sovereign
D. Janiec, Sovereign
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M. Cicalese, Sovereign

From:

Douglas Partridge,
Raymond Kapp,
Arcadis of New York, Inc.

Date:

November 6, 2020

Arcadis Project No.:

30056299

Subject:

Marsh Elevation Evaluation and Determination for Compensatory Wetland
Design
Harbor at Hastings Site, NYSDEC Site# 3-60-022
Hastings-on-Hudson, New York

SUMMARY

To evaluate and determine the targeted design elevation range for the proposed native low marsh habitat creation project at the Hastings site (hereafter site), Arcadis evaluated (1) expected salinity ranges; (2) expected estimates of sea level rise (SLR); (3) expected tidal elevation range; and (4) biological benchmark data for both smooth cordgrass and common reed. Based on the evaluation presented in this memorandum, the final design for the marsh platform elevation will be based on:

- Expected rate of SLR of 0.0175 feet/year (0.210 inches/year), representative of regional conditions.
- Projected tidal range at an assumed future completion timeframe for wetland construction (i.e., ~June 2026) from MTL of +0.460 feet to MHTL of +2.296 feet.
- Targeted upper 25 percent of the tidal range projected for the assumed future wetland completion timeframe, estimated at +1.361 feet to 2.296 feet.
- Mechanism to adjust the final elevation closer to the actual completion date based on updated SLR analysis.

Arcadis considered the lower threshold elevation of +1.361 feet for the marsh platform (top of marsh habitat) and added a safety factor of 0.2 feet that accounts for anticipated accuracy of final grading to propose a targeted marsh platform elevation of approximately +1.56 feet.

https://arcadiso365.sharepoint.com/teams/HastingsDesign/Shared Documents/Marsh Design/Marsh Design-Conceptual-Arcadis/Final November 2020 in Response to NYSDEC/Memo Hastings Site Wetland Design Elevation_11_06_20_FINAL.docx

In addition to target elevation, this memo includes discussions of other key elements to be included in marsh design:

- Natural accretion in the created habitat to predict the relative change of the marsh platform elevation over time.
- Plant species selection for the marsh and transition areas.
- Adaptive management plan, including qualitative and quantitative assessment of the restored plant communities to track progress towards project-specific performance criteria to be defined in the design, with specific emphasis on control of the invasive common reed.

INTRODUCTION

Arcadis of New York, Inc. (Arcadis) has developed this memorandum for discussion purposes with the following objectives:

- Summarize existing analysis of site specific tidal datums and estimates of SLR.
- Summarize recently obtained biological benchmark data that coincide with expected tidal ranges for target plant species.
- Detail how these data will be utilized to support determination of a final tidal elevation range and threshold elevation for the proposed low marsh habitat at the site.
- Summarize additional considerations that will be factored into determination of the marsh platform elevation and final wetland design for the site.

TIDAL DATUMS AND WATER-LEVEL RISE ESTIMATES

To support design of the low salt marsh to be created at the site, Sovereign completed an evaluation of the available water level data for the Hudson River in July 2020. The analysis is based upon publicly available stream gauge data from nine (9) gauge stations, from Albany, NY to the Atlantic Ocean. Data was publicly available from both United States Geological Service (USGS) and National Oceanic and Atmospheric Administration (NOAA), and were limited to a 30-year period. **Attachment A** includes an Evaluation of Hudson River Water Elevations prepared to support the design analysis for the low marsh habitat.

Based on their evaluation of the tidal data, Sovereign concluded that the Piermont gauge station data confirms the range of daily tidal fluctuations observed at the former Hastings gauge station and can be used to estimate tidal fluctuations at the site. However, the Piermont gauge station cannot be used to calculate SLR (as further discussed in **Attachment A**).

An average rate of SLR was calculated based on four Hudson River USGS gauge stations which contain data collected daily for more than one long term cycle as listed in **Attachment A**. These gauge stations include the USGS Albany, Below Poughkeepsie, West Point, and Hastings gauge stations. The calculated long-term average water level rise is 0.0175 feet per year (0.21 inches per year) (**Table 2** in **Attachment A**). This average regional SLR is a key basis of design for the marsh design elevation. Since the analysis uses averages of temporal datasets, the midpoint date for the Piermont Dataset (February 9, 2016) was used as the starting point to estimate SLR. **Table 3** in **Attachment A** provides a summary of the Piermont dataset from **Table 1**, the average sea level rise from **Table 2** and the estimated water levels for June 2020 (current reference period), the assumed future construction start-date and assumed construction

end-date. Sovereign estimated the current tidal datums for the site to be MLTL of -1.550 feet, MTL of +0.355 feet, and MHTL of +2.191 feet (**Table 3 in Attachment A**).

For the purposes of this analysis, a predicted future timeframe for wetland construction was required. This analysis assumed completion of the wetland construction 6 years into the future, relative to June 2020, with the understanding that the SLR analysis would be updated prior to the actual timeframe of wetland construction completion. Tidal datums at the site based upon an assumed completion timeframe of wetland construction (~June 2026) are estimated to be MLTL of -1.445 feet, MTL of +0.460 feet, and MHTL of +2.296 feet (**Table 3 in Attachment A**).

The application of the above data to the targeted design elevation for the proposed native low marsh habitat is discussed further in the *Design Implications* section.

BIOLOGICAL BENCHMARKS

As part of the *Reference Site Screening Summary* for the site, Sovereign concluded that no satisfactory reference site was identified within the water salinity range of the site (i.e., the study area) (Sovereign 2019b). In this reach of the lower Hudson River estuary, a native low marsh habitat dominated by smooth cordgrass is quite rare due to hardened shorelines, historic anthropogenic and natural disturbances, regional salinity ranges, and invasive characteristics of the non-native common reed. However, two potential biological benchmarks were identified in this reach of the Hudson River and have potential value to the project.

A biological benchmark can be defined as a surveyed elevation point of a tidal wetland plant species, onsite or nearby to the project location, in order to obtain site specific data about the hydroperiod (depth and frequency of inundation) that this given species can tolerate. The objective of obtaining biological benchmark data is to provide additional supporting information to the known tidal datums and expected tidal range for the native species of interest (as discussed above). Two populations of smooth cordgrass (one naturally occurring and the other created) were identified within this reach of the Hudson River as potential biological benchmarks that may have value to the final design:

- Piermont Marsh. This is the estuary's largest brackish tidal marsh. Protected as part of the Hudson River National Estuarine Research Reserve, it is located approximately 2 miles upstream on the western shoreline of the Hudson River. The New York State Department of Environmental Conservation (NYSDEC) previously mapped (2007) populations of smooth cordgrass along the man-made earthen pier as well as populations in isolated, small patches that occur along the fringe of the large tidal marsh. Arcadis confirmed the continued presence of these patches in a site reconnaissance in October 2019.
- Habirshaw Park Tidal Marsh Shoreline. This tidal marsh restoration was undertaken as part of a Hudson River Sustainable Shorelines Project, located approximately 4 miles downstream of the site on the eastern shoreline of the Hudson River. This tidal wetland creation project has successfully controlled common reed within a created low marsh habitat as observed during an Arcadis site reconnaissance in November 2019.

Piermont Marsh

Historically, this large brackish marsh was composed of multiple native species including smooth cordgrass and saltmeadow cordgrass (*Spartina patens*) (Lehr 1967 as cited in Wong 1999). Both native species are mostly gone from this marsh due to the expansive establishment of common reed. Vegetation

in the low salt marsh (below MHTL) is primarily common reed with patches of smooth cordgrass (Montalto et. al. 2003). The salinity levels in this reach of the Hudson River, as well as historical anthropogenic and natural disturbances within the marsh, have allowed the non-native common reed to displace the native species throughout the marsh habitats. With respect to this project, smooth cordgrass can still be found in very narrow bands along the man-made pier (peninsula) to the north of the larger marsh complex, along the eastern edge of the marsh complex, and within the marsh complex along some of the meandering tidal creeks.

In coordination with NYSDEC and their on-going field work within Piermont Marsh, NYSDEC agreed to survey the elevation of existing patches of smooth cordgrass at two locations within the reserve in November 2019. Data were collected by Chris Mitchell (Research Assistant) and transmitted by Angela Schimizzi (Marine Biologist, Region 3). Raw survey data, a map of locations for these habitat patches, and relevant e-mail correspondence between Arcadis and NYSDEC are included as **Attachment B**. The only data manipulation completed by Arcadis was to convert surveyed elevations from meters to feet. Smooth cordgrass was documented to occur from -0.33 feet to 1.50 feet. The mean and median elevation was 0.75 and 0.78 feet, respectively¹. Three patches of adjacent common reed were also surveyed to occur from 1.32 feet to 1.61 feet. These three elevations were intended to provide reference for the lower elevational boundary of this non-native species. As expected, these data demonstrate smooth cordgrass and common reed to occur below the MHTL and within expected low marsh habitats. In addition, these data demonstrate smooth cordgrass occurring in the lower 50 percent of its expected tidal range.

Based upon email correspondence with Ms. Schimizzi (**Attachment B**), the NYSDEC survey team did note (via the original email transmission) that the areas where smooth cordgrass still survives and were surveyed by NYSDEC tended not to be in a mucky peat (i.e., common low marsh substrate) but in areas that were very rocky with a mix of substrate materials. Many of these areas occur along the southern edge of the existing pier. In subsequent correspondence with Ms. Schimizzi and Mr. Mitchell, it was also discussed that the fact these surveyed populations occur in the lower portion of the expected tidal range is likely because of the following factors:

- Competitive pressures and dominance of common reed throughout the low marsh habitats; and
- Heavy herbivory pressure along the marsh fringes by the Canada goose (*Branta canadensis*).

Habirshaw Park Tidal Marsh Shoreline

The Habirshaw Park Tidal Marsh Shoreline project (hereafter Habirshaw Project) was completed in 2004 and included a tidal marsh creation project, including a smooth cordgrass dominated low marsh, as part of an urban re-development project supported in part by the Hudson River Sustainable Shorelines Program². The site is also home of the Center for the Urban River at Beczak (CURB)³. Design objectives included: (1) increase natural features of the shoreline; (2) improve access to the water and restored vegetated areas; (3) utilize non-functioning armoring materials to assist success of new tidal marsh; (4) showcase a natural shoreline with native species in the Hudson River and an urban area; and (5) naturalize upland parkland to decrease run-off and allow for water infiltration (Hudson River National Estuarine Research Reserve 2018).

¹ The mean and median elevation was determined by removing the -0.33 feet outlier. This outlier was 0.41 feet different than the next closest survey location.

² Led by the NYSDEC Hudson River National Estuarine Research Reserve

³ Alliance of Sarah Lawrence College and Beczak Environmental Center

To support the creation of a low marsh community dominated by smooth cordgrass, the project introduced tidal hydrology to the site through creation of a tidal channel and pool. Arcadis visited the Habirshaw Project site in November and December 2019 to observe existing conditions and searched for any available elevation data specific to an existing patch of smooth cordgrass that occurs on the eastern banks of the created tidal channel. With only sporadic adaptive management, the Habirshaw Project appears to have effectively controlled establishment and spread of common reed within the created low marsh habitat.

To obtain marsh elevation data, Arcadis reached out to Ryan Palmer, Director of CURB. Mr. Palmer directed Arcadis to Sven Hoeger of Creative Habitat Corp. who was the lead ecological designer for the project. Mr. Hoeger provided an excel table that included benchmark elevations that were obtained from Piermont Marsh in 2002 in support of this project as well as corresponding target elevations for target native species. **Attachment C** includes a copy of the data provided by Mr. Hoeger (as received). No additional data analysis was performed by Arcadis. Unfortunately, specific as-built design drawings or recent survey elevations were not available.⁴

The target elevation range for smooth cordgrass in support of the Habirshaw Project was identified as 1.1 to 1.8 feet by Mr. Hoeger based upon **Attachment C**, which references data collected in 2002 at Piermont Marsh, which identified smooth cordgrass growing between elevation 1.3 and 2 feet. Mr. Hoeger did not specifically recall the vertical datum, but it is assumed to be NAVD88.

DESIGN IMPLICATIONS

The creation of a low marsh wetland habitat on the site has been identified through on-going regulatory coordination to address anticipated regulatory mitigation requirements associated with site remediation activities. A native low marsh wetland habitat dominated by a monoculture of smooth cordgrass typically occurs from MTL to MHTL. As mentioned previously, in this reach of the lower Hudson River, this habitat is quite rare due to hardened shorelines and historic anthropogenic and natural disturbances, regional salinity ranges, and invasive characteristics of the non-native common reed. As such, determination of the marsh platform elevation for the Hastings site must consider and balance the following factors:

1. Expected salinity ranges,
2. Expected SLR estimates,
3. Expected tidal elevation range, and suitable marsh design elevation in the context of assumed design life for the project, and
4. Biological benchmark data for both smooth cordgrass and common reed.

The following sections summarize how each of these factors will be included in determining a final targeted design elevation range (in NAVD88) for the low marsh creation project.

Expected Salinities

The *Revised Feasibility Study* for the site (Haley & Aldrich 2011) reported the project area to be classified as mesohaline, meaning the salinity can vary between 5 and 18 parts per thousand (ppt). Past studies have shown that the salinity within this reach of the Hudson River can vary from 1 to 19 ppt (Haley &

⁴ Arcadis reached out to Ms. Schimizzi (NYSDEC) to see if she could locate original permitting /design drawings and confirm vertical datum, as well as final elevations for each habitat type.

https://arcadiso365.sharepoint.com/teams/HastingsDesign/Shared Documents/Marsh Design/Marsh Design-Conceptual-Arcadis/Final November 2020 in Response to NYSDEC/Memo Hastings Site Wetland Design Elevation_11_06_20_FINAL.docx

Aldrich 2011). The *Baseline Data Report Year 1 & 2* (Haley & Aldrich 2015) reported that salinity ranged from 0.8 to 17 ppt with a median of 6 ppt.

To support design of this compensatory mitigation site, Sovereign evaluated the chronic salinity condition in terms of evaluating long-term plant health (most tidal marsh vegetation exhibit a tolerance to acute salinity fluctuations). Historic specific conductance plots (@ 25°C) were evaluated from the USGS Hudson River at Piermont, NY monitoring station. Using a standard conversion equation, these data were converted to salinity values. The chronic range of water salinity was approximated between 3 ppt and 9 ppt, making it mesohaline with a slight tendency towards oligohaline (0.5 ppt to 5 ppt) (Sovereign 2019b).

Smooth cordgrass is known to survive throughout mesohaline conditions and extends even into oligohaline marshes (Stribling 1997). Unfortunately, the invasive common reed has shown a regional tolerance for the chronic ranges of water salinity in this region of the Hudson River throughout tidal marshes. This is exemplified by the dominance of common reed within low marsh habitats within the Piermont Marsh. As such, expected salinity will not limit growth of common reed in this reach of the river and a created low marsh habitat must rely on the tidal cycle to flood the marsh platform twice daily. Specifically, flooding has been shown to be one of the largest factors prevent seed germination (Marks et al. 1994). Seedling growth of common reed in tidal wetlands typically only occur in zones where extended water table drawdown below the soil surface allows for seedling growth and/or shoot emergence (Chambers et al. 2003). As such, providing an elevation that flushes twice daily with average tidal cycles will be an essential aspect for the design.

Expected SLR

Tidal restoration projects should evaluate the vulnerability of a marsh platform design elevation to anticipated SLR over the design life of the project. This is based upon the assumption that much of the historic marsh loss along the North Atlantic coastline can likely be attributed to accelerated SLR (Watson et al. 2017). This evaluation is accomplished through a comparison of the lower design threshold to the expected MTL over time.

As discussed above and in **Attachment A**, the calculated average regional rate of SLR in the Hudson River selected to support this wetland design is 0.0175 feet per year (0.21 inches per year) (**Table 2** in **Attachment A**). This calculated regional SLR estimate falls within New York States' model-based projections of sea-level rise in the Lower-Hudson-New York City Region (6NYCRR Part 490). Our estimate is similar to the State's Low-Medium Projection (25th percentile of model outputs) from current time through the 2080's of 0.23 inches/year (0.019 feet/year). Attachment D includes the State's projections for SLR for the New York City/Lower Hudson region.

Tidal Range, Suitable Marsh Platform Elevation, and Design Life

This average regional SLR evaluation is a key basis of design for the marsh design elevation. As noted earlier, for the purposes of this analysis, a predicted future timeframe for wetland construction was required. At this time, it is anticipated that wetland construction may commence approximately 5-7 years after the remedial construction phase at the site commences. This analysis assumed completion of the wetland construction 6 years into the future, relative to June 2020. The current tidal datums for the site are estimated to be MLTL of -1.550 feet, MTL of +0.355 feet, and MHTL of +2.191 feet. Tidal datums at the assumed wetland construction completion timeframe (are estimated to be MLTL of -1.445 feet, MTL of +0.460 feet, and MHTL of +2.296 feet. (**Table 3** in **Attachment A**). Closer to the actual wetland construction date, the analysis provided in **Attachment A** will be updated to include the available stream

gauge records. An adjustment to the final design elevation for the marsh platform may be required based on this update. Provision for analysis-based adjustment will be made part of the applicable final design drawings and specifications.

In terms of a suitable platform elevation to support a low marsh habitat, the *Basis of Conceptual Design Memorandum* targets the upper 25 percent of this tidal range (Sovereign 2019a). This upper 25 percent of the tidal range is intended to provide “elevation capital” for a created marsh habitat by providing an extended design life to adapt to SLR (Cahoon and Guntenspergen 2010, Cahoon et al. 2019). Elevation capital recognizes there may be a combination of anthropogenic factors that directly impact marsh vulnerability.

Utilizing the upper 25% of the tidal range as a guide, Sovereign calculated that this range, in June 2026 (assumed completion timeframe for this analysis), will be 1.361 feet to 2.296 feet, with a midpoint of 1.828 feet (**Table 4 in Attachment A**). This provides a “lower threshold elevation” of +1.361 feet for the marsh platform (top of marsh habitat). Understanding the lower threshold of +1.361 feet and adding a safety factor of 0.2 feet that accounts for anticipated accuracy of final grading, the targeted elevation for the created low marsh platform is approximately +1.56 feet.

To further this evaluation, Arcadis evaluated this “lower threshold” elevation to confirm that the design elevation will continue to provide “elevation capital” following marsh construction. Using a constant rate of SLR through the life of the project, a proposed tidal marsh habitat elevation of +1.56 feet at the assumed wetland construction completion timeframe provides the necessary elevation capital to sustain a low marsh habitat for at least 50-years after completion of restoration activities. In fact, this estimate is conservative and does not factor in accretion, a natural process in marsh ecosystems. Vertical accretion of sediment and plant biomass allows salt marshes to naturally increase elevation as water level rises. Arcadis will perform additional analysis of wetland design life for inclusion in the final design that will provide an estimate of natural accretion in the created habitat and in turn more accurately estimate the expected relative change of the marsh elevation over time in conjunction with expected SLR.

Biological Benchmarks in the Lower Hudson River

The proposed lower future design threshold of +1.56 feet is consistent with the highest observed elevation of smooth cordgrass in the Piermont Marsh in November 2019. However, the design elevation for the marsh must also balance the threat of common reed. Data collected in the Piermont Marsh in November 2019 also indicate that common reed can occur at and above the lower future design threshold of +1.56 feet. As such, providing elevation capital for the mitigation site must be weighed against potential threat of common reed establishment.

It is recognized that common reed likely established in low marsh habitats within Piermont Marsh through clonal expansion of populations established in more upland positions (i.e., above MHTL). As noted above, a created low marsh habitat must rely on the tidal cycle to flood the marsh platform twice daily which in turn will prevent seed germination or shoot emergence. Specifically, flooding has been shown to be one of the largest factors that may prevent seed germination (Marks et al. 1994). Seedling growth of common reed in tidal wetlands typically only occur in zones where extended water table drawdown below the soil surface allows for seedling growth and/or shoot emergence (Chambers et al. 2003). The risk for establishment of common reed increases as the design elevation is closer to MHTL.

Design thresholds obtained from the Habirshaw Project (Habirshaw Park, City of Yonkers, NY) generally support our proposed lower future threshold of +1.56 feet. The target elevation range for smooth cordgrass in support of the Habirshaw Project was identified as +1.1 to +1.8 feet; the datum used is likely

https://arcadiso365.sharepoint.com/teams/HastingsDesign/Shared Documents/Marsh Design/Marsh Design-Conceptual-Arcadis/Final November 2020 in Response to NYSDEC/Memo Hastings Site Wetland Design Elevation_11_06_20_FINAL.docx

NAVD 88. During visits to the Habirshaw Park in November and December 2019, Arcadis observed a population of smooth cordgrass immediately adjacent to a created tidal channel that had not been invaded by the non-native common reed with minimal subsequent management.

ADDITIONAL CONSIDERATIONS

Consistent with the NYSDEC call on June 23, 2020, additional considerations will be evaluated to determine the marsh platform elevation and final wetland design for the site. These additional considerations include estimate of natural accretion, native plant species selection, and inclusion of an adaptive management plan in the final wetland design.

Natural Accretion

The projected design life of 50 years as described herein, and based on regional SLR, does not consider expected natural accretion rates within the restored marsh. Historically, tidal marshes have maintained elevation relative to sea level through accretion of mineral matter from within the water column and organic matter inputs from primary productivity of the marsh. For tidal marshes to persist indefinitely within the context of SLR, they must grow at a rate equal to or greater than the rate of SLR. The SLR calculations show that the targeted elevation range for the marsh platform will still occur above MTL after 50 years following completion of restoration activities without factoring in marsh accretion. However, it can be assumed that some level of natural accretion will occur over the 50-year period, increasing the marsh platform elevation over time and reducing the vulnerability of the restored marsh to future SLR.

Additional analysis of design life will be completed as part of final wetland design to include an estimate of natural accretion in the created habitat to predict the relative change of the marsh platform elevation over time. This estimate will be based upon an identified regional reference for marsh accretion.

Plant Species Selection

As described in Ecological Communities of New York State (Edinger et al. 2014), “the vegetation of the low salt marsh is a monospecific stand of cordgrass (*Spartina alterniflora*)”. As such, smooth cordgrass will be the dominant species within this created low marsh habitat. In order to provide additional diversity as recommended by NYSDEC, the following native species provide potential minor plant associates that will be considered in the final wetland design: saltgrass (*Distichlis spicata*), saltmeadow cordgrass, American saltmarsh bulrush (*Bolboschoenus maritimus* ssp. *pauldosus*), and high tide bush (*Iva frutescens*).

Dominant plant species which may be included in the planting design along the perimeter of the marsh as it transitions to uplands include saltgrass, saltmeadow cordgrass, black grass (*Juncus gerardii*), perennial saltmarsh aster (*Symphyotrichum tenuifolium* var. *tenuifolium*), switchgrass (*Panicum virgatum*), and high tide bush. Other additional native grasses and flowering forbs will be considered for this transition area as part of a native seed mix. Additional woody species to be planted here could include bayberry (*Myrica pensylvanica*), groundsel-tree (*Baccharis halimifolia*), beach plum (*Prunus maritima*), eastern red cedar (*Juniperus virginiana*), rose species (*Rosa* spp.).

The final design will also consider that transitional upland plantings should provide native ecological value while also having aesthetic value to the waterfront community and visitors. It is also recognized that NYSDEC anticipates a future discussion or meeting specific to the planting plan prior to submittal of final design drawings.

Adaptive Management

A plan will be developed which includes monitoring and adaptive management for the required compliance interval. This plan will be driven by defined performance criteria for the created habitats. Monitoring protocols will be defined that facilitate both a qualitative and quantitative annual assessment of the restored plant communities to track progress towards project-specific performance criteria to be defined in the design. If deviations from performance criteria are documented, or concerns are noted based upon best professional judgement from site observations, adaptive management actions will be implemented consistent with the proposed plan. The adaptive management plan will focus upon (1) maintenance of existing grades and adequate tidal flushing; (2) percent vegetative cover of native species; and (3) percent vegetative cover of invasive species.

It is also recognized that adaptive management in transitional upland areas is critical to the success of intertidal wetlands. As such, the adaptive management plan will specifically address control of common reed in the entire created intertidal wetland and adjacent habitat. It is recognized that NYSDEC anticipates approval of an adaptive management plan to support management of the restored wetland habitat.

CONCLUSIONS

In summary, the final design for the marsh platform elevation will be based on:

- Expected rate of SLR of 0.0175 feet/year (0.210 inches/year), representative of regional conditions.
- Projected tidal range at an assumed future completion timeframe for wetland construction (i.e., ~June 2026) from MTL of +0.460 feet to MHTL of +2.296 feet.
- Targeted upper 25 percent of the tidal range projected for the assumed future wetland completion timeframe, estimated at +1.361 feet to +2.296 feet.
- Determined “lower threshold” of +1.56 feet for habitat provides suitable “elevation capital” within context of expected water level elevations for a 50-year design life.
- Mechanism to adjust the final elevation closer to the actual completion date based on updated WRL analysis.

The targeted lower threshold elevation can be readily adjusted based on additional regional tidal data available closer to the year of marsh construction to account for an updated SLR analysis. Any recommended change is expected to be relatively minimal, on the order of tenths of a foot. This approach is expected to:

- Provide elevation capital necessary to compensate for expected SLR over at least a 50-year period and support a native low marsh habitat dominated by smooth cordgrass.
- Reflect a target elevation that is consistent with observed and design elevation ranges of smooth cordgrass patches within natural and created salt marshes in the Lower Hudson River.

Arcadis recognizes that increasing this elevation range could increase the vulnerability to establishment of common reed. In contrast, decreasing this range could increase the vulnerability of habitat to expected SLR. Because the target elevation provided in this memo is based on an assumed future completion timeframe, applicable design drawings will include a note that the SLR analysis shall be updated to include the available stream gauge records for the regional stations closer to the actual construction completion

date. An adjustment to the final design elevation for the marsh platform may be required based on the update.

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ATTACHMENT A

USGS AND NOAA STREAM GAUGE ANALYSIS



**Revised Internal Draft
Attachment A**

Evaluation of Hudson River Water Elevations

**Former Anaconda Wire and Cable Company Site
Hastings-on-Hudson, New York**

Prepared by Sovereign Consulting, Inc.

November 4, 2020

To support design of the low salt marsh to be created at the Former Anaconda Wire and Cable Company Site at Hastings-on-Hudson, New York (NY) (Hastings), Sovereign completed an evaluation of the available water level data for the Hudson River in May 2020. The following provides an overview of the evaluation process and associated observations.

Sovereign reviewed the water level data from the former USGS gauge station at Hastings. Since the Hasting gauge station stopped collecting data in October 2010, Sovereign then evaluated the Piermont gauge station data, but found the data to be limited in duration with a 15-month data gap, from March 1, 2012 to May 31, 2013. In review of the data for these two-gauge stations, the tidal ranges appeared to be similar, but the calculated sea level rise was different by a factor of two.

To understand the sea level rise discrepancy between these two-gauge locations, Sovereign expanded the evaluation to include other USGS gauge locations and a NOAA gauge location, from Albany, NY to the Atlantic Ocean in the vicinity of New York City, NY. The following provides a list of the gauge stations, from upstream in the Hudson River to in the vicinity of the Atlantic Ocean that were used in the evaluation:

- Albany, NY – USGS
- Below Poughkeepsie, NY – USGS
- West Point, NY – USGS
- Piermont, NY – USGS
- Hastings-on-Hudson, NY – USGS
- Pier 84, NYC – USGS
- The Battery, NYC – NOAA
- Great Kills, NY – USGS
- East Rockaway Inlet, NY – USGS

The available data for each of the above gauge stations, for a period of up to 30 years, were downloaded and used to develop summary statistics for each gauge station. All elevations in this document are referenced to the North American Vertical Datum of 1988 (NAVD88). Table 1 provides the date range for the available data used in the evaluation, the frequency of the available data, and the following tidal information:

- Mean Higher High Tide
- Mean Lower Low Tide
- The difference between the two above measurements
- Mean High Tide
- Mean Low Tide
- The difference between the two above measurements
- Mean Water Level

The gauge stations are color-coded in Table 1 to represent locations within the Hudson River (green), and the locations influenced primarily by the Atlantic Ocean (blue). Based on our evaluation of the tidal data, it is our opinion the Piermont gauge station data does confirm the range of daily tidal fluctuations observed at the former Hastings gauge station, where the similarity can be seen in Table 1, and can be used to estimate future tidal fluctuations at the Hastings Site. As discussed below, however, the Piermont gauge station should not be used to calculate sea level rise.

To evaluate sea level rise in the Hudson River, Sovereign developed a chart to view the mean water levels for the available data. Figure 1 provides a plot of the mean daily water elevations. Data was available at some of the USGS gauge stations in the early 1990s, so the X axis for the chart begins in January 1991. Due to the limited data for the USGS Pier 84 gauge station and the available frequency of data for the NOAA gauge station at The Battery, the data for these two gauge stations were not included on Figure 1. To assist in the evaluation of the water level variations, Sovereign noted on the chart when tropical storms and hurricanes occurred in northeast since 1991. In review of Figure 1, note the spikes in mean water levels associated with Hurricane Irene that influenced the Hudson River water shed up to Albany, NY and Hurricane Sandy that influenced the lower Hudson River water shed.

Sovereign developed a chart to view the influence of seasonal variability, based on the yearly moving averages of the mean water levels for each gauge station. Figure 2 provides a plot of the yearly moving averages that provides clarity to observe seasonal and regional variations and other trends. The available water elevation data through May 2020 indicate a long cycle of 8 years, where the beginning high occurred during and as a result of Hurricane Irene in 2011. The ending high of this cycle occurred at the end of 2019, and the Hudson River water shed has been under drought conditions since that point in time. The data also indicates the low in this long cycle occurred during the summer of 2015. When looking at the estimated sea level rise for a gauge station, consideration must be given to the period of time the data represents in this last 8-year cycle. For example, the Piermont gauge station data collection began during the low portion of this last cycle, resulting in a calculated rate of sea level rise that is biased high.

Table 2 provides the date range and frequency of the available data and the calculated long term and more recent one-year sea level rise rates for the gauge stations plotted on Figure 2. The gauge stations are color-coded to represent locations within the Hudson River (green), and the locations influenced primarily by the Atlantic Ocean (blue). The calculated sea level rise rates in Table 2 are based on the slopes of the lines for each gauge plotted on Figure 2.

An average rate of sea level rise was calculated based on the four Hudson River USGS gauge stations included in Table 2, which contain data collected on a daily basis for more than one long term cycle. These gauge stations include the USGS Albany, Below Poughkeepsie, West Point and Hastings gauge stations. The calculated long-term average sea level rise is 0.0175 feet per year, which is illustrated by the green, long-dash line on Figure 2. This long-term average sea level rise complements the trend of the mean water elevations for the past 30 years from most of the gauge stations. As noted above, the Piermont data was not used in this calculation. Based on the available data for the sea level evaluation, it is our opinion the average sea level rise of 0.0175 feet per year is the appropriate metric to be used to establish the future elevation of the low salt water marsh. As a point of reference, The Battery, NYC gauge station sea level rise of 0.0094 feet per year also was plotted as the black, long-dashed line on Figure 2. The sea level rise for this gauge station appears to be biased low, when compared to the other gauge stations influenced by the Atlantic Ocean.

As indicated above, it is our opinion the Piermont gauge station can be used to estimate tidal fluctuations at the Hastings Site. To estimate the habitat platform elevation for the Hastings Site at the estimated future remedy completion date, the average sea level rise was applied to the Piermont dataset statistical results for Mean High Tide, Mean Low Tide and Mean Tide. Since the analysis uses averages of temporal datasets, the midpoint date for the Piermont Dataset (February 9, 2016) was used as the starting point to estimate sea level rise. Table 3 provides a summary of the Piermont dataset from Table 1, the sea level rise from Table 2 and the estimated sea levels for June 2020, the estimated remedy start date and estimated remedy end date. The project team has determined the desired elevation for the habitat

platform to be at the upper 25 percent of the difference between Mean High Tide and Mean Low Tide, to represent the upper 25 percent of the tidal range. Based on this criteria, Table 4 provides the estimated elevation of 1.361 feet for habitat platform at the estimated remedy end date.

Additional Considerations

Of interest are the sea level trends for the past year for active gauge stations during this period of time, where all but the Below Poughkeepsie gauge station indicate a downward trend, reflecting the drought conditions since the end of 2019. The Below Poughkeepsie gauge station stopped collecting data in November 2019, at the ending peak of the last long cycle, so the available data does not represent the recent decline in sea level elevations.

The Pier 84 gauge station has been collecting data for a single year, where water level data is available at a frequency of 15 minutes, without any available evaluation regarding the various tide cycles. The Piermont and Pier 84 gauge stations are demonstrating similar sea level fluctuations for a period of one-year, and these gauge stations bracket the Hastings Site. If the USGS provides similar tidal data analysis for the Pier 84 gauge station, the Pier 84 gauge station data could be used to augment the Piermont data.

Figures

Figure 1 - Hudson River Mean Water Levels - USGS Gauge Stations - As of May 2020
 Albany, Below Poughkeepsie, West Point, Piermont, Hastings, Great Kills and East Rockaway Inlet

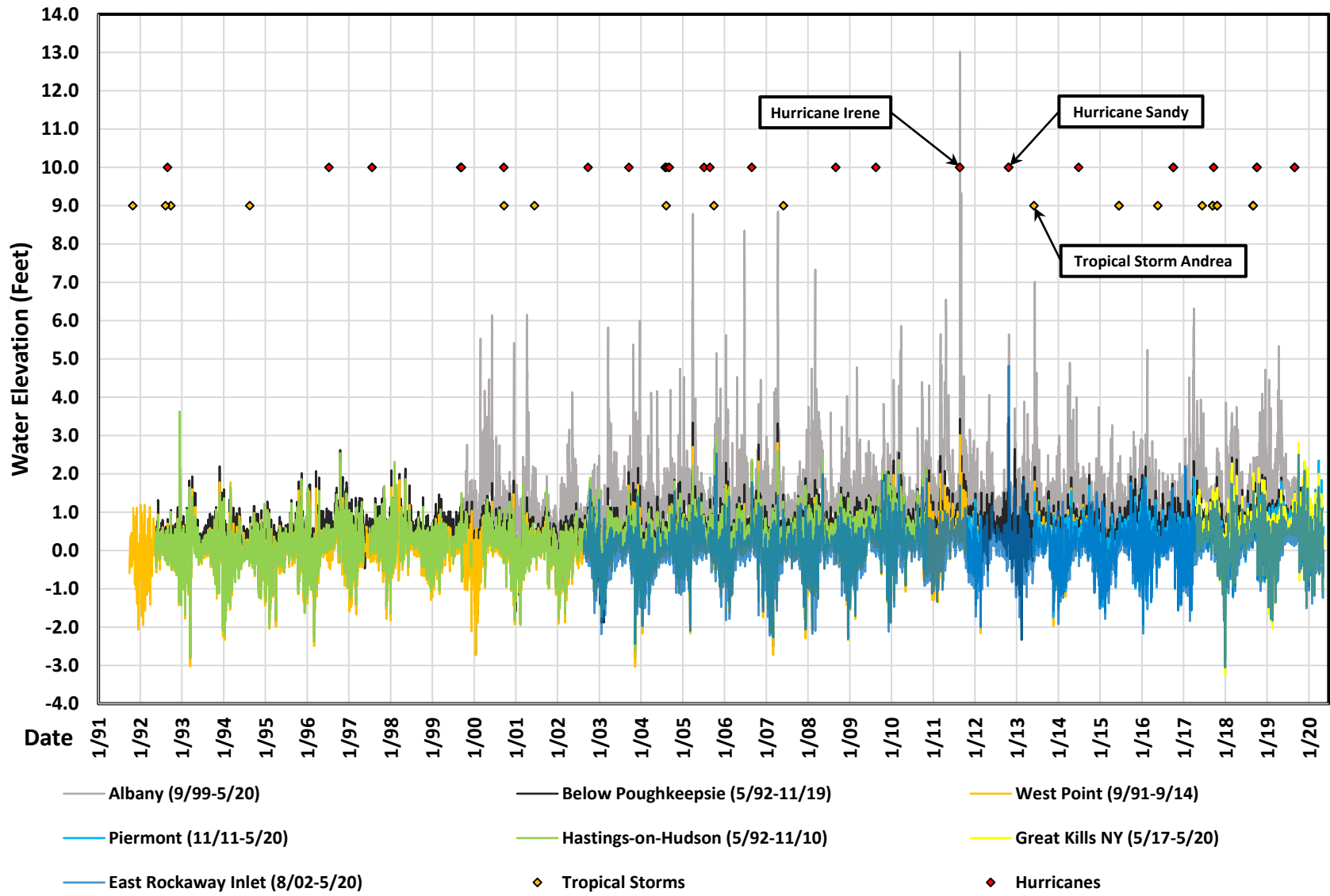
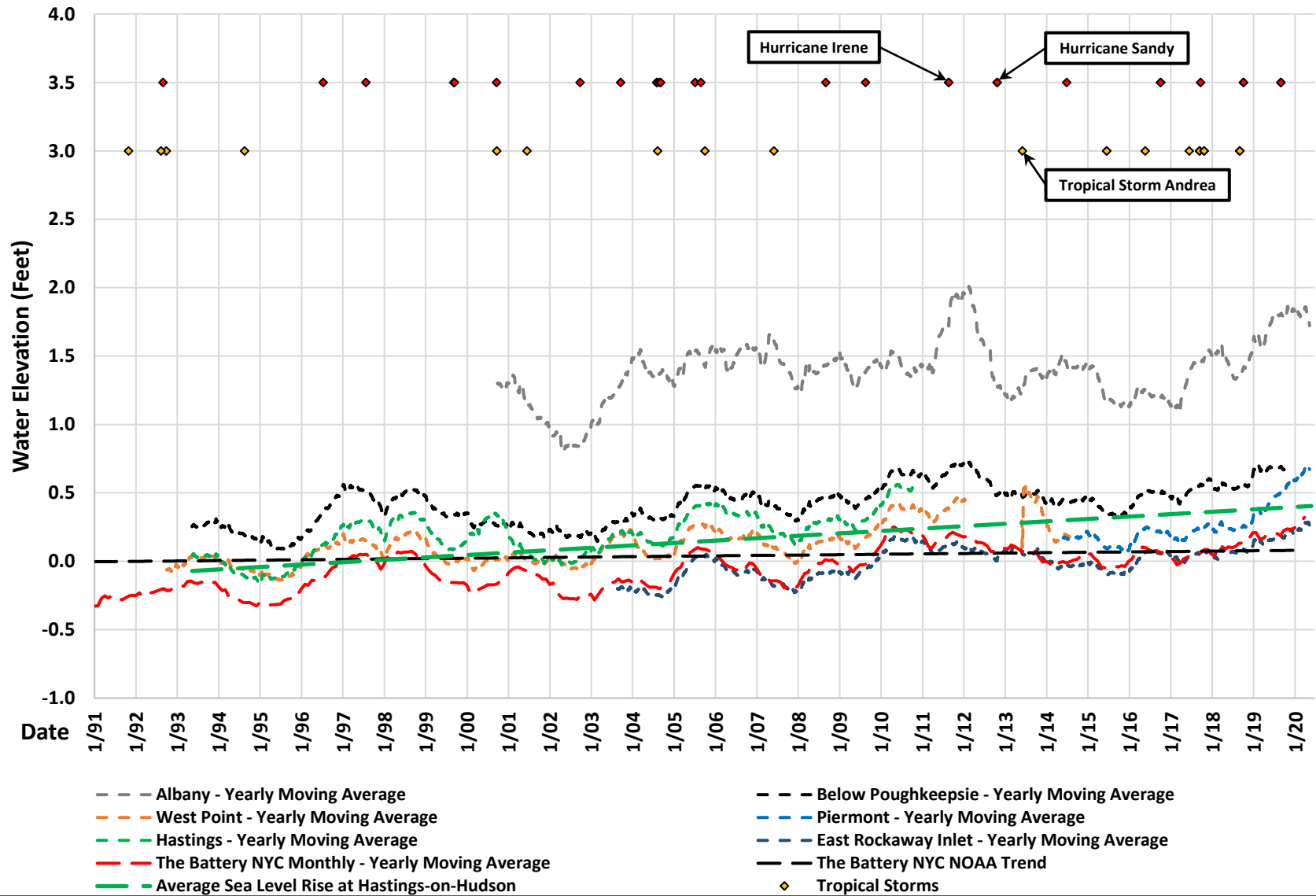


Figure 2 - Hudson River Rolling Average Water Levels - USGS Gauge Stations - As of May 2020
 Albany, Below Poughkeepsie, West Point, Piermont, Hastings, East Rockaway Inlet and The Battery NYC



Tables

Table 1 – Average Data within the Last 30 Years - Upstream Hudson River to the Atlantic Ocean

Gauge Station	Start Date	End Date	Data Frequency	Data Years	Mean Higher High Tide	Mean Lower Low Tide	Delta	Mean High Tide	Mean Low Tide	Delta	Mean Water Level
					Feet	Feet	Feet	Feet	Feet	Feet	Feet
Albany USGS Gauge Station	09/30/99	05/17/20	Daily	20.7	4.103	-1.478	5.581	3.784	-1.290	5.074	1.395
Below Poughkeepsie USGS Gauge Station	05/12/92	11/05/19	Daily	27.6	2.428	-1.373	3.801	2.093	-1.186	3.280	0.420
West Point USGS Gauge Station	09/30/91	09/11/14	Daily	23.0	2.026	-1.592	3.617	1.722	-1.410	3.133	0.114
Piermont USGS Gauge Station	11/01/11	05/17/20	Daily	8.6	2.379	-1.799	4.178	2.115	-1.625	3.741	0.279
Hastings-on-Hudson USGS Gauge Station	05/13/92	11/11/10	Daily	18.5	2.418	-1.799	4.217	2.120	-1.630	3.751	0.191
Pier 84 NYC USGS Gauge Station	05/06/19	05/18/20	15 Minutes	1.0	-	-	-	-	-	-	-0.487
The Battery NYC NOAA Gauge Station	01/90	04/20	Monthly	30.3	2.472	-2.639	5.111	2.146	-2.429	4.574	-0.142
Great Kills NY USGS Gauge Station	05/03/17	05/17/20	Daily	3.0	3.094	-2.374	5.468	2.759	-2.165	4.925	0.390
East Rockaway Inlet NY USGS Gauge Station	08/23/02	05/17/20	Daily	17.8	2.469	-2.404	4.873	2.165	-2.220	4.385	-0.003

Notes:



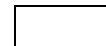
= River locations.



= Ocean locations.



= Not in service.



= No data.

Table 2 – Sea Level Rise/Year - Upstream Hudson River to the Atlantic Ocean							
Gauge Station	Start Date	End Date	Data Frequency	Data Years	Long Term		1 Year
					Feet	Inches	Inches
Albany USGS Gauge Station	09/30/99	05/17/20	Daily	20.7	0.018	0.21	-1.80
Below Poughkeepsie USGS Gauge Station	05/12/92	11/05/19	Daily	27.6	0.014	0.16	6.13
West Point USGS Gauge Station	09/30/91	09/11/14	Daily	23.0	0.017	0.20	
Piermont USGS Gauge Station	11/01/11	05/17/20	Daily	8.6	0.036	0.44	-3.24
Hastings-on-Hudson USGS Gauge Station	05/13/92	11/11/10	Daily	18.5	0.022	0.27	
Pier 84 NYC USGS Gauge Station	05/06/19	05/18/20	15 Minutes	1.0	-0.237	-2.85	-2.85
The Battery NYC NOAA Gauge Station	01/90	04/20	Monthly	30.3	0.010	0.12	-2.85
Great Kills NY USGS Gauge Station	05/03/17	05/17/20	Daily	3.0	0.023	0.28	-4.82
East Rockaway Inlet NY USGS Gauge Station	08/23/02	05/17/20	Daily	17.8	0.018	0.21	-5.69
Average					0.0175	0.21	-2.63

Notes:

	= River locations used for the average.
	= Ocean locations.
	= Not in service.
	= Data not representative of long term conditions.
	= Trend only for the first six months of the past year.
	= No data.

Table 3 – Piermont USGS Gauge Station – Project Sea Level Rise

Piermont Dataset Results (From Table 1)						
Piermont Dataset			Mean High Tide	Mean Low Tide	Mean High and Low Tide Delta	Mean Tide
Start Date	End Date	Mid-Point	Feet	Feet	Feet	Feet
11/01/11	05/17/20	02/08/16	2.115	-1.625	3.741	0.279

Average Sea Level Increase	0.0175	Feet/Year
(From Table 2)		

Estimated Sea Level Rise Using Piermont Dataset Results					
Criteria Dates		Mean High Tide	Mean Low Tide	Mean High and Low Tide Delta	Mean Tide
		Feet	Feet	Feet	Feet
Reference Date	06/01/20	2.191	-1.550	3.741	0.355
Estimated Remedy Start Date	06/01/22	2.226	-1.515	3.741	0.390
Estimated Remedy End Date	06/01/26	2.296	-1.445	3.741	0.460

Table 4 – Hastings Site Habitat Platform Elevation Results

Criteria Date		25 % of Delta	Upper 25% of Delta
		Feet	Feet
Estimated Remedy End Date	06/01/26	0.935	1.361

ATTACHMENT B

NYSDEC SMOOTH CORDGRASS SURVEY RESULTS



Attachment B. Raw Survey Data as Provided by NYSDEC for Smooth Cordgrass Survey Completed on November 21, 2019.

Point Id	Point Class	Date/Time	Coordinate Format	Coordinate Source XY	Latitude	Longitude	Ellip. Hgt.	Ortho. Hgt. (m)	Posn. Qlty	Hgt (ft) NAVD88
PM Phrag High	Averaged	11/21/2019 11:06	Latitude; Longitude; Orthometric Height	Fixed by Calculation	41° 02' 19.87612" N	73° 54' 27.28194" W	-	0.491	0	1.612
PM Phrag Low	Measured	11/21/2019 11:04	Latitude; Longitude; Ellipsoidal Height; Geoid Separation	Fixed by GPS	41° 02' 19.77849" N	73° 54' 27.27257" W	-30.898	0.405	0.012	1.329
PM Phrag Mid	Measured	11/21/2019 11:06	Latitude; Longitude; Ellipsoidal Height; Geoid Separation	Fixed by GPS	41° 02' 19.81168" N	73° 54' 27.31836" W	-30.818	0.485	0.009	1.59
PP Spartina 7	Measured	11/21/2019 11:42	Latitude; Longitude; Ellipsoidal Height; Geoid Separation	Fixed by GPS	41° 02' 32.34854" N	73° 54' 07.36608" W	-31.387	-0.102	0.009	-0.334
PM Spartina 5	Measured	11/21/2019 11:09	Latitude; Longitude; Ellipsoidal Height; Geoid Separation	Fixed by GPS	41° 02' 19.73260" N	73° 54' 27.14462" W	-31.28	0.023	0.008	0.075
PM Spartina 3	Measured	11/21/2019 11:02	Latitude; Longitude; Ellipsoidal Height; Geoid Separation	Fixed by GPS	41° 02' 19.69838" N	73° 54' 27.13012" W	-31.267	0.036	0.007	0.117
PM Spartina 4	Measured	11/21/2019 11:03	Latitude; Longitude; Ellipsoidal Height; Geoid Separation	Fixed by GPS	41° 02' 19.74039" N	73° 54' 27.15227" W	-31.256	0.047	0.013	0.154
PM Spartina 6	Measured	11/21/2019 11:10	Latitude; Longitude; Ellipsoidal Height; Geoid Separation	Fixed by GPS	41° 02' 19.70610" N	73° 54' 27.11586" W	-31.242	0.062	0.008	0.202
PM Spartina 9	Measured	11/21/2019 11:01	Latitude; Longitude; Ellipsoidal Height; Geoid Separation	Fixed by GPS	41° 02' 19.69117" N	73° 54' 27.05118" W	-31.232	0.071	0.008	0.234
PM Spartina 8	Measured	11/21/2019 11:00	Latitude; Longitude; Ellipsoidal Height; Geoid Separation	Fixed by GPS	41° 02' 19.67000" N	73° 54' 27.06662" W	-31.178	0.125	0.014	0.409
PM Spartina 11	Measured	11/21/2019 11:09	Latitude; Longitude; Ellipsoidal Height; Geoid Separation	Fixed by GPS	41° 02' 19.75435" N	73° 54' 27.20684" W	-31.155	0.148	0.005	0.487
PM Spartina 13	Measured	11/21/2019 11:11	Latitude; Longitude; Ellipsoidal Height; Geoid Separation	Fixed by GPS	41° 02' 19.66165" N	73° 54' 27.15925" W	-31.155	0.148	0.012	0.487
PM Spartina 7	Measured	11/21/2019 11:10	Latitude; Longitude; Ellipsoidal Height; Geoid Separation	Fixed by GPS	41° 02' 19.65853" N	73° 54' 27.15936" W	-31.141	0.162	0.006	0.531
PP Spartina 8	Measured	11/21/2019 11:43	Latitude; Longitude; Ellipsoidal Height; Geoid Separation	Fixed by GPS	41° 02' 32.37265" N	73° 54' 07.26478" W	-31.115	0.17	0.006	0.559
PP Spartina 1	Measured	11/21/2019 11:36	Latitude; Longitude; Ellipsoidal Height; Geoid Separation	Fixed by GPS	41° 02' 32.43444" N	73° 54' 06.95707" W	-30.98	0.305	0.008	0.999
PP Spartina 3	Measured	11/21/2019 11:38	Latitude; Longitude; Ellipsoidal Height; Geoid Separation	Fixed by GPS	41° 02' 32.42636" N	73° 54' 06.98702" W	-30.98	0.305	0.012	1.002
PP Spartina 2	Measured	11/21/2019 11:37	Latitude; Longitude; Ellipsoidal Height; Geoid Separation	Fixed by GPS	41° 02' 32.42609" N	73° 54' 06.98662" W	-30.962	0.323	0.016	1.059
PM Spartina 10	Measured	11/21/2019 11:08	Latitude; Longitude; Ellipsoidal Height; Geoid Separation	Fixed by GPS	41° 02' 19.77149" N	73° 54' 27.23050" W	-30.968	0.335	0.008	1.1
PM Spartina 12	Measured	11/21/2019 11:04	Latitude; Longitude; Ellipsoidal Height; Geoid Separation	Fixed by GPS	41° 02' 19.71167" N	73° 54' 27.23184" W	-30.961	0.343	0.009	1.124
PP Spartina 6	Measured	11/21/2019 11:41	Latitude; Longitude; Ellipsoidal Height; Geoid Separation	Fixed by GPS	41° 02' 32.44282" N	73° 54' 07.31684" W	-30.942	0.343	0.007	1.126
PM Spartina 2	Measured	11/21/2019 11:08	Latitude; Longitude; Ellipsoidal Height; Geoid Separation	Fixed by GPS	41° 02' 19.72213" N	73° 54' 27.28209" W	-30.921	0.382	0.008	1.253
PM Spartina 1	Measured	11/21/2019 11:07	Latitude; Longitude; Ellipsoidal Height; Geoid Separation	Fixed by GPS	41° 02' 19.77510" N	73° 54' 27.27842" W	-30.916	0.387	0.007	1.27
PP Spartina 4	Measured	11/21/2019 11:39	Latitude; Longitude; Ellipsoidal Height; Geoid Separation	Fixed by GPS	41° 02' 32.47503" N	73° 54' 07.06486" W	-30.894	0.391	0.007	1.281
PP Spartina 5	Measured	11/21/2019 11:40	Latitude; Longitude; Ellipsoidal Height; Geoid Separation	Fixed by GPS	41° 02' 32.45781" N	73° 54' 07.15592" W	-30.829	0.456	0.009	1.496
RTCM-Ref 0000	Control	11/22/2019 8:33	Latitude; Longitude; Ellipsoidal Height; Geoid Separation	Fixed by GPS	41° 04' 56.22098" N	73° 49' 04.12567" W	63.296	94.259	0	309.248698



Legend

- Smooth Cordgrass Locations

NOTES

1. Survey of known populations of smooth cordgrass (*Spartina alterniflora*) completed by NYSDEC on Nov. 20, 2019.
2. Data was processed using horizontal datum NY E NAD83 Geoid 12A. Orthometric heights after processing representative of NAVD88.



ATLANTIC RICHFIELD CO.
HASTINGS-ON-HUDSON, NEW YORK

NYSDEC SMOOTH CORDGRASS SURVEY



Partridge, Doug

From: Schimizzi, Angela E (DEC) <Angela.Schimizzi@dec.ny.gov>
Sent: Friday, November 22, 2019 11:20 AM
To: Martha Gopal
Subject: RE: RTK

One more thing. I wanted to add that I have not reviewed this data yet and that it would be beneficial to get elevation data from another reference site, like the Beczak Environmental Education Center, as well. Chris, the research assistant, wanted me to mention that the areas where the spartina was present tended to be very rocky and a mix of material – not the typical substrate of a marsh.

This spring we should also have updated hi-res LiDAR data for the entire Piermont Marsh. I can send you that data for your list of reference elevations once it is completed.

Thank you,

Angela Schimizzi

Marine Biologist - Region 3, Division of Marine Resources

New York State Department of Environmental Conservation

Norrie Point Environmental Center, 256 Norrie Point Way, P.O. Box 315, Staatsburg, NY 12580

(845) 889-4745 x117 | angela.schimizzi@dec.ny.gov

www.dec.ny.gov | |  |  | 

From: Schimizzi, Angela E (DEC)
Sent: Friday, November 22, 2019 11:03 AM
To: Gopal, Martha <MGopal@sovcon.com>
Subject: FW: RTK

Hi Martha,

Please see the attached. Let me know if you have any questions.

Thank you,

Angela Schimizzi

Marine Biologist - Region 3, Division of Marine Resources

New York State Department of Environmental Conservation

Norrie Point Environmental Center, 256 Norrie Point Way, P.O. Box 315, Staatsburg, NY 12580

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From: Mitchell, Christopher G (DEC) <christopher.mitchell@dec.ny.gov>
Sent: Friday, November 22, 2019 10:32 AM
To: Schimizzi, Angela E (DEC) <Angela.Schimizzi@dec.ny.gov>
Subject: Re: RTK

Data is processed using horizontal datum NY E NAD83 Geoid 12A

Orthometric height (Meters) should be representative of NAVD88 based on the GEOID separations using the NYSNET (NY State Spatial Reference Network) Real Time CORS (Continuously operates reference station) base station in Valhalla NY *NYVH* (I attached a copy of the Datums metadata from NYSNET)

The quality column can be perceived as standard error for each shot, the smaller the number the more accurate the data (also in Meters) I think all of the shots are sub 2cm accuracy with most around 1 cm.

-Chris

Chris Mitchell

Research Assistant, NEIWPCC/Hudson River National Estuarine Research Reserve,
Division of Marine Resources

New York State Department of Environmental Conservation

Norrie Point Environmental Center

256 Norrie Point Way, P.O. Box 315, Staatsburg, NY 12580

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www.dec.ny.gov |  | 

Partridge, Doug

From: Schimizzi, Angela E (DEC) <Angela.Schimizzi@dec.ny.gov>
Sent: Friday, March 27, 2020 11:40 AM
To: Partridge, Doug
Cc: Kapp, Raymond; Martha Gopal
Subject: RE: Piermont Data - Surveyed Smooth Cordgrass Populations

Hi Doug,

I had a phone call yesterday with Chris Mitchell and Brian DeGasperi, the habitat restoration biologist at Norrie Point. We talked about it and the general consensus was that the "PP" elevations were taken on the boardwalk in fringing, marginal locations that could be skewing the elevations to be in the lower portion of spartina's typical growth range. If you look at the "PM" elevations, it is more consistent. Brian also wanted it to be noted that competition with phrag is most likely keeping the spartina lower than ideal and there is heavy herbivory pressure from geese throughout the entire marsh complex that could also be a factor.

We are still on schedule to have the LIDAR flyover on April 9th and are looking to get the final data by May/June. We hope that remains on schedule but with the current state of things, we cannot guarantee it. Once I have that data, I will send it your way.

As for the second question, I anticipate that I will be able to go back into the office at the end of next week. I will be able to check our files and get you more information regarding the permitting plans for Bezcak. I will confirm with my supervisor if I can give out some of that information or not. I believe it is a case study site for our long-term monitoring effort so it might be readily available without a FOIL request.

Sidebar for Martha - I am working on my comments regarding the construction work windows and should have that to you by this afternoon or Monday.

Thank you,

Angela Schimizzi

Marine Biologist - Region 3, Division of Marine Resources

New York State Department of Environmental Conservation

Norrie Point Environmental Center, 256 Norrie Point Way, P.O. Box 315, Staatsburg, NY 12580

(845) 889-4745 x117 | angela.schimizzi@dec.ny.gov

www.dec.ny.gov |  |  | 



From: Partridge, Doug <Doug.Partridge@arcadis.com>
Sent: Tuesday, March 24, 2020 1:27 PM
To: Schimizzi, Angela E (DEC) <Angela.Schimizzi@dec.ny.gov>
Cc: Kapp, Raymond <Raymond.Kapp@arcadis.com>; Martha Gopal <mgopal@sovcon.com>
Subject: RE: Piermont Data - Surveyed Smooth Cordgrass Populations

ATTENTION: This email came from an external source. Do not open attachments or click on links from unknown senders or unexpected emails.

Angela,

As I mentioned in my previous emails, we have been working with the data received from both NYSDEC as well as data specific to Habirshaw Park. I've broken this email into two sections to address each and hoping we could continue our discussion either over email or through a phone conference. We appreciate any time you and Chris can provide to assisting us! We appreciate that you are working remotely, and don't have access to everything.

Part 1.

Specific to the most recent data collected at Piermont Data from 21 patches of smooth cordgrass (*Spartina alterniflora*), the elevation range was -0.33 to 1.5 feet (NAVD88) (See attached). As Chris noted in his email (November 22, 2019), the orthometric height (meters) should be representative of NAVD88. As such, the only manipulation of the data that we performed was to convert the orthometric height (meters) into feet.

We compared this data to our expected tidal datums:

1. Accounting for sea level rise, the mean tide level was assumed to be 0.59 feet and mean high tide line of 2.44 feet (NAVD88).
2. Straight analysis of existing gauge data, the mean tide level was assumed to be 0.24 and mean tide line of 2.09 feet (NAVD88).

This data surprised us due to fact elevations were lower than expected when compared to expected tidal range of this species, as well as previous benchmark data collected for Habirshaw (see below in Part 2). Specifically, (1) we have a fair number of patches below the mean tide level (i.e., at least 28%); and (2) almost all of the surveyed patches occur in the lowest 50% of the expected tidal range. We appreciate the dominance of common reed in this marsh, and noted Chris' original comment about the rocky substrate. However, after reviewing this data, we were curious if you or Chris had any additional thoughts or observations from field about the relatively low elevations of the 21 patches of smooth cordgrass? The intention of this questions is to get a better handle on any field observations/context that could better assist with our interpretation of these data correctly. We appreciate the fact that the lower elevations may be just indicative of the dominance of common reed in this marsh. However, they these data are distinctly lower than reference data from 2002 that we received for Habirshaw, as summarized below. As such, we felt it was a question worth inquiring about at this time as we did not observe all of these patches in the field.

Part 2.

We agreed with your recommendation to seek elevation data from Habirshaw. We contacted the Beczak Environmental Center, as well as the designer. The only data that we were able to obtain specific to this restoration effort was the attached spreadsheet provided by Sven Hoeger, formerly with Creative Habitat Corp., that identified (1) elevation range of native species within Piermont Marsh (believed to be 2002 data); and (2) proposed design elevation of native species specific to Habirshaw Park. Specific to smooth cordgrass, reference data from Piermont was 1.3 to 2.0 feet. They adjusted for water level differences, and design elevation at the Park is believed to be between 1.1 to 1.8 feet.

We have been unable to definitively confirm the vertical datum for this data provided by Mr. Hoeger, however are assuming they are in NAVD88 for time being. The difference of elevation range to those just collected in Piermont is distinct. Unfortunately, the original design/permitting drawings have not been located at this time in order to confirm vertical datum as well as identify final design grades. My question for you is whether you or someone at NYSDEC may have the ability to locate historical design drawings associated with the original permit package? We understand that you may want us to submit a FOIL request for the permit application, assuming NYSDEC issued the permit (circa 2003-2004). In addition, if this Piermont reference data is known to you and/or your team, would you be able to provide us with the 2002 source elevation data for Piermont?

We understand the potential difficulty to access historical records at this time.

Again, thank you for any assistance you can provide at this time! I hope you are staying safe and healthy during this challenging time. Please let me know after you have had a chance to discuss with Chris, and we can take it from there.

Talk soon,

Doug

Douglas Partridge | Principal Ecologist | Doug.Partridge@arcadis.com

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ATTACHMENT C

HABIRSHAW PARK TIDAL MARSH RESTORATION PROJECT –
BENCHMARK ELEVATION DATA UTILIZED TO SUPPORT TIDAL
MARSH DESIGN



Attachment C. Benchmark elevation data for Habirshaw Park Tidal Marsh Restoration as provided by Sven Hoeger.

Line	Plant species		Piermont					Habirshaw			
			Low	High	MHT	Low to MHT	Hgh to MHT	MHT	calc Low	calc High	
1	Spartina	alterniflora	1.3	2	2.73	-1.4	-0.7	2.5	1.1	1.8	
2	Phragmites	australis	2.2	3.3	2.73	-0.5	0.6	2.5	2.0	3.1	
3	Typha	angustifolia	2.7	3.3	2.73	0.0	0.6	2.5	2.5	3.1	
4	Scirpus	robustus	2.8	3.3	2.73	0.1	0.6	2.5	2.6	3.1	
5	Spartina	patens	2.7	3.6	2.73	0.0	0.9	2.5	2.5	3.4	
6	Distichlis	spicata	2.7	3.6	2.73	0.0	0.9	2.5	2.5	3.4	

ATTACHMENT D

New York State Sea Level Rise Projections for New York City/Lower Hudson



Attachment D. Sea Level Rise Projection for the New York City/Lower Hudson Region. Table from 6 NYCRR Part 490.4 (b)

Time Interval	Projections (inches)				
	Low	Low-Medium	Medium	High-Medium	High
2020's	2	4	6	8	10
2050's	8	11	16	21	30
2080's	13	18	29	39	58
2100	15	22	36	50	75

APPENDIX D

Technology Screening Decision Document for Compensatory Wetland
Separation and Protection (Arcadis, August 2020)



MEMO

To:
Paul Johnson,
Remediation Management (RM)

Copies:
L. Littrell, RM
D. Tsao, RM
M. Gopal, Sovereign
M. Gravelding, Arcadis

Arcadis of New York, Inc.
One Lincoln Center
110 West Fayette Street
Suite 300
Syracuse
New York 13202
Tel 315 446 9120
Fax 315 449 0017

From:
Lance Ketcham,
Raymond Kapp,
Arcadis of New York, Inc.

Date:
August 20, 2020

Arcadis Project No.:
30056299

Subject:

DRAFT & CONFIDENTIAL – For Discussion

Technology Screening Decision Document for Compensatory Wetland
Separation and Protection
Harbor at Hastings Site, NYSDEC Site# 3-60-022
Hastings-on-Hudson, New York

INTRODUCTION

This memorandum provides a Technology Screening Decision Document (TTSD) for the separation layer that New York State Department of Environmental Conservation (NYSDEC) has required to address residual contaminants expected to remain in the historic fill beneath and within the vicinity of the 1.34-acre compensatory wetland to be constructed within the Site. The TTSD summarizes the results of Arcadis' assessment of potential design options for the separation layer based on stated remedial objectives and decision criteria.

BACKGROUND AND OBJECTIVES

The governing documents for remediation of the Site require the design and installation of a separation layer between historic fill and the final wetland elevation of the Site following completion of the remedy. For the compensatory wetland to be constructed on historic fill remaining after remedial excavation, NYSDEC has indicated that a 2-foot minimum separation is required between the historic fill containing

residual PCBs and the created marsh habitat layer (organic rich sediment platform for intertidal plantings and a substrate for the intertidal environment). Removal of PCB-contaminated fill from this area of the site will be limited to depths of 9-12 feet beneath the existing ground surface, leaving residual PCBs in the subsurface in accordance with the OU1 and OU2 Records of Decision (NYSDEC 2012a and 2012b). Several figures are attached that show the available environmental data and the proposed work in the wetland. **Figures 1 and 2** plot the available data regarding soil and groundwater PCB concentrations to be left in place beneath the wetland. **Figure 1** displays the PCB concentrations at or beneath the excavation termination depths within the planned marsh footprint and vicinity. **Figure 2** displays total PCB concentrations in groundwater monitoring wells along with the corresponding depths of the screened intervals. A plan view of excavation depths from the surface is presented in **Figure 3**. A cross section showing excavation depths relative to the planned separation layer and planned marsh elevations is presented in **Figure 4**. The base (bottom) of the separation layer is generally at the depth of planned remedial excavation (-4 ft EL), except for a few required deeper excavations that will be backfilled to this common base elevation before adding the uniform separation layer.

The objectives of the wetland separation layer, which is below the water table elevation, are to provide:

- The NYSDEC-required 2-foot minimum separation between the wetland habitat and the contaminated historic fill.
- Mitigate potential contamination of the habitat layer by PCBs via the groundwater pathway from the contaminated historic fill.

The objective of this TSDD is to evaluate design options for the separation layer based on the following criteria:

- Social, including:
 - Safety risk to workers during construction
 - Safety risk to public during construction (associated with relative time to construct this component of the remedy)
 - Acceptability to regulators and stakeholders (anticipated)
 - Implementability (constructability)
- Environmental, including:
 - Effectiveness in meeting remedial objectives
 - Time to Complete (considers energy usage, using applicable construction equipment)
 - Short and long-term integrity (reliability)
- Cost, including:
 - Capital Costs for the separation layer and habitat substrate
 - Long-term inspection and monitoring costs for the separation layer and habitat substrate

DESIGN OPTIONS

This TSDD considers the following separation layer options, all of which include the NYSDEC-required 2-foot separation between the wetland and underlying historic fill:

- High density polyethylene (HDPE) liner – impermeable membrane to isolate the wetland from the groundwater pathway.
- Geosynthetic clay liner (GCL) – low permeability (5×10^{-9} cm/sec (typ.)) hydraulic seal to minimize groundwater flow into the wetland.
- Granular activated carbon (GAC) amended sand filter - in-situ attenuation of PCBs and other organic compounds from the groundwater pathway to the wetland.
- Reactive core mat (RCM) and GAC amended sand filter – enhanced attenuation of PCBs and other organic compounds, with RCM added to capture potential non-aqueous phase, if any, in the groundwater pathway to the wetland.
- AquaBlok® Products. - bentonite-based sealing material used in saturated settings (below groundwater table and under surface waters) that can be placed through the water column to the bottom of the remedial excavations to form a low-permeability ($\sim 5 \times 10^{-8}$ cm/sec (typ.)) separation layer.
- Geotextile and sand filter - baseline separation option, allowing groundwater flow into the wetland without any mitigation of potential contaminant transport.

Arcadis also evaluated the ecoSPEARS technology and determined that there was no application for use as a separation option and eliminated the technology from the TSDD analysis.

KEY ASSUMPTIONS

Assumptions for the TSDD include:

- All options are assumed to be placed between an elevation of approximately -2.0 ft and -4.0 feet NAVD88, concurrent with the “NYSDEC-required 2-foot thick separation layer as indicated on Cross Section B-B’ (Figure 4).
- All costs are engineering estimates, based on the assumptions stated in the TSDD.
- Monitoring costs are based on a 30-year performance evaluation period, for the purpose of this evaluation and include labor, materials, and lab analysis where sampling is indicated. Arcadis assumed that annual post-construction monitoring will provide data to support a lower frequency of subsequent monitoring. For this analysis, annual monitoring would be reduced to 5-year intervals after the first 5 years of annual data are evaluated. For the baseline option, Arcadis assumed no monitoring requirements, consistent with the minimum action concept.
- Future repair costs in response to severe erosion events cannot be accurately predicted and are not included in the cost estimates. However, erosion of the underlying separation layer due to ice flow, wave action or flooding is an unlikely scenario because the separation layer will lie beneath a 3-foot thick habitat layer protected by a river-side wave barrier and a two-way inlet/outlet structure.
- All separation layer options are permanent passive remedies that do not rely on any operating systems or media replenishment.
- The HDPE option is a high-performance geomembrane widely used for solid waste containment (such as landfill liners), mining, and water containment applications. The permeability of HDPE is known to be the lowest among all polymers used in geomembrane applications. Advantages also include resistance to chemicals and environmental degradation.

- The GCL option is a layer of bentonite clay between two geosynthetic layers. GCLs have a total thickness of less than one inch and provide better hydraulic performance than several feet of compacted clay. A fully hydrated GCL typically has a permeability of $\sim 5 \times 10^{-9}$ cm/sec.
- The GAC Option is a layer of sand blended with GAC. The amount of GAC required for a hypothetical 100-year design life for treatment is based on a groundwater total PCB concentration of 1.4 ug/l, a seepage velocity of 0.02 feet per day, and the USEPA ambient water quality criterion of 0.03 ug/l total PCBs for marine waters as the compliance criterion in the habitat porewater above the GAC-amended sand layer. If NYSDEC requires compliance with New York State Class SB (saline) surface water standards for total PCBs (1.2×10^{-4} ug/l for wildlife protection and 1×10^{-6} ug/l for health via fish consumption), it would lower the compliance criteria by 2 to 4 orders of magnitude, requiring a substantial increase in the GAC option cost. It is assumed for this evaluation that the Class SB saline standards will not be required, otherwise this would further reduce the viability of this option.
- The RCM option is combined with the GAC option. RCM is an in-situ technology suitable for retaining PCBs and other organic compounds, including LNAPL constituents, in the organoclay matrix. The RCM layer is intended to provide a physical filtering and chemically reactive layer to isolate the potential contamination from the created wetland above. In this case, the RCM would be placed beneath the GAC layer for enhanced attenuation of organic compounds and extend the life of the GAC layer. For the comparison of options, a single layer of RCM is assumed to be sufficient to sorb potentially mobile PCBs in groundwater in conjunction with a reduced amount of GAC blended in the sand layer.
- The AquaBlok option considers use of AquaBlok 2080FW, a bentonite-based sealing material designed for use in freshwater settings. It provides uniform delivery of powdered sodium bentonite directly through a water column, in saturated settings (e.g. below groundwater table), or where mechanical compaction is difficult or not possible. It will provide a low-permeability (hydraulic conductivity of $\sim 5 \times 10^{-8}$ cm/sec (typ.)) seal when hydrated. Resembling small stones, a major benefit of AquaBlok 2080FW is ease and speed of handling and installation. Alternatively, a blend containing AquaBlok 3070SW, which is a saltwater-compatible formulation of AquaBlok's bentonite-based sealing material for applications where water with salinity in the range of 12-35 parts per thousand (ppt) will hydrate the product, may be considered subject to pre-construction groundwater testing. However, the saltwater formulation has a higher hydraulic conductivity (i.e., it is more permeable) than the freshwater formulation.
- The baseline geotextile and sand filter separation layer and the wetland habitat substrate layer, with the associated cost estimates, are part of each option. See Table 1 for example layering for the separation options. Relative to the other options, which provide a barrier to contaminant entry via the groundwater pathway in addition to NYSDEC-required physical separation, the baseline option is treated as a minimum action alternative in this evaluation

TSDD SUMMARY

The TSDD screening results are presented in Table 2. The assessment scores for each option are based on a scale of zero to 4, as indicated in the Table 2 notes. The cumulative scores for each major performance criterion were weighted 33.3% social, 33.3% environmental, and 33.3% cost to calculate a final overall score. The final scores indicate relative performance value, ranging from least value for the

baseline geotextile and sand filter option, at an estimated cost of \$800,000, to the best value for the GCL option, at an estimated cost of \$975,000.

The baseline option in this analysis meets 1 of 2 remedial objectives for the separation layer. It provides separation only, without any mitigation of potential impacts to the newly created marsh from residual site contaminants via the groundwater pathway. As such, it is treated in this analysis as a no-action alternative for groundwater impact mitigation. All other options meet the remedial objective for mitigation of groundwater impact to the marsh in some form. The HDPE and the GCL options offer the most reliable and stringent levels of protection with maximum hydraulic conductivities lower than 1×10^{-7} cm/sec. The GCL barrier added to the baseline design uses a proven passive technology and is the most effective, sustainable, and economical option for the marsh.

Based on this analysis, the GCL option adds approximately \$175,000 (~22%) to the baseline cost estimate and provides the best value for long term social and environmental reliability and effectiveness in separating the marsh from historic contaminated fill, and protecting the marsh from future contamination via the groundwater pathway.

With selection of GCL for design, the specifications will allow for contractor substitution provided that the substitute is equivalent to GCL in permeability and performance. Based on our analysis, one such substitution may include a material like AquaBlok provided that the proposed product meets a maximum hydraulic conductivity of 1×10^{-7} cm/sec and fits within the 2-foot separation layer.

TABLES

Table 1. Example Separation Layer Sections

Table 2. Screening of Remedial Alternatives for Wetland Habitat Separation Layer

FIGURES

Figure 1. Potential Soil PCB Concentrations under Wetland

Figure 2. Groundwater Concentrations

Figure 3. Habitat Mitigation Plan View

Figure 4. Cross Section B-B'

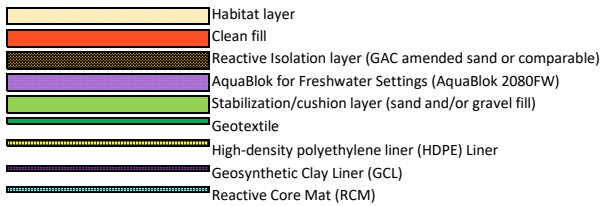
REFERENCES

NYSDEC. 2012a. Record of Decision Amendment, Harbor at Hastings, Operable Unit Number 01: Onsite Contamination, State Superfund Project, Hastings-on-Hudson, Westchester County, Site No. 360022. March.

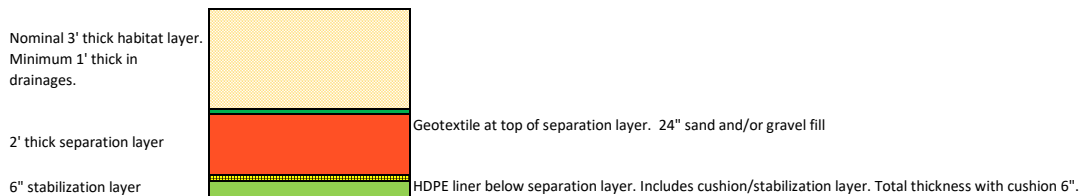
NYSDEC. 2012b. Record of Decisions, Harbor at Hastings, Operable Unit Number 02: Hudson River Sediments, State Superfund Project, Hastings-on-Hudson, Westchester County, Site No. 360022. March.

Table 1
Example Isolation Layer Sections
Harbor at Hastings Site, Hastings-on-Hudson, New York
Technology Screening Decision Document

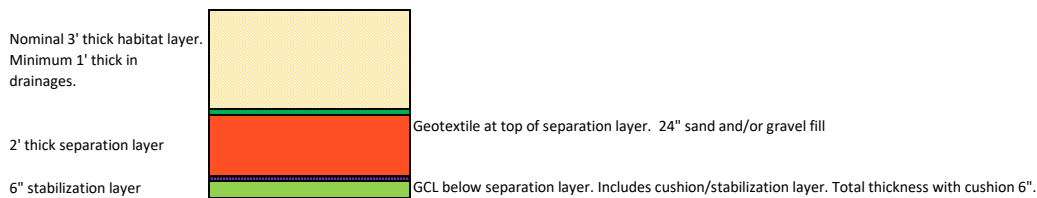
Legend:



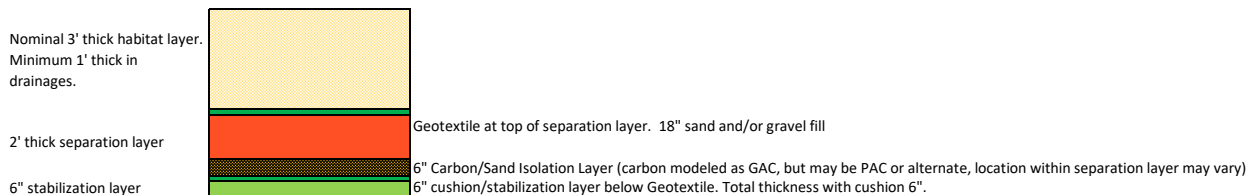
HDPE Liner



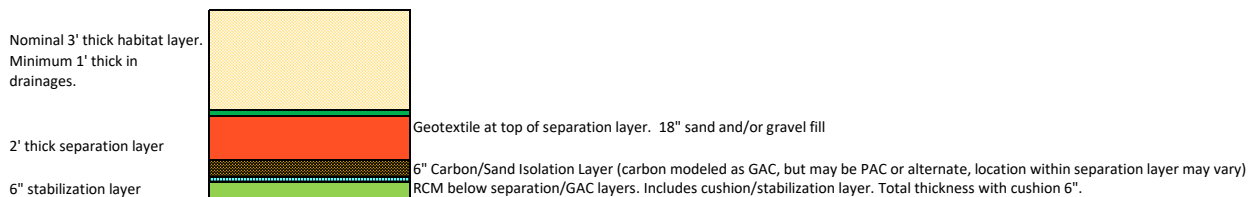
GCL Liner



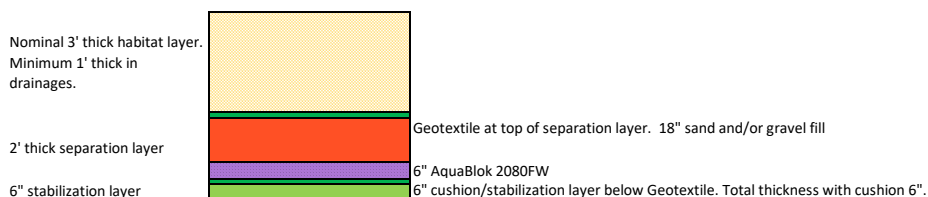
GAC (or equivalent) Amended Sand Filter Layer



RCM Plus GAC (or equivalent) Amended Sand Filter Layer



AquaBlok for Freshwater Settings



Geotextile and sand filter (baseline condition)

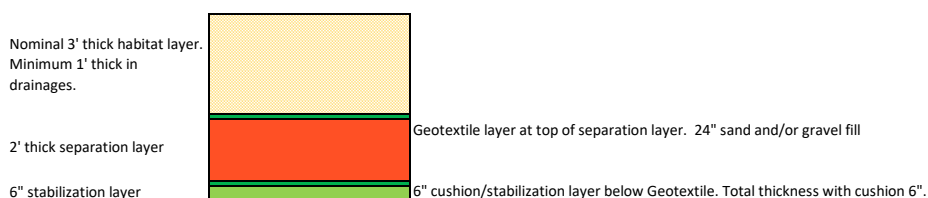















Table 2
Screening of Remedial Alternatives for Wetland Separation Layer

DRAFT FOR DISCUSSION

Harbor at Hastings Site, Hastings-on-Hudson, New York
Technology Screening Decision Document

Remedial Alternatives	Social								Environmental				
Options for Separation Layer Between New Wetland and Underlying and Adjacent Historic Fill	Construction Safety- Least Risk to Workers	Construction Safety- Least Risk to Public ⁽²⁾	NYSDEC and EPA Acceptance	Stakeholder Acceptance	Protection of Public Health, Welfare & Environment	Compliance with Applicable Laws & Regulations	Implementability	Social Score Weighting Factor 33.3%	Time Frame to Implement the Remedy & Energy Usage	Ability to Meet RAOs (<2 years)	Short-Term Effectiveness (1-6 months)	Long-Term Effectiveness	Environmental Score Weighting Factor 33.3%
HDPE Liner													
	1	2	4	4	4	4	1	6.7	1	4	4	4	4.33
GCL Liner													
	3	3	4	4	4	4	3	8.3	3	4	4	4	5.00
GAC (or equivalent) Amended Sand Filter Layer													
	3	3	2	2	2	4	3	6.3	2	4	4	2	4.00
RCM Plus GAC (or equivalent) Amended Sand Filter Layer													
	3	3	3	3	3	4	3	7.3	2	4	4	3	4.33
AquaBlok for Freshwater Settings													
	3	3	4	4	4	4	3	8.3	3	4	4	3	4.66
Geotextile and sand filter (baseline condition) ⁽¹⁾													
	3	4	1	1	1	2	4	5.3	3	1	1	0	1.67

Remedial Option Layers:

	Habitat layer		Geotextile
	Clean fill		High-density polyethylene liner (HDPE) Liner
	Reactive Isolation layer (GAC amended sand or comparable)		Geosynthetic Clay Liner (GCL)
	AquaBlok for Freshwater Settings (AquaBlok 2080 FW)		Reactive Core Mat (RCM)
	Stabilization/cushion layer (sand and/or gravel fill)		





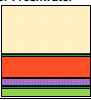

Notes:

- (1) Limited action option. Residual PCBs will remain in historic fill and may migrate into habitat porewater without prior attenuation. Represents risk of future remediation if impacts are evident.
(2) Public Safety considers relative duration to complete remedy component, to the extent that duration contributes to potential general impacts of remedial construction on the local community.

Table 2
Screening of Remedial Alternatives for Wetland Separation Layer

Harbor at Hastings Site, Hastings-on-Hudson, New York
Technology Screening Decision Document

DRAFT FOR DISCUSSION

Remedial Alternatives	Economic								Overall Assessment	Comments	
	Material Cost for This Wetland	Installation Cost for This Wetland	Total Capital Costs (Materials Plus Installation)	Performance Monitoring (OMM) and Associated Costs 30 Years	Total 30 Year OMM Cost (NPV)	Total Capital Cost Plus 30-Yr. OMM (NPV)	Costs Scoring	Cost Score Weighting Factor 33.3%	Total Weighted Scoring Results	Installation Challenges and Conditions	Long Term Integrity
Options for Separation Layer Between New Wetland and Underlying and Adjacent Historic Fill 	\$ 740,000	\$ 1,090,000	\$ 1,830,000	Baseline plus annual inspection first 5 yrs., then inspections every 5 years until year 30. No sampling.	\$ 145,000	\$ 1,975,000	0	0.00	11.0	Extremely challenging to install. Area too large for a single membrane without seams. Requires dry compacted surface for liner installation, seam welding, and testing. Circumferential dewatering and wastewater treatment is required. Workers must work inside a protected 9-foot deep excavation.	Excellent, provided that the liner is properly installed and tested for integrity prior to completion of the separation layer and habitat layer.
GCL Liner 	\$ 620,000	\$ 240,000	\$ 860,000	Baseline plus annual inspection first 5 yrs., then inspections every 5 years until year 30. No sampling.	\$ 145,000	\$ 1,005,000	3	1.00	14.3	Can be installed without complete dewatering. Self-sealing material with bulk bentonite in seams. No additional geotextile needed as the geotextiles in the GCL replaces one of the geotextile layers in the baseline condition.	Excellent. Self-sealing material that remains flexible. Benefit of low permeability of clay (~5x10 ⁻⁸ cm/sec (typ.)) and protection of dual sided geotextile.
GAC (or equivalent) Amended Sand Filter Layer 	\$ 750,000	\$ 260,000	\$ 1,010,000	Baseline plus annual inspection and porewater sampling first 5 yrs., then inspections and sampling every 5 years concluding in year 30.	\$ 520,000	\$ 1,530,000	1	0.33	10.7	Requires well mixed media and complete coverage verification. Can be installed without dewatering. Additional cost of placement is restricted to mixing with existing backfill, because fill placement is already accounted for in base cost. Requires additional GW investigation for cost-effective design.	Good. Will attenuate PCBs. Uncertainty of existing conditions and variability is a design limitation which increases potential for breakthrough. If NAPL is present or higher than anticipated flow rates, may consume GAC early. There is a potential for fouling and isolated breakthrough.
RCM Plus GAC (or equivalent) Amended Sand Filter Layer 	\$ 880,000	\$ 300,000	\$ 1,180,000	Baseline plus annual inspection and porewater sampling first 5 yrs., then inspections and sampling every 5 years concluding in year 30.	\$ 520,000	\$ 1,700,000	0	0.00	11.7	Requires a base RCM which replaces one of the geotextile layers in the baseline condition, overlapped seams under filter media to capture and attenuate organic NAPLs. Requires well mixed GAC media and complete coverage verification, like any earthen backfill. Requires additional investigation for cost-effective design.	Excellent. Will attenuate PCBs and mitigate potential NAPL seepage. Uncertainty in existing conditions is a design limitation which increases potential for breakthrough. Greater ability to sorb NAPL than GAC alone. There is a potential for fouling and isolated breakthrough.
AquaBlok for Freshwater Settings 	\$ 840,000	\$ 220,000	\$ 1,060,000	Baseline plus annual inspection first 5 yrs., then inspections every 5 years until year 30. No sampling.	\$ 145,000	\$ 1,205,000	2	0.67	13.7	Can be installed without dewatering. Installation methods could include a stone slinger, conveyor, telebelt, or similar. Assumed 6-inch hydrated layer.	Good. Self-sealing material that remains flexible. Benefits of low permeability of clay. Expected permeability ~5X10 ⁻⁸ cm/sec (typ.).
Geotextile and sand filter (baseline condition) (1) 	\$ 590,000	\$ 210,000	\$ 800,000	No post-construction monitoring or inspection included for this option.	\$ -	\$ 800,000	4	1.33	8.3	Baseline physical barrier to historic fill is required to separate the habitat layer from remaining historic fill. No additional costs included for this option because it is baseline condition.	Fair. Provides the required 2 feet of separation from historic fill, but little additional protection from contaminant migration into the wetland.

Notes:

RAO = remedial action objective

Technical and Safety Ranking: 0 = lowest rating/undesirable

4 = highest rating/most desirable

Total capital costs plus monitoring rounded to nearest \$10,000

Cost Ranking -% Higher than Baseline Option Cost:

≤ 20%	\$ 960,000.00	4
≤ 40%	\$ 1,120,000.00	3
≤ 60%	\$ 1,280,000.00	2
≤ 80%	\$ 1,440,000.00	1
≤ 250%	\$ 2,000,000.00	0

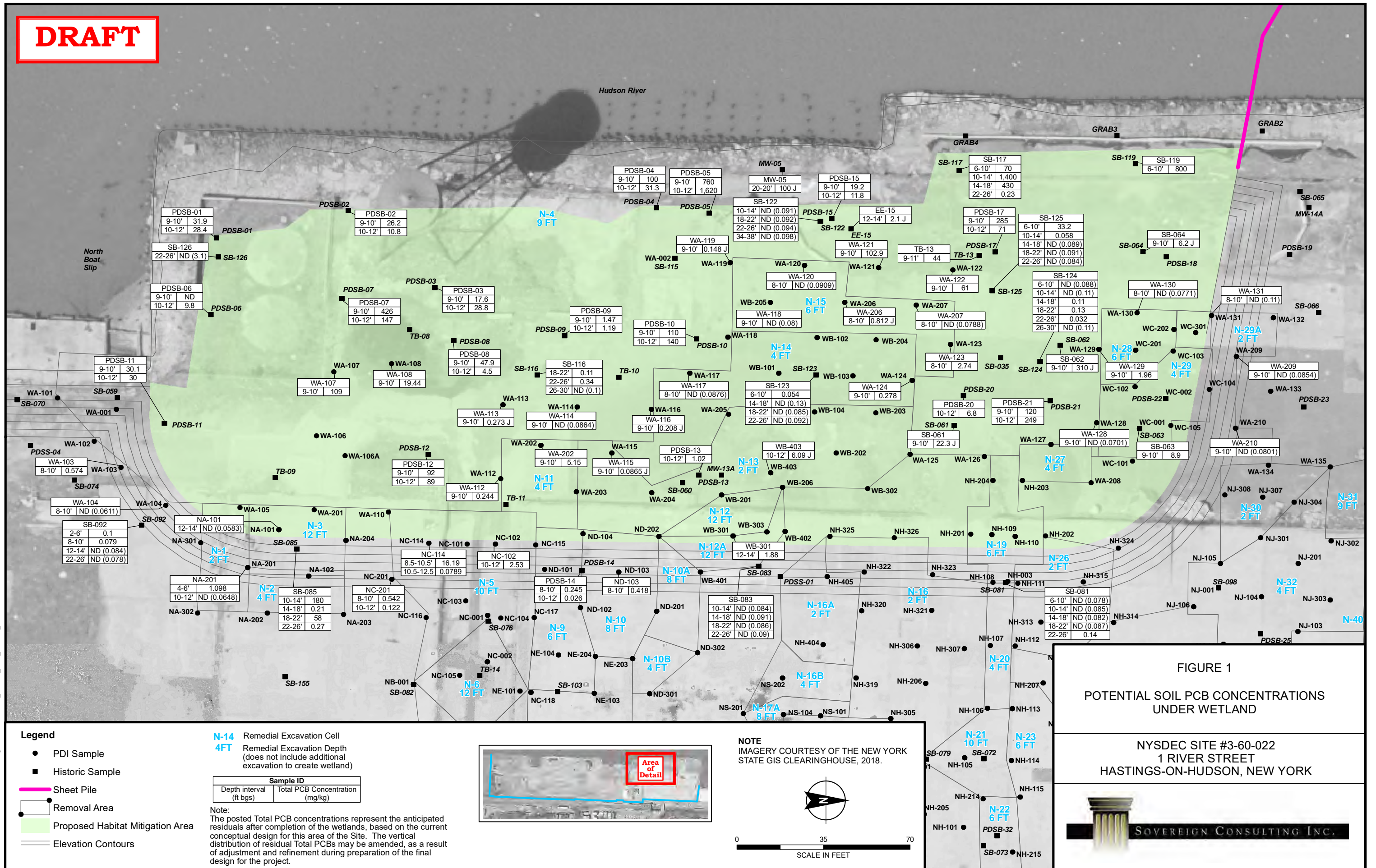
High level of protection

High level protection may diminish over time

Adequate separation, but may not prevent contamination of wetland from groundwater pathway

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MW-05 (4-20')		
8/5/2014	0.826	
9/16/2015	0.574	
9/28/2016	3.126	
9/28/2016 (DUP)	2.7	

PDMW-03 (29-39')		
10/28/2005 ND (0.51)		
4/16/2008 ND (0.17)		

PDMW-01 (49-59')		
10/28/2005	1.2	
2/20/2008 ND (0.17)		

MW-03A (5-15')		
10/24/2005 ND (0.52)		

MW-09 (4-20')		
8/4/2014	0.241	
9/15/2015	0.177	
9/27/2016	0.527	

PDMW-20S (4-14')		
8/4/2014	ND (0.05)	
9/15/2015	ND (0.01)	
9/27/2016	ND (0.01)	

PDMW-19S (unk)		
4/14/2006	0.52 J	
8/4/2014	0.979	

PDMW-27S (4-14')		
12/2/2014	0.065	
9/23/2015	0.079 J	
9/23/2015 (DUP)	0.056	
9/26/2016	0.2338	
11/28/2017	ND (0.1)	
9/20/2018	ND (0.1)	
9/16/2019	ND (0.095)	
9/16/2019 (DUP)	ND (0.096)	

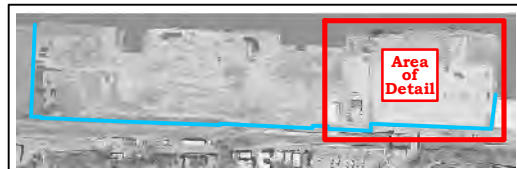
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Legend

- Monitoring Well
- PDI Sample
- Historic Sample
- Sheet Pile
- Proposed Habitat Mitigation Area

Monitoring Well ID	(Screened Interval (ft bgs) or Unknown)
Date	Total PCB Concentration (µg/L)

Orange shading indicates baseline monitoring well (PDMW-19S and PDMW-27S remain, others abandoned 2016) PDMW-27S screened interval assumed equal to that of PDMW-20S, which it replaced



NOTE
IMAGERY COURTESY OF
THE NEW YORK STATE GIS
CLEARINGHOUSE, 2018.



0 80
SCALE IN FEET

FIGURE 2

GROUNDWATER CONCENTRATIONS

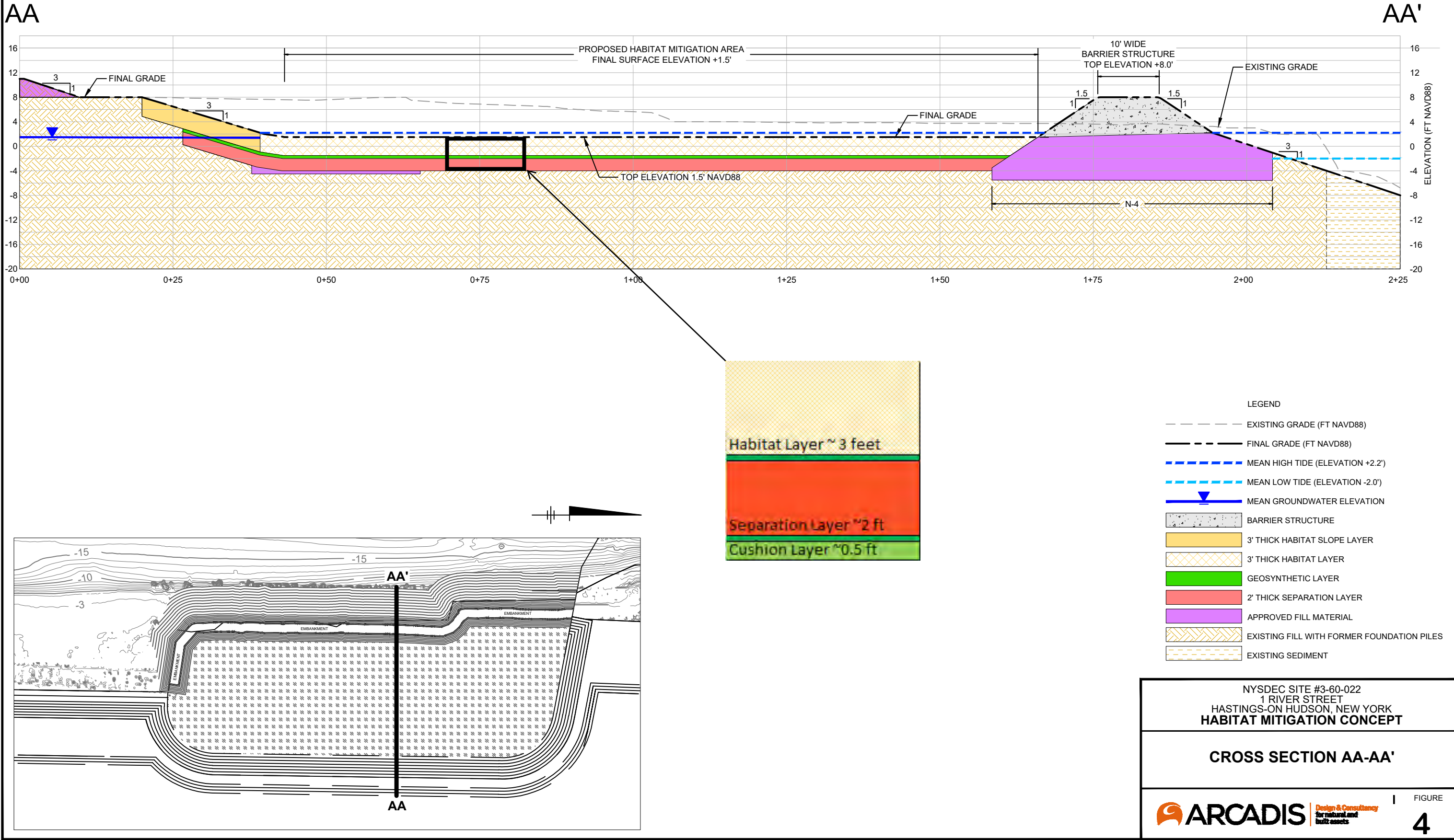
NYSDEC SITE #3-60-022
1 RIVER STREET
HASTINGS-ON-HUDSON, NEW YORK



SOVEREIGN CONSULTING INC.



CITY: IRVINE DIV/GROUP-ENVCAD DB:ENVCAD
C:\Users\Oday\OneDrive - ARCADIS\BP Hastings\Habitat Mitigation\New Drawings\A-A' v20190918\Hastings cross section updates\AA-AA' WITHOUT EXCAVATION BND-NEW.dwg LAYOUT: AA-AA' SAVED: 9/20/2019 11:59 AM ELEVATION (FT NAVD88) TABLE: --- PLOTTED: 9/20/2019 12:44 PM BY: DAY, ORAN



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