Tibbetts Brook Wetland Restoration: Conceptual Plan

The City of New York Department of Parks & Recreation

Van Cortlandt Park, the Bronx, New York
June 14, 2018

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Tibbetts Wetland lies within the southwest corner of Van Cortlandt Park, the Bronx's largest park and the location of the borough's largest freshwater lake. Tibbetts Wetland was historically the floodplain for Tibbetts Brook, which drains a 2,508-acre watershed.

Today, Tibbetts Brook is diverted away from Tibbetts Wetland via a piped connection from Van Cortlandt Lake to the Broadway sewer. Hydrologic modifications like this have significantly changed the landscape within the Park and water quality downstream in the Harlem River.

The Tibbetts Brook Wetland Restoration: Conceptual Plan recreates the connection between the Lake and Tibbetts Wetland, and restores hydrologic and ecological values within this area of Van Cortlandt Park. NYC Parks, together with a team of engineers, water resources planners, ecologists, and landscape architects from HDR, Biohabitats, and dlandstudio, identified the baseline data available for 30% design and also the data limitations that need to be addressed to complete design.

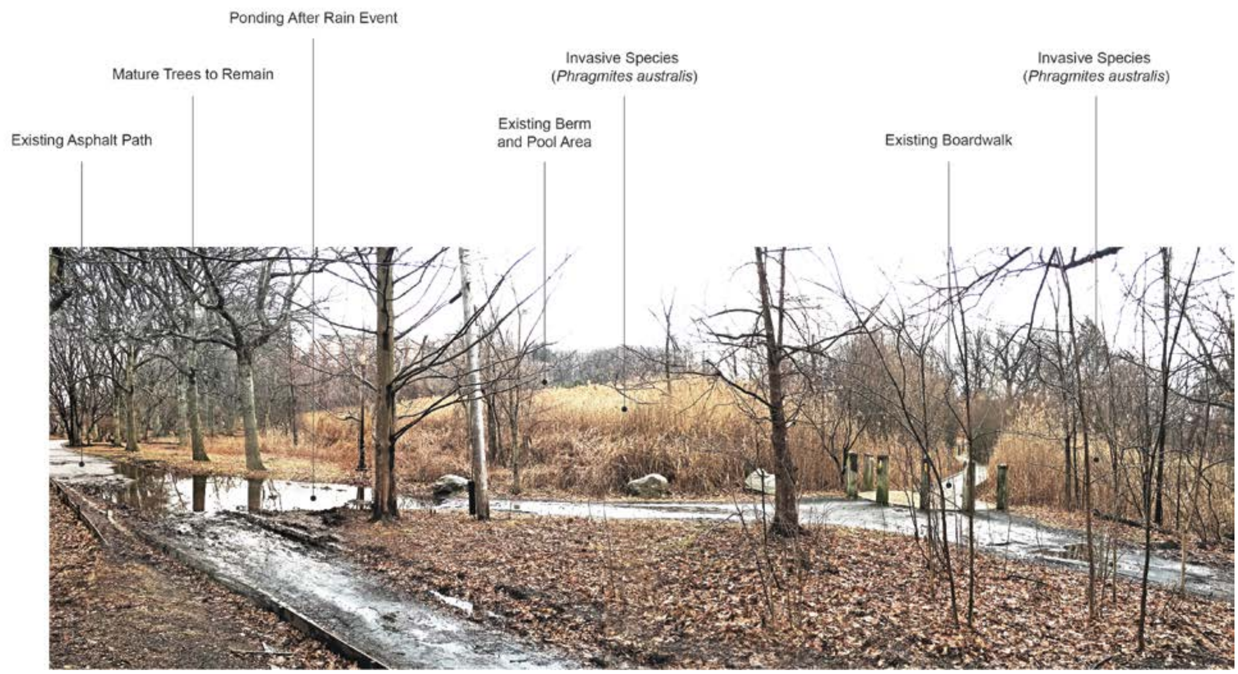
The proposed 30% design consists of a meandering stream, open water ponds, and diverse freshwater wetland zones to temporarily detain water, filter sediments and pollutants, enhance biodiversity, and reduce the potential for invasive plant species dominance. The 30% design includes innovative nature-based and engineering techniques such as a sand seepage berm, multiple flow control structures, and a spillway that combines "hard" and "soft" engineering for an aesthetic and functional design.

The 30% design also includes improved pedestrian connections and environmental experiences for park users. Several design features were directly influenced by the community engagement process, and key stakeholders expressed support for the conceptual plan as a first step toward a longer term vision to restore Tibbetts Brook. The conceptual plan will help NYC Parks to advance planning for a future connection to the Harlem River from Tibbetts Brook. Without this future connection, the potential for significant combined sewer overflow reductions in the Harlem River is limited.

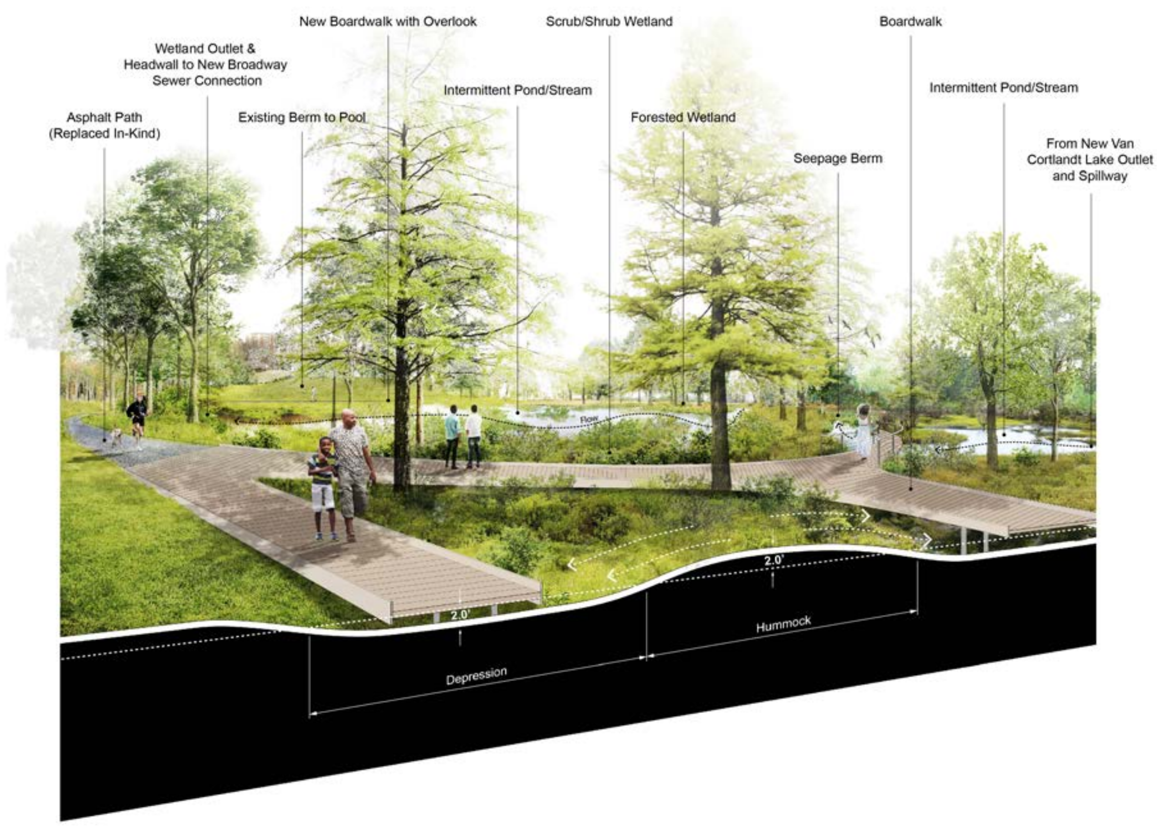
The development of the Tibbetts Brook Wetland Restoration: Conceptual Plan including 30% design drawings and details and this Design Report was made possible with grant funding from the United States Department of the Interior and the National Fish and Wildlife Foundation. Future funding is needed to complete the additional data collection and analyses identified during 30% design and to advance final design. Assessments of stormwater drainage infrastructure, groundwater, and wetland and lake water levels are just a few examples of the data needs described in this Design Report.

While several unknowns exist at the time of writing this Design Report, the illustrative rendering that follows provides a clear indication of what is possible at Tibbetts Wetland, and the myriad of benefits anticipated with the future implementation of the Tibbetts Brook Wetland Restoration: Conceptual Plan.

Tibbetts Wetland Restoration: Concept Plan



Northeast view from the Putnam Greenway overpass, before.



Rendered northeast view from the Putnam Greenway overpass, after.

1 Introduction

1.1 Project Scope

The New York City Department of Parks and Recreation (NYC Parks) initiated the Tibbetts Brook Wetland Restoration: Conceptual Plan (Project) as an innovative effort to correct a historic drainage approach and restore the hydrologic and ecological value of Tibbetts Wetland in Van Cortlandt Park (Park). Funding for the Project was provided by a grant from the United States Department of the Interior and the National Fish and Wildlife Foundation (NFWF).

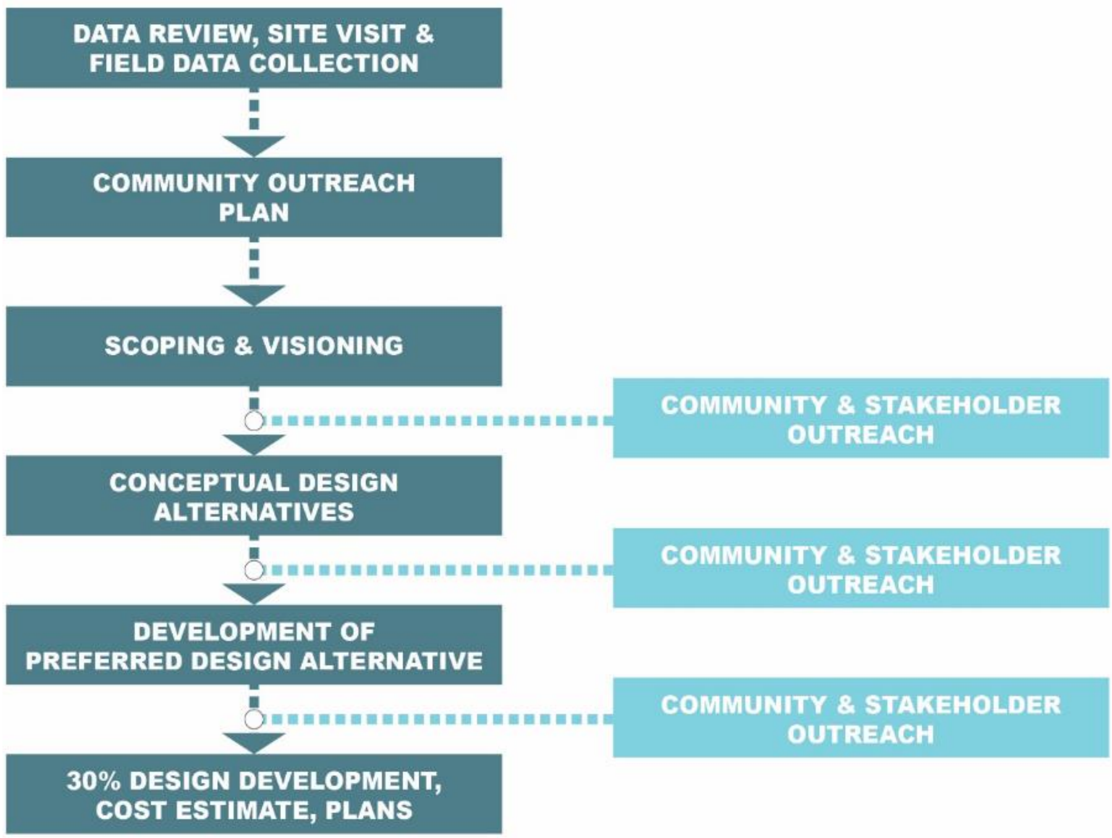
The Project will restore the hydrologic functions of the Tibbetts Wetland including evapotranspiration and filtration, and remove a small volume of stormwater from the combined storm sewer system by providing limited detention during wet weather. The Project will also improve ecological functions by recreating diverse habitats within the southwestern areas of the Park, and enhance open space and environmental experiences for park users.

> Stream daylighting is a general term that is used to describe the re-establishment of surface flow from flow that has been piped. Daylighting techniques can range from the establishment of a distinct single thread channel to a more diffuse or braided wetland system to a combination of both or a combination that also employs piping flow where needed. Reestablishing a connection of Tibbetts Brook to Tibbetts Wetland and eventually the Harlem River in phases would have qualitative and quantitative benefits with respect to regional resiliency and water quality; use of the Park for recreational, social and cultural spaces; and intrinsic ecological values to the community.

The design intent of the Project is to also integrate the wetland restoration with a potential hydrologic connection from Van Cortlandt Lake (Lake) to the Harlem River. Future planning and design will evaluate stream daylighting techniques and alignments for connecting the Tibbetts Brook Wetland Restoration inside the Park to a combination of piped and surface flow along the historic Putnam Rail Line to the Harlem River. A future connection to the Harlem River would remove base flow from Tibbetts Brook that currently flows into the combined sewer system to the Wards Island Wastewater Treatment Plant (WWTP) and contributes to combined sewer overflows (CSOs) in the Harlem River.

The scope of work for the Project included data gathering and site characterization, identification of design requirements and inputs, community outreach, development and review of conceptual design alternatives, and selection of a preferred alternative. Figure 1 illustrates the activities conducted by the Project Team, comprised of HDR, Biohabitats, and dlandstudio, to develop the Project.

Figure 1. **Conceptual Plan Development**



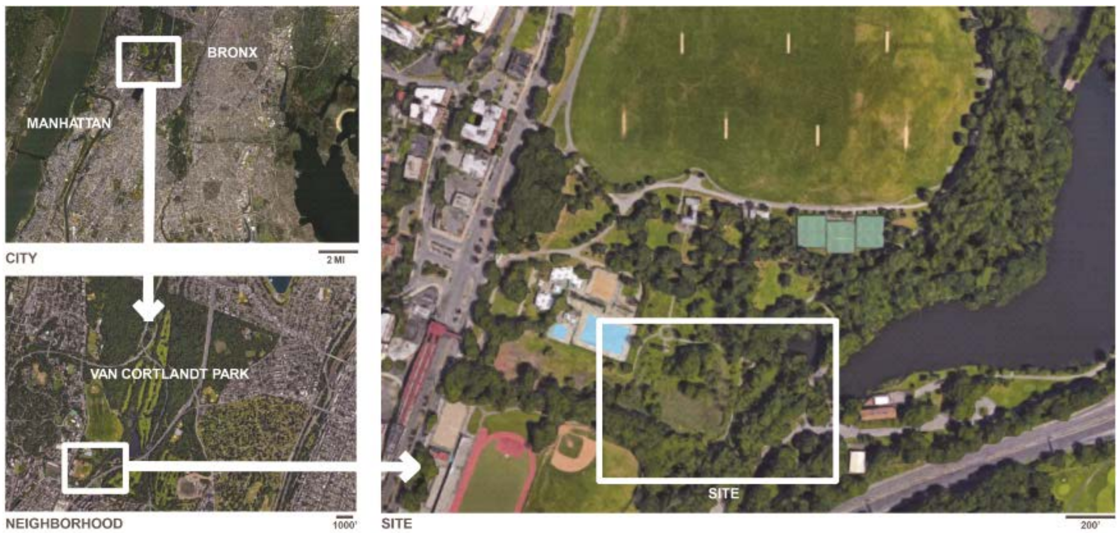
For the preferred alternative, 30% design drawings including renderings, plans, details, costs, and storage volume calculations were developed (see Appendices A–C). Throughout the Project, an Issues Log was updated to advance design requirements and inputs, and to identify data needs and next steps following the Project (see Appendix D).

This Design Report is intended to be comprehensive documentation for the development of the Project, including 30% design. As such, this Design Report describes the decision making surrounding the selection of the preferred design alternative, goals and objectives for the selected alternative, and key design features consistent with the scope of the Project.

1.2 Project Location

The Project is located within the 1,146-acre Park in the Borough of the Bronx, New York, as shown in Figure 2. The existing Tibbetts Wetland is six acres in size and is located southwest of the Lake.

Figure 2. Project Location



Tibbetts Brook was historically a tributary to the Harlem River. Today, Tibbetts Brook extends one mile within the Park from the border of the Bronx and Westchester County, and discharges into the Lake. Flow from the Lake is then piped underground before connecting to a sewer that runs under Broadway to the west of the Park.

The Park is situated in the middle of Community Boards 7, 8, and 12, and provides diverse opportunities for recreation and appreciation of natural areas including freshwater lakes and ponds, oak forests, and wetlands. While the Park is a tremendous natural resource in an urban environment, it is distressed by a number of ecological issues surrounding the Project site (Figure 3), including large stands of *Phragmites australis* and water quality issues due to eutrophication in the 13-acre Lake.

Figure 3. **Project Site**

1.3 Conceptual Planning Approach: Process and Findings

1.3.1 Data Gathering, Organization, and Review

The Project Team compiled existing datasets and literature along with field data collected by NYC Parks during the Project to document site characterization information, describe design inputs and requirements, create conceptual design alternatives, and develop 30% design documents for the preferred alternative. Data were filed in a centralized Reference Library on a Sharepoint File Transfer Site established for the Project.

Source information is referenced throughout this Design Report and is listed in Section 8. For the objectives of the Project, existing hydrologic and topographic data were considered adequate to develop a range of flow diversions and conceptual design alternatives to divert flows from the Lake to the Tibbetts Wetland.

Site visits conducted by the Project Team on September 19, 2016, and March 30, 2017, also supplemented the data used. Data gaps were identified throughout the Project as part of an ongoing Issues Log shared between the Project Team and NYC Parks. Data gaps that could not be filled during the Project are described in detail in Section 3.5.3.

1.3.2 Agency Input, Review, and Coordination

NYC Parks directed the work of the Project Team for the Project. NYC Parks also coordinated internal reviews of key project deliverables in accordance with the Agency's typical design process for Capital projects.. Review comments were then implemented by the Project Team before key deliverables were finalized.

The Project Team also attended key review meetings with NYC Parks to present additional information for the different conceptual design alternatives developed and also to review the preferred alternative with the Parks Without Borders program staff in advance of starting the 30% design. Parks Without Borders is an NYC Parks initiative to make public parks more open, welcoming, and beautiful by focusing on improving entrances, edges, and park-adjacent space.

Throughout the Project, NYC Parks also met with the New York City Department of Environmental Protection (NYCDEP) to share information about the design intent, status, and also to provide information about the anticipated stormwater management benefits of the Project. Meetings between NYC Parks and NYCDEP are expected to continue for future phases of the Project and for the development of NYCDEP's *Long Term Control Plan for the East River and Open Waters*, which includes the Harlem River.

1.3.3 Community and Stakeholder Engagement

Part of the value of the community outreach process was to test the viability of ideas, the validity of information and assumptions, and to build consensus. Further, the engagement process was an opportunity to inspire the community and stakeholders to continue to be actively involved in advancing the Project through subsequent stages.

Early in the Project, the Project Team worked closely with NYC Parks to develop an effective engagement plan that built on best practices for engagement from relevant planning and design efforts occurring in the Bronx and across the City today. This plan also built on NYC Parks' presentations about the Project since executing its grant funding from NFWF and guided the Project Team's execution of community outreach activities.

The Project Team relied upon a series of community and stakeholder forums and meetings to better understand the constraints of our conceptual design alternatives (Table 1). Following NYC Parks and Project Team presentations of project vision, concepts, analysis, and design proposals, interactive discussions helped develop the collective knowledge of current site conditions and potential future conditions, users, and opportunities for wetland restoration. These presentations also exposed limitations in analysis, planning, or design that require attention and resolution.

Table 1. Community Outreach Activities

Workshops and Meetings	Date and Location
Van Cortlandt Park Community Council Meeting	10.11.2016 – Van Cortlandt Golf House, 115 Van Cortlandt Parkway South
Stakeholder Visioning Meeting	12.09.2016 – NYC Parks' Ranaqua Offices, 1 Bronx River Parkway
Parks Without Borders (NYC Parks Bronx Design Team)	02.01.2017 – NYC Parks' Olmsted Center, 117-2 Roosevelt Avenue
Community Workshop #1: Preferred Concept Design Review	09.19.2017 – Manhattan College School of Engineering, 3825 Corlear Avenue, Room 215
Community Board 8: Draft 30% Design Presentation	01.24.2018 – Park Gardens Rehabilitation and Nursing Center 6586 Broadway
Community Board 12: Draft 30% Design Presentation	02.06.2018 – CB12 District Offices, 4101 White Plains Road
Community Board 7: Draft 30% Design Presentation	02.14.2018 – CB7 District Offices, 229-A East 204th Street
Community Workshop #2: Draft 30% Design Review	02.26.2018 – Manhattan College School of Engineering, 3825 Corlear Avenue, Room 215

The community and stakeholder engagement plan attached in Appendix E includes overview information about the community outreach process implemented, the direct input obtained during the community workshops, and summaries of stakeholder meetings conducted for the Project. Appendix F is the presentation about the Project that was shared with the community and stakeholders.

1.3.4 Project Goals and Objectives

The primary goal of the Project is to develop a conceptual plan including 30% design drawings for a wetland restoration where Tibbetts Brook has been piped underground within the Park. Specifically, the conceptual plan was developed in accordance with the following design objectives:

- Restore wetlands: Establish and expand open water and wetland areas within the existing Tibbetts Wetland area to maximize wetland function and establish more complex, diverse habitat.
- Enhance ecological features: Increase native plant diversity and abundance and create microtopographic features throughout the wetland complex to mimic natural mound and pool features, improve site soil conditions, address invasive species, and create conditions better suited for native plants and increased biodiversity.
- Improve water quality: Provide stormwater storage to slow the flow of runoff to the City's sewer system and thereby reduce contributions to CSOs. Implement design practices to temporarily store, filter, and slow water movement through the restored wetland complex, improving water quality.

- Redesign pathways and align with other park improvements: Include a redesigned path system through hydrologic and ecological features to improve the user experience and reduce maintenance efforts.
- Integrated design: Coordinate with other on-going City programs and Park projects, and create opportunities for phased improvements, flexible programming, and additional amenities in the future.
- Plan for future connections: Create outlets from the Lake and Tibbetts Wetland that can be integrated with potential opportunities for a future sewer bypass and connection to the Harlem River.

View of historic salt marshes and elevated train line looking south from 240th Street, circa 1909. (From the photo collection of Herb Maruska, courtesy of the Friends of Van Cortlandt Park.)

1.3.5 Key Project Deliverables

On August 22, 2016, the Project Team received an Order to Work notice from NYC Parks, starting the Project schedule. In addition to the data gathering, community outreach, and agency input milestones described above, key deliverables developed for the Project are summarized in Table 2.

Table 2. Key Project Deliverables

Deliverable	Date
Community and Stakeholder Engagement Plan	October 3, 2016
Preliminary Data Review and Site Characterization (Technical Memo 1)	November 14, 2016
Design Inputs and Requirements Summary (Technical Memo 2)	November 28, 2016
Development of Two Conceptual Design Alternatives and Cost Estimates	January 31, 2017
Selection of the Preferred Alternative	September 22, 2017
Updated Engagement Plan with Documentation of Community and Stakeholder Input	March 26, 2018
30% Design and Cost Estimate	March 30, 2018
Design Report with Technical Appendix	May 21, 2018

2 Background and Context

2.1 Available Data

Reviews of baseline data provided by NYC Parks and from other available sources were used to support site characterization at project initiation. Key data reviewed and the design inputs gleaned from each are summarized below. These references and site visits (conducted by the Project Team on September 19, 2016 and March 30, 2017) were used for the development of conceptual design alternatives. A list of additional references reviewed by the Project Team is presented in Section 8.

- Friends of Van Cortlandt Park Water Quality Data – Water quality sampling plan 2015 through June 2016 and 2015 conclusions for a series of water quality tests along the Upper Tibbetts Brook reach and in the Lake.
- NYCDEP's Van Cortlandt Park Bluebelt: Basis of Design Report: Proposed Improvements to Reduce Combined Sewer Overflow Events (2012) – Evaluation of alternatives to reduce CSO discharges from the Wards Island WWTP drainage area. This report also includes stormwater flow data and analyses for base and wet weather flows, and Lake water quality characterization.
- NYCDEP Sewer Mapping Data – This data was compared to historical drainage plans to identify a potential 42-inch sewer line entering the Park and within proximity to the Project site.
- NYC Parks' Van Cortlandt Park Natural Areas Management Plan (2013) – A summary of Park historic and existing natural resources, with specific long-term restoration objectives.

- NYC Parks' US Environmental Protection Agency (EPA)-Funded Stream Assessment of Van Cortlandt Park (2016) – Tibbetts Brook cross-sectional measurements taken at multiple locations upstream of the Lake.
- NYC Parks' Tree Survey – Data compiled in 2016 provided key information about location and caliper size of trees to minimize removals during design.
- NYC Parks' Vegetation Community Survey – Maps and species lists for existing ecological communities documented in 2015; invasive species documented in each community area.
- NYC Parks' Wetlands Delineation and Mapping – Data collected in 2016 to delineate the Tibbetts Wetland including soil and vegetation species documented at two observation points. The wetland delineation used a portion of the data collected for the Putnam Greenway project.
- NYC Parks' Topographic Survey of Proposed Daylighting Locations (CAD) – Contained existing site contours, utility locations, and other features as of 2016 and sufficient for the development of alternative design concepts.
- NYC Parks' March to April 2017 Groundwater Level Dataset – Two monitoring wells with data loggers recording water level provided groundwater elevations in NAVD88. Dataset was reviewed with data collected in other locations of the Park to evaluate existing wetland hydrology.
- Natural Resources Conservation Service (NRCS) and NYC Parks' Ground Penetrating Radar and Electromagnetic Survey – Data collected in November 2017 and February 2018 to determine the location of the combined sewer line on the western edge of the Project site. While this data detected the likely presence of a subsurface pipe, the delineation and location of a combined sewer line would require additional data.

North American Vertical Datum of 1988 (NAVD88) consists of a leveling network on the North American Continent, affixed to a single origin point on the continent. (National Geodetic Survey, 2016). A vertical datum is a surface of zero elevation to which heights of various points are referred in order that those heights be in a consistent system. More broadly, a vertical datum is the entire system of the zero elevation surface and methods of determining heights relative to that surface.

2.2 Site Characterization

2.2.1 Historic Context

Formerly Mosholu Creek, Tibbetts Brook was historically a tributary to the Harlem River as illustrated in Figure 4. The Van Cortlandt family first dammed its meandering course in 1699 to power millworks. The land area surrounding Tibbetts Brook was farmed and used for growing grain, milling, and lumber operations, until 1888 when the Van Cortlandt family donated the property to New York City. A review of historic drainage maps indicates that Tibbetts Brook was piped underground sometime between 1898 and 1934 to the Broadway sewer system to allow development in the Park and beyond its borders.

Figure 4. **Historic Tibbetts Brook, 1898 (United States Geological Survey Topographic Map)**

2.2.2 Hydrology, Geomorphology and Water Quality

The Tibbetts Brook watershed encompasses 2,508 acres of land area that lies within Westchester County and the Park. Inside the Park, Tibbetts Brook extends one mile from the Bronx and Westchester County border, and connects a series of freshwater ponds and the Lake (Figure 5). Upon discharging into the Lake, water flows through the upper basin (2.5 acres) and lower basin (13.1 acres). From the lower basin, water is piped west through a 96-inch brick sewer downstream of the Lake overflow weir for approximately 1,200 feet to the Broadway sewer, which flows south to the Wards Island WWTP.

Figure 5. Present Day Hydrology (within the Park)

Tibbetts Brook's hydrology, geomorphology, and water quality are described below as three distinct but connected features: Upper Tibbetts Brook (a reference site for the Project), the Lake, and Tibbetts Wetland. Descriptions are based on available data summarized in Section 2.1 and observations from site visits conducted September 19, 2016 and March 30, 2018.

Upper Tibbetts Brook

Upstream of the Lake and within the Park, Tibbetts Brook sits within a broad, gently sloping (less than two percent) glacial outwash valley. The watershed can be characterized as urban, with many constructed features (e.g., roads, highways, off ramps, public parking areas, public trails, and golf courses) confining the floodplain and controlling the geomorphology and hydrology of Tibbetts Brook within the Park. Several impoundments, collectively referenced as the Henry Hudson Lagoons, exist along Upper Tibbetts Brook in the northern areas of the Park. Two of these impoundments (Elm and Birch Ponds) were identified as potential additional water storage areas as part NYCDEP's *Van Cortlandt Park Bluebelt: Basis of Design Report (2012)*. By removing sediment that has filled these ponds and restoring these large wetland systems, NYCDEP estimated that 39 acre-feet of storage could be created.

Where constructed features are located near Tibbetts Brook, the valley and floodplain are confined with some natural and artificial terracing. Additionally, multiple culverts were observed in the Upper Tibbetts Brook reach as it flows into the golf course. These culverts also serve as points of constriction that alter the hydrology and sediment transport of the reach, especially during flood flows. Where no channel incisions or embankments were observed, the Upper Tibbetts Brook reach appears to be well connected to the active floodplain.

At the Upper Tibbetts Brook reach, Tibbetts Brook was observed to be a single thread, meandering channel with a 25 to 30-foot width at the effective discharge (i.e., bankfull) elevation (Photo 1 in Appendix G). The effective discharge elevation was visually observed in the field as occurring at the break in slope between the top of the bank and connection to the flat active floodplain. The approximate mean depth of the effective discharge was visually estimated between 2.5 and 3 feet with an estimated cross sectional area between 60 and 90 square feet. Where Tibbetts Brook is connected to the active floodplain, the flood-prone area was visually estimated at a minimum width of 75 to 200 feet.

Water levels at the time of the September 19, 2016 site visit were likely elevated due to active precipitation, and the water was turbid. It was not possible to observe the low-flow channel of the active streambed. The streambed is assumed to be dominated by silt and sand, with some areas of organic matter and leaf litter that may have collected behind large woody debris, similar to other reaches assessed in the watershed (NYC Parks, 2016).

The downstream end of the Upper Tibbetts Brook reach experiences backwater from the Lake, and this area is likely experiencing aggradation of sediment during discharge events. Visual observation of the water surface slope indicates a relatively flat slope less than 0.01 (foot/foot). The banks of Tibbetts Brook appear to be stable, and no evidence of active streambank erosion was observed. Large woody debris was observed in Tibbetts Brook and in the adjacent floodplain, which adds to channel roughness and habitat complexity (Photo 2 in Appendix G).

Van Cortlandt Lake

The Upper Tibbetts Brook reach flows south into a large wetland complex at the north end of the freshwater Lake. The north end of the Lake appears to be an active depositional zone for sediment, with fringe wetlands dominated by *Phragmites australis* encroaching upon open water habitat. A bridge carrying the Putnam Greenway over the Lake crosses at the north end, with a second bridge carrying the Putnam Greenway over the Lake at the south end near the Lake overflow weir. Similar to the Upper Tibbetts Brook reach, the Lake valley is broad and gently sloping. The Lake, which is approximately 13 acres in surface area, is formed by a constructed impoundment at the location of the historic Van Cortlandt mill dam at the south end of the Lake.

Growth of filamentous green algae and duckweed was observed to be covering the majority of the Lake surface (Photo 3 in Appendix G), suggesting a eutrophic condition likely driven by the deposition of sediment and excess nutrients from stormwater discharge to the Lake from the surrounding watershed. The Friends of Van Cortlandt Park published a report in 2016 that summarized water quality data collection and results for the year. The report documents the overabundance of phosphorous within the Park's waterbodies and continued issues with eutrophication. Monitoring data also included results related to nitrate, dissolved oxygen, pH, conductivity, fecal coliform, and temperature, as well as information on invertebrates and community ecology. The Friends of Van Cortlandt Park's water quality collection efforts are on-going.

Tibbetts Wetland

The area southwest of the Lake and west of the Putnam Greenway is an existing depressional forested, scrub-shrub, and emergent wetland area. The existing Tibbetts Wetland area gradually slopes upward to the surrounding uplands except for the eastern side, which slopes steeply along the Putnam Greenway, and the western side, which slopes steeply near the public swimming pool (see Appendix H).

The area southwest of the Lake and east of the Putnam Greenway is a generally flat developed area consisting of walkways, parking areas, and catch basins. A bridge on the Putnam Greenway with a walkway overpass heads west to the Tibbetts Wetland area and further to Broadway. Additional infrastructure and utilities located on the eastern side of the Putnam Greenway were considered for alternatives development and the siting of the Lake outlet.

The hydrology of the existing Tibbetts Wetland area appears to be supported by seepage from the historic mill dam at the south end of the Lake, and through stormwater runoff from the surrounding drainage area (Photo 4 in Appendix G). Some groundwater discharge may be present within the wetland, although further field investigation would be required to document the presence of this source of hydrology. Areas of standing surface water were observed during the September 19, 2016 site visit, indicating existing soil compaction and poor drainage of stormwater runoff (Photos 5 and 6 in Appendix G).

2.2.3 Ecological Communities

The Upper Tibbetts Brook reach drains through a predominantly forested riparian area with some short sections of shrub and grassy areas where it passes near golf course fairways. Where it runs between two golf course fairways, the active floodplain of Tibbetts Brook is comprised of forested deciduous riparian wetlands and uplands with some areas exhibiting microtopographic (hummocks and depressions) features that add to habitat complexity. The riparian wetlands are likely to provide multiple functions—including groundwater recharge; flood storage; sediment and pathogen retention; and nutrient removal, retention, transformation.

Micro pools within the floodplain wetlands were dry at the time of the September 19, 2016 site visit, but are likely ephemeral and provide a wildlife habitat function during the early summer. In the understory of the riparian zone, areas of shrub and emergent communities exist, which also appear to be providing an additional function of bank stabilization (Photos 1, 7, and 8 in Appendix G).

The Lake shoreline is predominantly forested with mature deciduous species. Some areas at the north end of the Lake are dominated by emergent wetland vegetation. On the eastern side of the Lake, emergent wetlands, shrub, and grass-dominated communities appear near the golf course.

The Tibbetts Wetland is a mix of emergent, scrub-shrub, and forested areas dominated by both native and invasive species (Photos 9 and 10 in Appendix G; see also Appendix H). A large stand of invasive *Phragmites australis* dominates the interior portion of the Tibbetts Wetland area with little evidence of native species diversity aside from along path edges. The canopy layer that exists appears to be dominated by more native species (see Section 3.2.3 for additional information). Tibbetts Wetland likely provides multiple ecological functions including sediment and pathogen retention; nutrient removal, retention, and transformation; and wildlife habitat.

2.2.4 Parallel Park Programs, Access and Uses

Public access in the Upper Tibbetts Brook reach is available through the Van Cortlandt Park Golf Course, but no recreation trails were observed directly adjacent to Tibbetts Brook, and the stream corridor between the golf course fairways is mostly fenced, which makes access difficult. Where the Upper Tibbetts Brook reach drains into the Lake, the John Kiernan Nature Trail crosses Tibbetts Brook. However, the trail is in disrepair and is temporarily fenced off from Tibbetts Brook. No access to Tibbetts Brook was available during the course of the Project.

Public access to the Lake is available from trails to the west (Putnam Greenway), south, and the golf course to the northeast of the Lake. Recreational opportunities surrounding the Lake include walking/running, biking, fishing, and bird watching. Public benches are located at the southern end of the Lake, which provide additional viewing opportunities. At the southwestern end of the Lake is the overflow weir (Photo 11 in Appendix G), where water discharges to the Broadway sewer. Access to the weir is restricted by fencing; however, viewing opportunities exist off of the path on the south end of the Lake.

The Tibbetts Wetland area and upland areas to the west actively provide opportunities for various types of recreation including walking/running, biking, birding, and picnicking, which appears to be very popular during summer months. To the west of the Tibbetts Wetland area is the picnicking and barbequing area (Photo 12 in Appendix G), which is a predominantly mowed lawn area with some mature trees providing shade. The area also frequently floods during heavy rain events.

A trail system in and around the Tibbetts Wetland area also provides opportunities for exploration and environmental interpretation, including the central wetland boardwalk area (Photo 9 in Appendix G). A wetland viewing platform previously existed on the western side of the Tibbetts Wetland area, overlooking the wetland restoration area; however, recent vandalism (fire) in the Park destroyed this feature (Photo 13 in Appendix G). Public safety along the corridor from the Tibbetts Wetland area to the south end of the Park was also described as concerns among park users and stakeholders.

The southwestern portion of the Park encompassing the Project site is a wonderfully dynamic landscape. Long paths with subtle curves lead park patrons through pockets of forest, reveal views across open spaces, and weave through densely vegetated wetland zones. Public amenities dot the landscape—barbecue areas, a pool, ball fields, and open lawns—and provide opportunities for structured activity. A variety of landscape types, from the sculpture circle and Van Cortlandt House Museum (mansion) to established forest and degraded freshwater wetland, populate the area. From the west, Broadway, the Van Cortlandt Park–242nd St. subway, and Bx9 bus provide opportunities for neighborhood and regional access to the site.

As a part of the Parks Without Borders program, NYC Parks is redesigning the Broadway gateway to the Park. This redesign effort, immediately adjacent to the wetland restoration concept, includes new (lower) fencing, paving, and site furnishings, as well as new activities and programs that will help to activate the Park edge, make it more accessible, welcoming, and integrated into the surrounding neighborhood fabric.

3 Design

3.1 Design Inputs and Requirements

3.1.1 Topography

A detailed topographic survey was performed by NYC Parks in 2016 for Tibbetts Wetland and areas downstream extending to the southern boundary of the Park (excluding the parking lot to the east). In addition, NYC LiDAR (2010) data was used to extend elevation contours around and upstream of Van Cortlandt Lake to account for the current geomorphology of some of Tibbetts Brook. Past and current field reconnaissance observations also support the characterization of the topography and geomorphology. These design inputs were compiled as one of several base maps for the Project (see Appendix H).

The survey was used to establish design elevations for conceptual design alternatives including flow diversions from the Lake, and dry and wet weather water elevations. The existing topography was identified early in the Project as a potential design limitation for surficial flow from the Lake and also for future connections to the Harlem River. The topography drops from an elevation of 18 feet NAVD88 at the Lake to 11 feet NAVD88 within a 100-foot distance. The topography then flattens to 8 feet NAVD88 throughout the Project site. The Project Team considered locations of higher elevations during the siting of a new Lake outlet to maximize gravity flow throughout the restored wetland and for future connections.

3.1.2 Flow Regime

Based on NYCDEP's *Van Cortlandt Park Bluebelt: Basis of Design Report (2012)*, flow data indicate a base flow of 4.6 million gallons per day (MGD) or 7 cubic feet per second (cfs) at the overflow weir of the Lake. In addition, monitoring data from the fall of 2011 provided 10 storm events that ranged from 0.03 to 1.76 inches of rain. This information was used to develop the flow range and dynamic wet weather conditions applied to the modeling of potential CSO reductions for NYCDEP's 2012 report. The base flow of 7 cfs was used as the maximum flow for the conceptual design of the proposed lake outlet structure for the Project.

Base flow is particularly important to provide a consistent flow of water into the wetland and reduce water elevation fluctuations for a sustainable ecological community. For the Tibbetts Brook Wetland Restoration, the flow to be diverted from the Lake is likely to be limited so as not to overwhelm the wetland system, avoid nuisance water conditions in actively programmed areas, and to limit the fluctuation in water surfaces which can impact vegetation establishment and diversity. This design input is also important for seamless integration with a potential future project that would connect the Lake to the Harlem River, and to divert the full base flow for a tangible CSO reduction.

Therefore, lake diversion and outlet control structures are conceptually designed to accommodate up to 7 cfs. The rate of flow from the Lake outlet structure could be adjusted to greater than 7 cfs for increased stormwater detention during final design if additional data demonstrate that increased flow can be supported by the wetland system. The control structure at the wetland outlet will also be refined during final design. With the proposed conceptual plan, up to 7 cfs could also exit the wetland outlet; however, it is anticipated that the wetland system would feasibly accommodate up to 4 cfs. A water budget is recommended as part of final design for the outlet structures. Future hydrologic and hydraulic (H&H) modeling (with NYCDEP's InfoWorks model) is recommended to estimate CSO reductions associated with the Project and future connections to the Harlem River.

3.1.3 Critical Water Surface Elevations

The elevations noted in Table 3 were used to determine how much fluctuation in water elevations can be included in the wetland restoration conceptual design alternatives and specifically for designing pond and ecological uplift opportunities. Elevations were converted from Bronx Datum to NAVD88 using a factor of 1.508 feet (Federal Emergency Management Agency, 2016).

Table 3. Critical Water Surface Elevations

Key Water Elevation	Time Period	Elevation (feet NAVD88)	Data Source
Van Cortlandt Lake, Water Surface	Current	14.91	BODR (2012)
Van Cortlandt Lake, Top of Overflow Weir	Current	15.11	NYC Parks Baseline Survey AutoCAD File (2016)
Existing Tibbetts Wetland, Water Surface	Historic (1934)	4.51	BODR (2012)
Existing Tibbetts Wetland, Land Surface	Current	7.20	NYC Parks Baseline Survey AutoCAD File (2016)
Estimated Groundwater Elevation	Current	7.00	NYC Parks Groundwater Level Dataset (Mar/Apr 2017)

3.1.4 Ponding and Localized Flooding

A compilation and review of site visit notes, photos, and anecdotal information from park staff, users, and stakeholders described the locations of localized flooding around the existing Tibbetts Wetland, including along pathways and the barbecue areas. Specifically, Friends of Van Cortlandt Park suggested the following areas as locations of ponding during spring, fall, and winter months:

- Cattail marsh area to the east of the sculpture circle (the soil can remain moist during the summer and the water level is very high).
- Barbecue area extending to the existing Tibbetts Wetland (ponds form along the trail where there are currently cattails and Phragmites).
- Long, low-lying swath along the Putnam Greenway (a pond can remain all year round but usually occurs during the spring and fall).
- Smaller area along current bike path that connects the Putnam Greenway with Tibbetts Wetland.

3.1.5 Stormwater Detention

From project initiation, water storage during wet weather was considered limited by existing park structures and uses, potential groundwater elevations, and water elevations required by the restored wetland (to be determined with future water budget). The Project is not envisioned to provide significant stormwater detention benefits such as CSO reduction or flooding relief by itself, but would do so by connecting to and integrating with a larger initiative to divert full base flow from the Lake to the Harlem River. Potential detention volumes provided by wet weather water elevations as part of the Project were calculated (see Section 3.5.3), and additional information about potential opportunities for a future connection to the Harlem River was compiled (see Section 6).

NYCDEP identified stormwater detention opportunities in the *Van Cortlandt Park Bluebelt: Basis of Design Report (2012)*. In the 2012 report, increasing the wetland storage within the Henry Hudson Lagoons area, lowering the water surface elevation to increase the storage capacity of the Lake, and restoring the Tibbetts Wetland to provide storage capacity south of the Lake were evaluated as CSO reduction strategies. A water budget and/or H&H modeling for proposed detention within or upstream of the Lake would be needed to identify the impacts of these features on the design of this Project.

Low elevation area at western edge of Tibbetts Wetland with surface ponding.

3.1.6 Connection Points (for Lake and Wetland Outflow)

Multiple options were considered for designing new connections or retrofitting existing connections to divert flows from the Lake to the restored wetland and from Tibbetts Wetland to the Broadway sewer as part of the Project. Several options were described in NYCDEP's *Van Cortlandt Park Bluebelt: Basis of Design Report (2012)* for establishing a hydrologic connection between the Lake and Tibbetts Wetland including:

- Modify the existing weir structure to allow managed inflow to the proposed Tibbetts Wetland area.
- Modify the existing lake drainage valve (pipe infrastructure that allows for dewatering of the pond) infrastructure to allow managed inflow to the proposed wetland restoration area.
- Create a new control structure at the Van Cortlandt Lake edge that would be closer to the Putnam Greenway, either east or west of the bridge.

Development of design inputs and requirements by the Project Team identified options for a new connection from the Project to the Broadway sewer. Two leading concepts emerged for establishing a hydrologic connection for overflow from the Tibbetts Wetland to the Broadway sewer including:

- Tie in to existing storm drain that returns flow to the Broadway sewer.
- Create a new connection to Broadway sewer that is sized for flow regime.

For connection point options, additional design decisions based on available topographic and utilities data were needed for:

- Surficial or piped connections from the Lake to the Tibbetts Wetland.
- Flexibility and adaptability of flow control structures at both the Lake and wetland outlets for future connections to the Harlem River, or as required by future climate conditions and NYC Parks' operations and maintenance.

Additional data collection and analyses (outside the scope of the Project) were also identified:

- Geotechnical considerations related to the placement of a control structure and the existing retaining wall for the southern section of the Lake east of the bridge.
- Additional geotechnical analyses and conditions assessments (video or closed circuit television, CCTV, inspection) to determine location, adequacy, and capacity of the existing sewer infrastructure within the Park, including what is believed to be a 42-inch sewer line within proximity of the Project and connected to the Broadway sewer (NYCDEP, 2015).

3.1.7 Connection Points for Future Opportunities

The Project Team was required to consider potential opportunities for future connections to the Harlem River along the Putnam Greenway throughout the Project and for various aspects of conceptual design alternatives. Key design inputs are existing park features, structures, utilities, topography, and critical water surface elevations to identify flow diversion options from the Lake and sufficient elevations to maintain gravity flow. Preliminary analysis of NYC LiDAR (2010) data suggests this will be feasible; however, additional survey information (outside the scope of the Project) is needed to the east of the Putnam Greenway. Additional information about potential opportunities for future connections is presented in Section 6.

3.1.8 Water Quality Improvements

Enhancing surface water features of Tibbetts Brook will provide water quality improvements to downstream conveyances. State stormwater design guidelines assume that wetlands are capable of 80 percent total suspended solids removal and 40 percent total phosphorous removal (NYSDEC, 2015).

In addition, volumetric losses from evapotranspiration and exfiltration from the system can be estimated for water quality benefit. These volumetric losses can be estimated using wetland water balance tools, literature values, and local soils information. For CSO reduction benefits, NYCDEP's *Van Cortlandt Park Bluebelt: Basis of Design Report (2012)* estimates that a base flow bypass alternative would reduce annual CSO volumes by up to 139 MG or more dependent on storage provided. To estimate potential CSO reductions in the Harlem River associated with the Project (since not a base flow bypass alternative), NYCDEP's InfoWorks model for the Wards Island Wastewater Treatment Plant and Open Waters of New York Harbor must be used.

3.2 Ecological Considerations

3.2.1 Sediment

In general, the Lake and the upstream lakes act as large sediment traps for the Tibbetts Brook watershed. Sediment loads and transport downstream of the Lake are expected to be minimal.

3.2.2 Soils

Limited soils data exist with respect to the Tibbetts Wetland and areas outside of the existing wetland that may be incorporated into the restoration concept. According to NRCS soil survey data, the Project area generally consists of very deep, very poorly drained soils formed in woody and herbaceous organic materials overlying loamy deposits in depressions on lake plains, outwash plains, till plains, moraines, and floodplains (see Appendix H). Saturated hydraulic conductivity is moderately high or high in the organic layers and moderately low to high in the loamy material. NYC Parks compiled pH values from soil samples collected in 2017 that ranged from 5.34 to 5.70.

3.2.3 Ecological Communities

The ecological communities, including the freshwater wetland habitats, within the Project site were characterized by NYC Parks' *Tibbetts Brook Entitation Survey (2015)* and *Wetland Delineation (2017)*. The Project area is dominated by lawn, *Phragmites australis*, *Quercus palustris* (pin oak) forest, and floodplain swamp tree species including *Fraxinus caroliniana* (ash) and *Liriodendron tulipifera* (tulip). This information is presented as a base map in Appendix H.

The design intent of the Project is to enhance existing surface water features, as described and delineated by NYC Parks. Potential changes to the existing ecological communities in and around Tibbetts Wetland are described based on these characterizations and the development of conceptual design alternatives. It is anticipated that wetland plant communities will generally be restored by having a longer hydro-period, but that some tree die-off might occur due to the change in soil saturation and inundation durations. Tree removal must also be reduced as part of the development of conceptual design alternatives.

3.2.4 Invasive Species & Management Needs

Existing invasive plant species, including *Phragmites australis*, are well documented in the Project area. The significant coverage of existing invasive plant species is illustrated in Appendix H. The Project incorporates design strategies to remove invasive plant species and restore native plant species. Operations and maintenance activities needed to provide longer-term management of invasive plants are described in NYC Parks' *Van Cortlandt Park Natural Areas Restoration Plan* and identified in Section 5.

3.3 Design Alternatives

3.3.1 Description

Based on the above described design inputs and requirements, two conceptual design alternatives were developed by the Project Team for review with NYC Parks and stakeholders. Both concepts explored a new outlet from the Lake east of the Putnam Greenway Bridge and a new outlet that would connect Tibbetts Wetland to the Broadway sewer.

- **Concept 1** creates three distinct zones of water storage—an upper water storage area, middle wetland complex, and lower wetland complex. The overall goal of the concept was to generate a series of open water and freshwater wetland areas that will temporarily detain water volumes during storm events, filter out up to 80 percent of suspended sediments and up to 40 percent of total phosphorus from the base flow (NYS Stormwater Management Design Manual, January 2015), and reduce the potential of invasive plant species dominance within the restored ecological complex.
- **Concept 2** creates three distinct zones of water storage—an upper water storage area, middle wetland complex, and lower wetland complex. The overall goal of the concept was to create longer, undefined flow paths through a series of open water and freshwater wetland areas that will temporarily detain water volumes during storm events, filter out up to 80 percent of suspended sediments and up to 40 percent of total phosphorus from the base flow (*NYS Stormwater Management Design Manual, January 2015*), and reduce the potential of invasive plant species dominance within the restored ecological complex. The concept provides multiple flow paths for water to step down in elevation through the system, creating a braided system of flows across the site.

Additional key features for each concept are described in Table 4, and noted differences are further described below.

Table 4. Comparison of Conceptual Design Alternatives and Existing Conditions

Feature Type	Feature	Unit	Existing	Concept 1	Concept 2
Wetland	Open Water Area	acre	0.0	1.1	0.6
	Wetland/Microtopography	acre	4.0	4.2	4.7
	Total Wetland Acreage	*acre*	*4.0*	*5.3*	*5.3*
Recreation	Boardwalk Length	linear feet	201.0	1,317	1,271
	Path Length	linear feet	477.0	1,108	1,527
	Passive Recreation & BBQ Areas	acre	0.1	0.1	0.4
Hydrology	Pipe Connection Length (to Broadway sewer)	feet	0.0	668	202

3.3.2 Hydrologic Flow Differences from Lake to Wetland

Concepts 1 and 2 differ in how water flows from the Lake to the restored wetland complex. To move water from the Lake to the southeastern area of Tibbetts Wetland, Concept 1 included establishing a new outlet from the Lake on the east side of the Putnam Greenway. This flow would be contained within a pipe located east of and running parallel to the Putnam Greenway. An existing storm drain could potentially be modified to convey the diverted flows as well as local stormwater runoff from the area. The pipe would discharge flows into the southeast corner of Tibbetts Wetland, while also providing the potential to allow for future connections continuing towards the Harlem River.

In contrast, Concept 2 focused on surface conveyance as the method for the connection between the Lake and Tibbetts Wetland. The outlet from the Lake would be located in the same area as that proposed under Concept 1. Using the underutilized area along the eastern edge of the Putnam Greenway, this surface feature would be located where the asphalt path runs east of the Putnam Greenway and would include a small open water feature and pool that provides some energy dissipation and allows the water surface elevation to be managed in consideration of potential opportunities for future connections to the Harlem River. The surface stream would convey flows south along the Putnam Greenway and then west via a cascade beneath the existing Putnam Greenway Bridge, eventually discharging into the southeastern area of Tibbetts Wetland.

3.3.3 Hydrologic Flow Differences within Tibbetts Wetland

Another key difference between Concept 1 and Concept 2 was how water flows through the restored wetland complex. To increase water storage on site, as well as improve water quality and habitat diversity, Concept 1 generates a series of open water and freshwater wetland areas that will temporarily detain water volumes during storm events. Also within Concept 1, a major feature is a defined, preferential surface water flow path within the lower wetland complex, which flows from a single weir in the middle wetland complex.

Concept 2 creates longer, undefined flow paths within the upper storage area and wetland complexes. The primary objective of Concept 2 is to provide multiple flow paths for water to step down in elevation through the system, creating a braided system of flows across the site.

3.3.4 Wetland Cut and Fill Comparison

Under both concepts, fill within the existing delineated wetland areas was included for the placement of multiple sand seepage berms and, under Concept 2, with the placement of passive recreational areas and earthen berms. The sand seepage and earthen berms are an integral part of the design, serving to lengthen, retain and diffuse water flows across the site to enhance the functionality of the wetland areas, create more diverse habitats, and reduce the dominance of non-native plants. Table 5 presents estimated total cut and fill for both concepts.

Table 5. Comparison of Tibbetts Brook Wetland Restoration Concepts—Cut and Fill

Earthwork	Concept 1	Concept 2
Cut (cubic yards)	4,355	8,378
Fill (cubic yards)	4,962	7,789
Net Total (cubic yards)	607 (Fill)	589 (Cut)

3.4 The Selected Design Alternative and 30% Design

The preferred alternative concept was developed based on reviews and discussions of the conceptual design alternatives, and feedback received from NYC Parks staff and project stakeholders. Similar to Concepts 1 and 2, the preferred alternative concept restores diverse wetland zones, enhances ecological features, improves water quality, provides stormwater detention, and creates synergies with ongoing park projects and future opportunities for the potential reconnection of Tibbetts Brook to the Harlem River.

Development of the preferred alternative concept, as shown in Figure 6 and Appendix A, emphasized a new lake outlet west of the Putnam Greenway, instead of a new outlet east of the Putnam Greenway Bridge as proposed in Concepts 1 and 2. The location of the new outlet was shifted west to reduce conflicts with utility crossings and adjacent infrastructure, estimated tree impacts, and required grading with railroad berm utilities within the Park, while still maintaining as much elevation as possible for flow to move through the Tibbetts Wetland.

From the Lake outlet, the proposed spillway provides visible surface flow as close to the Lake as feasible. The flow would transition from the spillway to a restored wetland complex that includes a meandering stream, open water areas, and freshwater wetland zones. A sand seepage berm forms an upper pond to temporarily detain water and filter sediments and pollutants before allowing flow through the rest of the wetland complex.

A new wetland outlet and piped connection to the Broadway sewer are proposed as part of the conceptual plan. A flow control structure would be located at this outlet to differentiate the water elevations required to sustain wetland plantings from the volume of water that can be stored beyond this elevation during wet weather or if future climate and operational conditions necessitate. The preferred alternative concept includes redesigned pedestrian connections for park users and will help NYC Parks advance its goal of planning for the potential future restoration of Tibbetts Brook flow to the Harlem River.

Figure 6. Preferred Alternative Concept Design

Table 6 summarizes the key features of the preferred alternative concept design including proposed wetland and passive recreation acreages, and path and pipe lengths under existing and proposed conditions. These key features were further developed for the 30% design drawing set including: existing conditions, layout and materials plan, grading plan, planting plan, details, and design sections. The 30% design drawing set is attached as Appendix B and is described in detail in the next section of this Design Report.

Table 6. Preferred Alternative Concept Design Summary

Feature Type	Feature	Unit	Existing	Proposed
Wetland	Open Water Area	acre	0.0	1.1
	Wetland/Microtopography	acre	4.0	4.5
	Total Wetland Acreage	*acre*	*4.0*	*5.6*
Recreation	Boardwalk Length	linear feet	201	645
	Path Length	linear feet	477	977
	Passive Recreation & BBQ Areas	acre	0.1	Unchanged
Hydrology	Pipe Connection Length (to Broadway sewer)	feet	0.0	178.0

3.5 30% Design Features

3.5.1 Wetland Zones

Intermittent Pond/Stream

Intermittent ponds and streams are waterbodies that contain surface water for only part of the year. Typically, within an intermittent pond or stream, the amount and duration of surface water largely depends on annual precipitation. With the Project, the amount and duration of surface water will also be affected by outflows from the Lake. In general, the open water areas shown in Figure 6 will hold more water in winter and early spring when there tends to be more precipitation, and will be dry during the summer when evapotranspiration is greatest.

Example of intermittent pond/stream zone. (Photo courtesy of Creative Commons CCO.)

Transitional Wetland

Transitional wetlands include the land that lies between upland and aquatic ecosystems, with varying periods of saturation dependent on the land's position within the landscape, as shown on Figure 6. With the Project, the transitional wetland zone lies in the northernmost portions of the restored wetland buffering upland areas that include existing structures (pool and mansion) from other wetland zones. The transitional wetland is designed to be periodically saturated, supporting both hydrophytic plants and upland plants. The amount of saturation within the transitional wetland will be dependent on the amount of precipitation occurring annually. In general, the soils within this habitat will be frequently saturated during the early part of the growing season and drier toward the latter part of the growing season.

Example of transitional wetland zone. (Photo taken at Woodrow Marsh, Staten Island in 2011.)

Scrub/Shrub Wetland

Scrub/shrub wetlands are dominated by water-tolerant shrubs and small trees located within the floodplain. With the Project, the scrub/shrub habitat transitions from the lower-lying intermittent pond/stream habitat to the slightly higher elevated forested wetland habitat shown on Figure 6. The vegetation within this habitat is generally less than 10 to 20 feet in height and also includes herbaceous plants. Similar to the transitional wetland habitat, the amount of saturation within the scrub/shrub wetland will be dependent on the amount of precipitation occurring annually, but the habitat's hydrology will also be affected by the discharges from the Lake. Microtopographic features will be graded throughout to allow water to pond in the lower depressional areas and support mosses and other shorter grasses during dryer periods, while the higher mounded features will support small trees, shrubs and herbaceous plants.

Example of scrub/shrub wetland zone. (Photo taken at Woodrow Marsh, Staten Island in 2007.)

Forested Wetland

Forested wetlands occur on seasonally or perennially wet flats or slopes, are typically hydrated from groundwater discharge or inflowing streams, and sometimes occur within riparian zones. Forested wetlands differ from riparian forest in their higher water tables, longer duration of soil moisture, finer-textured soils, and are typically flooded for several weeks during the growing season (seasonal flooding). Within the Project, the forested wetlands serve as the transitional zone between the lower-lying intermittent pond/stream and scrub-shrub habitats, and the higher elevated upland habitats and park paths (see Figure 6). The soils within the forested wetland will typically be wet in spring and early summer, but will dry later in the growing season. The dominant plants within the forested wetland areas will be trees that are well suited to wetter soils, such as maples, oaks, and sweetgum. To enhance the transitive nature of this habitat and create more diversity within this zone, microtopography will allow water to pond in the lower depressional areas and support mosses, while the hummocks or higher mounded features will support trees, shrubs, and other shorter grasses and sedges.

Example of forested wetland zone. (Photo taken at Butler Manor, Staten Island in 2017.)

3.5.2 Proposed Elevations and Wetland Cut and Fill

Grading was based upon existing ground elevations and groundwater elevations identified by NYC Parks' survey and monitoring data. The lowest proposed wetland elevation is 5 feet NAVD88. The open water pond areas of the Project are located at the lowest lying elevations to reduce excavation. The high point for the open water pond areas is elevation 10.33 feet NAVD88 at the location of the wetland overlook.

The top of the proposed sand seepage berm is at elevation 8.75 feet NAVD88, creating an upper pond closest to the stream course that discharges flow from the spillway and Lake outlet. Proposed higher grades are located in areas where paths and boardwalks would be constructed, serving as berms to demarcate and contain water elevations during both dry and wet weather conditions. The transitional wetland then extends to a high elevation of 12 feet NAVD88.

Table 7 includes estimated quantities for cut and fill to achieve the grading plan included in the 30% design drawing set (Appendix B). NYC Parks will conduct field investigation of soils contaminants during advanced design. If clean, excavated soils will be used onsite to create the new pathway and overlook. The Project Team recommends that remaining excavated soils be placed adjacent to Tibbetts Wetland or other areas of the Park to improve grading and reduce localized flooding.

Table 7. 30% Design Earthwork—Cut and Fill

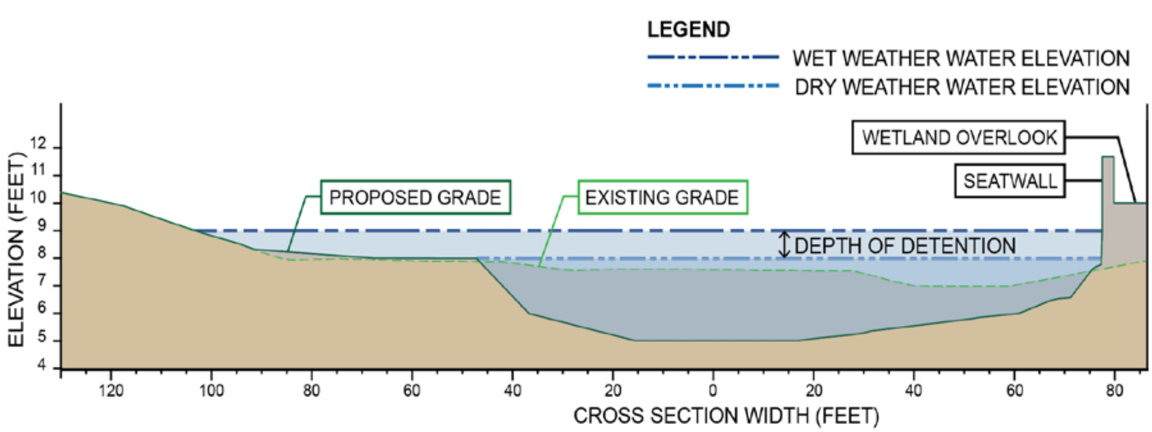
Earthwork Area	Cut (cubic yards)	Fill (cubic yards)
Within Delineated Wetland Area	4,600	400
Approximately 100 Feet of Wetland Adjacent Area	2,700	1,500
Outside Wetland and Wetland Adjacent Areas	1,900	1,900
Total	9,200	3,800
Net Total	5,400 (Cut)	

Additional data is required to confirm proposed grading and water elevations, including groundwater data, Lake water levels and bathymetry, and a water budget. Limitations to the proposed 30% design and required data analyses are described in Section 3.6.

3.5.3 Stormwater Detention Potential

Lake water elevations, topography, and groundwater elevations were major factors in developing the 30% design grading plan. The proposed grading of the site along with the wetland outlet structure elevations provide the stormwater detention potential for the Project. Figure 7 illustrates these key design features and the detention provided.

Figure 7. Stormwater Detention Cross Section (Wetland Overlook Southeast to Existing Path)



The wetland outlet includes two outlet elevations—one for dry weather and one for wet weather. By closing the lower outlet (elevation 8 feet NAVD88) and opening the higher outlet (elevation 9 feet NAVD88) for wet weather, the wetland is able to pool or detain additional flow from the Lake, slow the rate of stormwater to the Broadway sewer during peak rainfall events, and reduce contributions to CSOs. Actual CSO reductions associated with the Project and future connections to the Harlem River would need to be developed based on a water budget and H&H modeling. Table 8 illustrates the elevations at which stormwater detention during wet weather is provided above the dry weather water elevation for the open water pond areas.

Table 8. Pond Stage and Detention Volume Relationship during Wet Weather

Key Elevations (description)	Elevation (feet)	Area at Elevation (square feet)	Area at Elevation (acre)	Detention Between Elevation (acre feet)	Detention Between Elevations (cubic feet)
Dry Weather Water Elevation	8.00	62,520	1.44	NA	NA
Wet Weather Water Elevation	9.00	107,237	2.46	1.95	84,878

The total volume of water detention during wet weather is estimated to be 84,878 cubic feet, or approximately 635,000 gallons. This is the volume of water that would be stacked on top of the permanent pool (with a design capacity of 62,520 cubic feet or approximately 454,000 gallons of water) as set by the dry weather water elevation at the wetland outlet structure and (to a lesser degree) the sand seepage berm.

These volumes during dry and wet weather do not account for evapotranspiration that is expected to occur with the Project, or additional stormwater benefits such as water quality treatment. Figure 8 illustrates the limits of the dry and wet weather water elevations on the conceptual layout rendering. Based on these water elevations, grading adjustments were implemented for 30% design to keep water from flooding paths or boardwalks during either dry or wet weather conditions. Additional refinements may be required following H&H assessments and during final design.

3.5.4 Outlets and Flow Control Structures

Lake Outlet

To connect Van Cortlandt Lake with Tibbetts Wetland, a new outlet from the Lake would be created west of the Putnam Greenway. The outlet would be constructed approximately one foot below the existing surface elevation of the Lake (elevation 15.1 feet NAVD88) to draw from the water column instead of the water surface. At this elevation, the piped connection is not expected to convey floatables (trash and debris) or floating aquatic vegetation, such as duckweed, that float on the Lake's surface to the restored wetland.

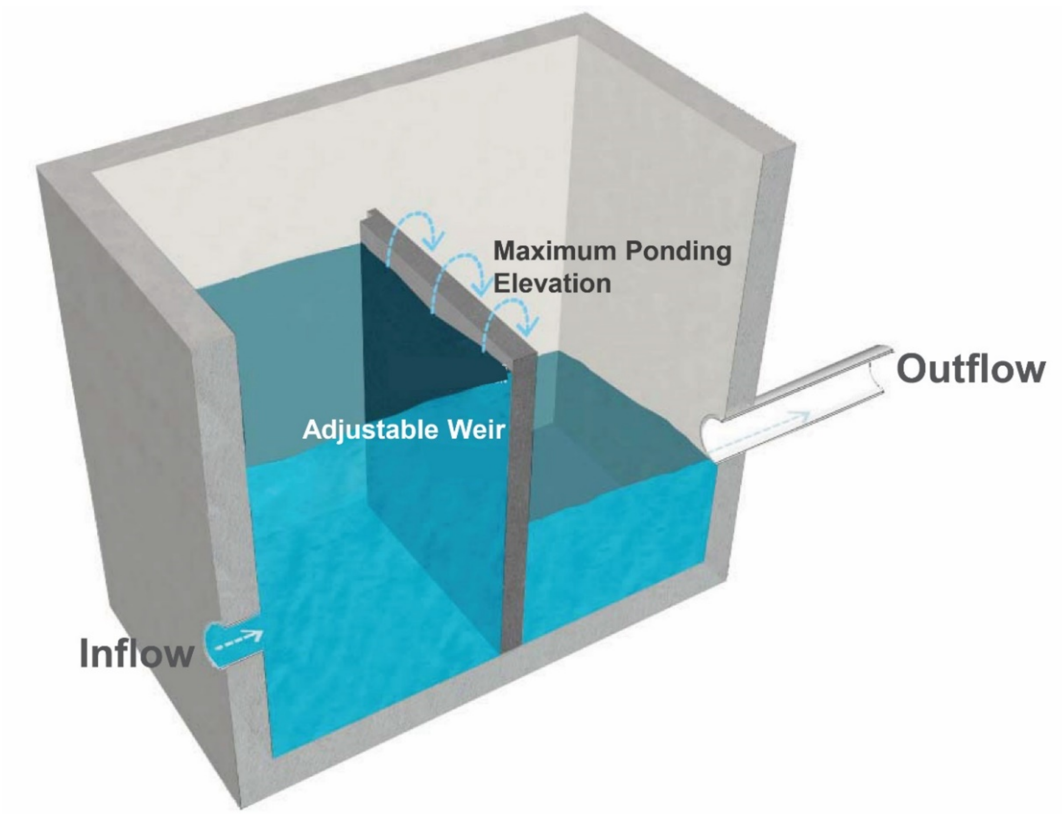
The invert elevation of the pipe from the Lake would be approximately 12.6 feet NAVD88. The proposed 16-inch pipe entering and exiting the chamber would allow a maximum 7 cfs of flow, consistent with the base flow estimated in NYCDEP's *Van Cortlandt Park Basis of Design Report (2012)*. This would also accommodate potential future connections to the Harlem River.

Figure 8. Dry and Wet Weather Water Elevations Concept Design

The new outlet chamber would include flow control structures that allow for adaptive management and flexibility to adjust flow rates both seasonally to increase wetland functionality, and over time as future phases of the Project are implemented. The proposed 30% design for the Lake outlet chamber includes two control structures in series. The water from the Lake first flows through a manual gate at the piped connection that can be either open or fully to partially closed to restrict discharge rates. Water then must build up to a pre-set height controlled by an adjustable weir (such as stop boards) before discharging out the downstream pipe of the chamber and to the spillway.

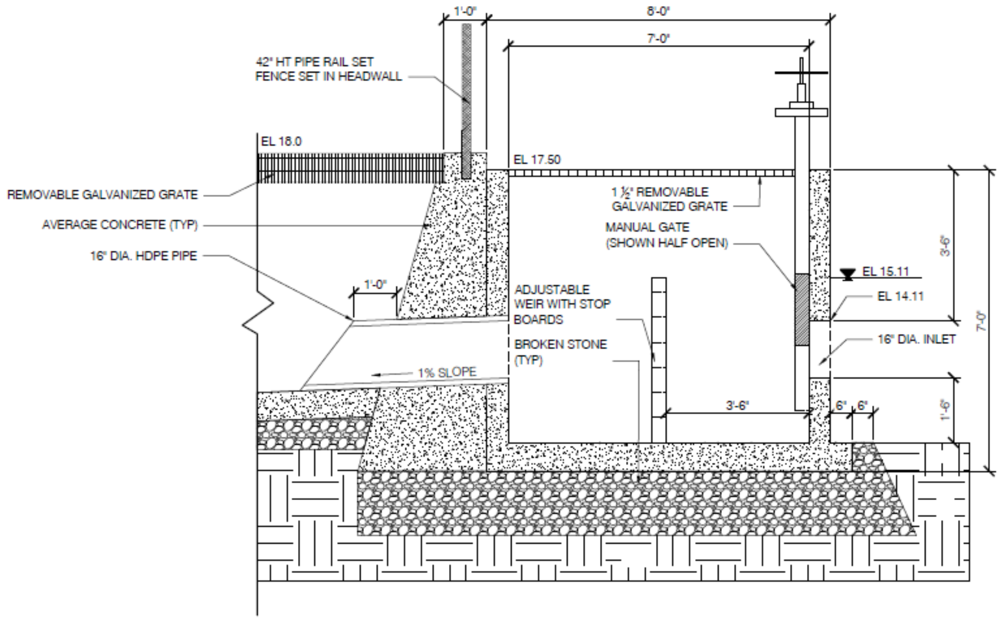
The maximum ponding elevation set by the weir within the chamber dictates the water elevation upstream of the chamber. The water elevation upstream of the chamber can only be as high as the weir within the chamber. Figure 9 illustrates the basic concept of an adjustable flow control structure.

Figure 9. Adjustable Weir Structure for Outlet Flow Control (Philadelphia Water Department, 2014)



The detail in Figure 10 illustrates the design intent of the Lake outlet chamber (see also Appendix B). Without bathymetry information and geotechnical data for the Lake substrate, the size of the structure is approximate. The width is based on the space required to access the gate and stop boards. The depth is based on the estimated minimum invert elevation that would create a 1.5-foot sump at the bottom of the chamber to allow debris and sediment to settle. The structure may be sized differently in the future when more information is available.

Figure 10. Detail of the Proposed Lake Outlet



The proposed Lake outlet chamber with multiple flow control structures allows for debris or sediment that may discharge from the Lake to settle out within the chamber (before overflowing the board stops and discharging to the restored wetland). Maintenance staff will be able to focus efforts within this chamber, easily accessible via a grate cover, to clean out accumulated debris and sediment, and should not have to clean other areas of the restored wetland as frequently. The frequency of clean outs at the Lake outlet chamber is expected to be low (one or two times annually) given that the Lake provides significant pretreatment upstream of Tibbetts Wetland.

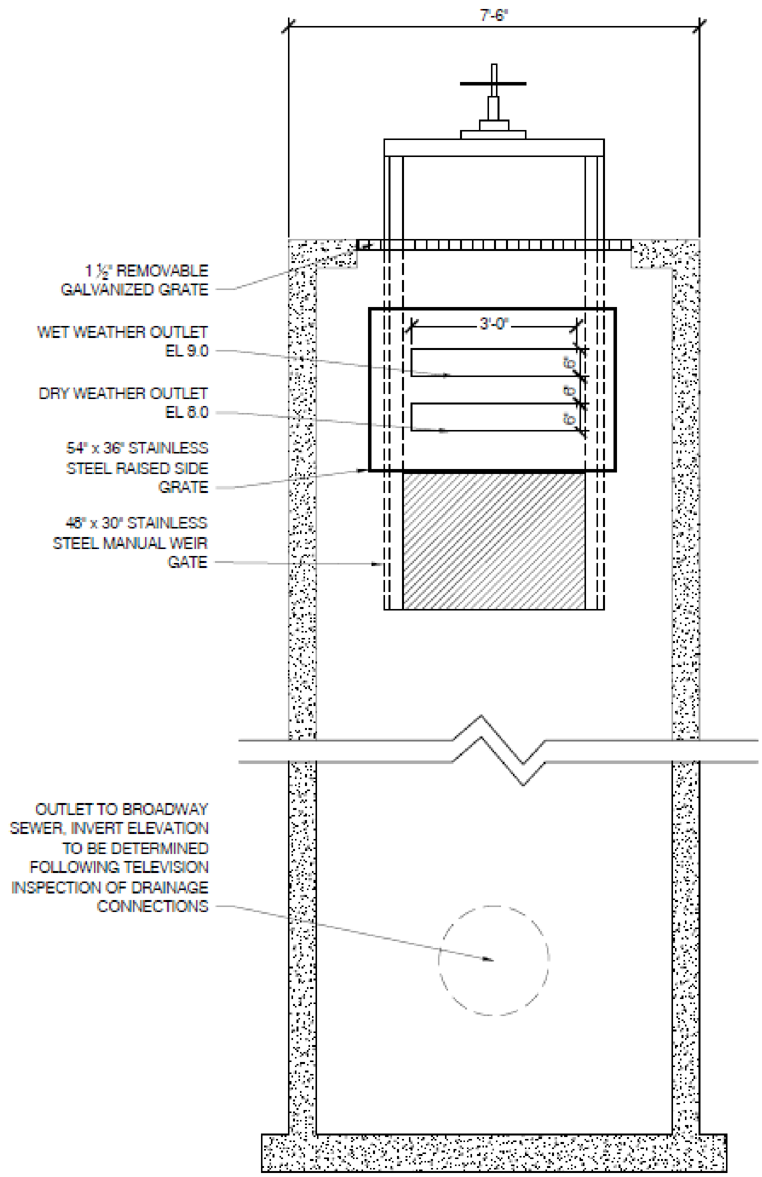
The existing outlet for the Lake, located west of the Putnam Greenway and north of the new proposed outlet, will remain unchanged and will still serve to convey flows to the Broadway sewer. As a result of the new flow diversion west of the Putnam Greenway, the flow that discharges from the Lake via the existing weir can be reduced based on the Lake and Tibbetts Wetland water budget to be developed.

Wetland Outlet

The proposed connection to the existing Broadway sewer will be through a new outlet installed on the western edge of the lower pond area. The new outlet structure will be constructed with a headwall and grate, and will be accessible by NYC Parks staff via a gravel path approximately 10 feet to the west. The outlet will be connected west to the historically mapped stormwater infrastructure that drains to the Broadway sewer. CCTV inspection to identify the location and elevation of this connection is needed.

The outlet location and structure will allow the water from the Lake to flow through the open water storage areas and wetland complexes, improving water quality and habitat, before discharging to the Broadway sewer. The proposed outlet design includes two openings, a lower elevation opening at 8 feet NAVD88 and a higher elevation opening at 9 feet NAVD88. The detail in Figure 11 illustrates the design intent of the wetland outlet chamber (see also Appendix B).

Figure 11. Detail of the Proposed Wetland Outlet



The lower opening allows water to pool or pond to 8 feet NAVD88 throughout the restored wetland. This depth of water is provided for wetland plantings and to allow habitat to thrive, and will be refined as necessary based on groundwater data collection and the water budget for the Lake and Tibbetts Wetland.

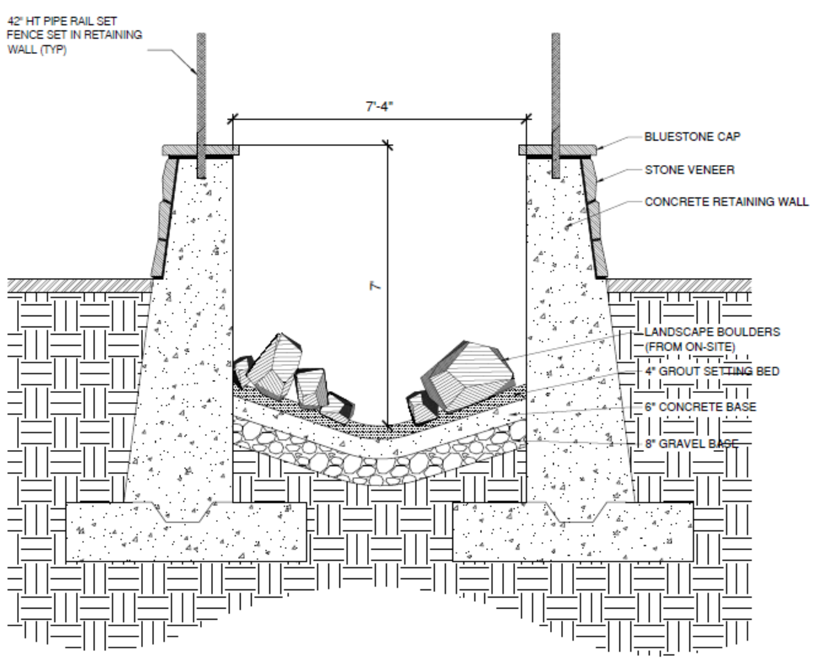
If desired and feasible, the restored wetland can store or detain additional water above the water elevation of 8 feet NAVD88 and to a maximum elevation of 9 feet NAVD88. The lower elevation opening could be closed to allow for this storage up to the higher elevation opening in advance of rainfall events or seasonal rainfall projections.

3.5.5 Spillway

The proposed spillway begins at the Lake outlet chamber headwall with a top of wall elevation of 18 feet NAVD88. The invert of the piped connection from the Lake outlet is 12.6 feet NAVD88. The pipe exits the Lake outlet chamber and discharges onto the spillway below the pedestrian path paralleling the Lake. The spillway, consisting of a 7-foot wide channel layered with boulders, river stone, and bedding sand in between concrete retaining walls, runs for a length of 42 feet at a one percent slope. The spillway then connects at elevation 12.2 feet NAVD88 to the proposed 180 linear foot stream course that flows into the upper pond of the restored wetland.

The proposed flow path for the spillway preserves the greatest number of existing trees, compared to alternative alignments considered. The detail in Figure 12 illustrates the design intent for the proposed spillway (see also Appendix B). Additional data regarding lake bathymetry and a wetland water budget are required to complete engineering and design.

Figure 12. Detail of Proposed Spillway



3.5.6 Seepage Berm

A sand seepage berm is included in the 30% design to raise the water elevation in the upper wetland area. A layer of sand and wood chips would be graded to create a low-head sand berm. This permeable structure captures stormwater runoff, and improves wetland habitat by raising the water surface of the pond nearest the spillway. The improved wetland habitat will filter sediment, debris, and pollutants from the water before they enter the lower wetland area. This technique is employed in the Chesapeake Bay Watershed to reduce nutrient contributions including phosphorus and nitrogen in receiving waterbodies (Anne Arundel County Government, 2012).

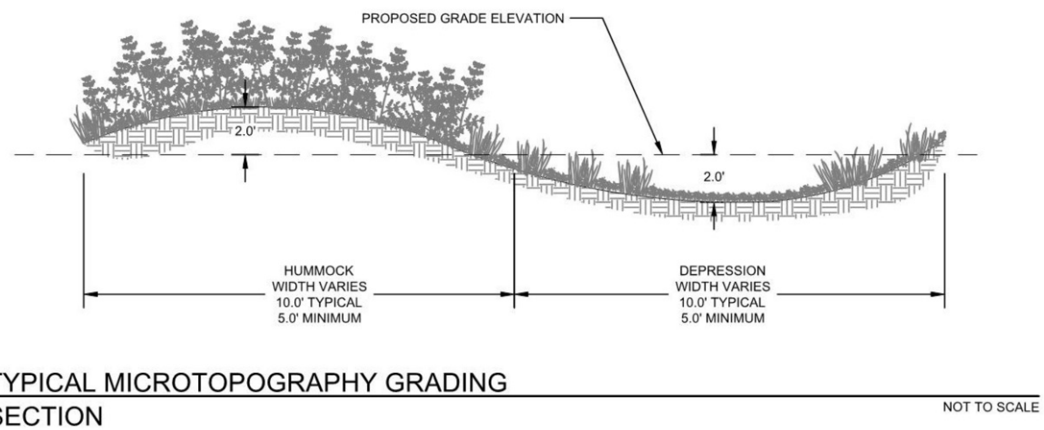
Additional design based on a water budget is needed. Sand seepage berms are often designed with shallow arched weirs to safely convey stormwater to downstream areas and may be necessary based on projected flows from the Lake outlet and spillway. The porosity of the berm will need to be determined based on H&H assessments (of flows from the Lake outlet and spillway) to maintain the required water elevations throughout the site. Armoring may also be necessary to protect the structural integrity of the sand seepage berm as determined through the analysis of anticipated flows (during dry and wet weather conditions).

Sand seepage berm constructed as part of the Lizard Hill Wetland Restoration in Worcester County, Maryland.

3.5.7 Microtopography

The design includes areas of microtopographic grading which can be thought of as a series of hummocks and depressions designed to mimic mound and pool features commonly found in natural freshwater wetlands. Microtopography provides a complex of ecological habitat niches with a range of hydrologic conditions. These small-scale grade changes are limited to a maximum of 2.0 feet above and below the average proposed grade (Figure 13), and serve to interweave the pond with scrub/shrub, and forested wetland zones. Both surface water and groundwater can filter in, around, and through the hummocks and depressions, encouraging groundwater connectivity and establishing a more robust ecosystem.

Figure 13. Microtopography Cross Section



3.5.8 Landscaping and Plant Material

The proposed plantings are all native species, selected for their adaptability to site conditions and water inundation levels. Wetland plants are sensitive to water levels as reflected by wetland indicator status categories. The indicator status categories for each proposed plant species are identified on the planting plan in Appendix B, and defined by the United States Army Corps of Engineers (2012) as:

1. Obligate Wetland (OBL)—Plants almost always occur in wetlands. Typically found in standing water or in soils saturated near the surface for 14 consecutive days or more.
2. Facultative Wetland (FACW)—Plants usually occur in wetlands but are occasionally found in wetland-adjacent areas. Plants within this category are usually found in areas where the soil is saturated or within an area of seasonal flooding.

3. Facultative (FAC)—Plants are equally likely to occur in wetlands or non-wetlands. Within this category, plants have a wide tolerance of soil moisture conditions.
4. Facultative Upland (FACU)—Plants usually occur in non-wetlands, but are occasionally found in wetlands. Drier conditions are typical of this category, and plants are found in areas that rarely have flooding or saturated soils.
5. Obligate Upland (UPL)—Plants almost never occur in wetlands or areas with saturated soils.

The planting plan should be adjusted based on the water budget and H&H assessments to be developed to include species that can be supported by the dry and wet weather water elevations anticipated.

Within the restored wetland, a diversity of species will be planted to allow each species to find its niche and promote a healthy plant community. The planting plan and microtopography create plant communities that minimize maintenance to the extent possible and are more resistant to invasive species. Invasive species currently onsite will likely reappear following construction despite herbicide treatment. Early removal before establishment would effectively manage the spread of these invasive species.

Microtopographic grading and wetland plantings constructed at a Port Authority of New York and New Jersey site.

As part of the Project, tree plantings are proposed to enhance plant community development and landscape aesthetics, and to achieve restitution requirements (see planting plan in Appendix B). At the time of writing this Design Report, an estimated eight trees will be removed, totaling 76-inches in diameter breast height (DBH) or 32 total basal area (BA). Restitution for tree removals will be compensated, and the restitution requirement would be determined during future data analyses for advanced design (see Section 3.6) as well as updated tree survey information.

3.5.9 Utilities and Sewer Connection

Several existing utilities will require removal or relocation to support the 30% design (see grading plan in in Appendix B). Reloctions include an electric line and a potential cable television (CTV) line, while removals include a 2-inch waterline and a 6-inch drain line and catch basin. Several heavily-silted catch basins will require cleaning as well to improve localized drainage.

CCTV inspection is required to verify the connection (location, elevation, and condition) to the Broadway sewer from the proposed wetland outlet. Just south of the existing wetland outlet is a manhole that may drain to the Broadway sewer. If a connection exists, the new outlet will connect to this structure, as long as the existing drainage pipe has sufficient capacity for the anticipated flow. If the connection does not exist, or the drain is undersized, a new drainage pipe will need to be installed to make the connection from the new wetland outfall.

3.5.10 Boardwalk and Paths

The path system is designed to accommodate multiple functions including pedestrians and, in some locations, cyclists, while still maintaining adequate dimensions for maintenance and emergency vehicles on existing asphalt paths. The path framework is designed to have a light touch on the land, to work with changes in elevation and topography, and to reduce impact on existing mature vegetation, while still making key park circulation connections.

The 30% design consists of 645 linear feet of new boardwalk, as well as 232 linear feet of gravel path and 326 linear feet of asphalt path to be replaced in kind. The mix of path types is consistent with the materials currently found in the Park. The proposed location for each path type is based primarily on topographical and hydrological conditions. Boardwalks are proposed in locations where open or ponded waters will flow underneath, while asphalt and gravel pathways are designed to be a minimum of 12 inches higher (freeboard) than maximum water elevations at 9 feet NAVD88.

The circulation network draws from the character of the existing path system and its curvilinear form. An arc guides users from the edge of the Parks Without Borders gateway to the western edge of the restored wetland. The arc next transitions from gravel path to boardwalk, then back to gravel path as it passes the sculpture circle and mansion. Continuing to the northeast, the arc rises in elevation, where it converges with the existing asphalt path before connecting back to a boardwalk that parallels the Putnam Greenway. The remainder of the arc is positioned to meet specific points of connection across the

Putnam Greenway to existing parking lots and points east, and to enhance access for pedestrians, joggers, bicyclists, and other park users.

3.5.11 Amenities and View Points

The long, arcing path that cradles the bulk of the Project provides a host of vantage points from which park users can experience this new landscape. The Project identifies several view points for the restored wetland (Figure 14) including along the Lake at the top of the spillway, from the mansion steps, along the east boardwalk, where the Putnam Greenway and east boardwalks meet, and from the overlook at the west boardwalk.

The overlook is designed to be a path-side wetland overlook platform with a seatwall that provides the opportunity for park users to view the pond and meandering stream across its length, as it winds its way through scrub/shrub and forested wetlands. The overlook, located at the proposed high point for the Project site (elevation 10.33 feet NAVD88), was carefully designed based on community input, and prevents barbecue-related uses and loitering. For this reason, the overlook width was capped at five feet. Bollards would be installed to only allow foot traffic along the entire 50-foot length of the overlook.

The proposed public use design does not prescribe specific activities or social or recreational features for inclusion, but does create the opportunity for flexible future programming and amenities. The 30% design improves park access, quality of path network (both directly and indirectly), and connections to existing park features, such as the Putnam Greenway and the existing barbecue area. These objectives were of particular importance to Park users and NYC Parks. The Project is also anticipated to promote educational opportunities, increased and diversified habitat for bird watching and plant identification walks, and new walking and jogging routes.

3.6 30% Design Limitations and Data Analyses Required

3.6.1 Groundwater Elevations

Additional groundwater data collection and analysis is needed to confirm the depth to groundwater including seasonal variations within the Project site. A full year of seasonal data collection via shallow wells or borings is recommended to confirm elevations on the grading plan during final design. This information would also support the development of a water budget and H&H assessments to determine whether storage or detention within the restored wetland could be increased. Dewatering necessary to construct the Project would also be determined based on this data collection and analysis effort.

Figure 14. Potential Amenities and View Points

3.6.2 Lake Bathymetry and Water Elevations

A survey report from 2002 developed by NYC Parks was reviewed for the Project to better understand depths and storage volumes provided by the Lake, as well as historic sedimentation. Updated bathymetry data and water elevation monitoring data from within the Lake is needed to develop the water budget for the Project before completion of final design.

3.6.3 Water Budget and Projected Flows

A water budget for Upper Tibbetts Brook, Van Cortlandt Lake, and Tibbetts Wetland is needed to confirm appropriate water surface elevations that would promote ecological uplift opportunities (for both dry and wet weather conditions) and stormwater detention (for wet weather conditions) within the restored wetland complex. Weir elevations at both the new Lake and Wetland outlets can then be set to achieve these elevations during final design. The current weir elevation at the existing Lake outlet may also be modified, based on this information, to restrict flow and maintain water elevations in the Lake.

H&H calculations or modeling can then be undertaken for the final sizing of the Lake outlet chamber, and for the final design of the spillway and sand seepage berm (to include the appropriate erosion and sedimentation practices and substrate). To estimate potential CSO reductions in the Harlem River, NYCDEP's InfoWorks modeling for the Wards Island WWTP must be used.

3.6.4 Outlet Structure Sizing and Design

Final sizing and design of the flow control structures for both the Lake and wetland outlets is dependent on the findings of the water budget and H&H assessments described above. Geotechnical assessments are also needed to determine the final placement of the structure along the existing retaining wall for the southern edge of the Lake east of the bridge. The final siting and design of the outlet structures should also be informed by additional feedback from operations and maintenance staff at NYC Parks, as the flow control structures will require regular cleaning and potential weir adjustments over time.

3.6.5 Pipe Verification

Information about a feasible connection to the Broadway sewer remains a key data gap for the Project. Additional geotechnical analyses and conditions assessments (CCTV inspection) to determine the location, adequacy, and capacity of the existing sewer infrastructure within the Park (including a potential existing 42-inch sewer line) would provide the needed information for the final design of the connection from the proposed wetland outlet to the Broadway sewer.

3.6.6 Utilities Verification

A vault and CTV line are noted on survey drawings, within the new wetland boundary. Removal and relocation of the vault and associated utilities is not proposed or included in the cost estimate for the Project as it is unknown what the vault contains or its size. Similar assessments to the pipe verification described in Section 3.6.5 should be conducted for these unknown utilities.

3.6.7 Reuse of Excavated Materials

Approximately 3,800 cubic yards of fill are expected to be removed from the existing Project site. The Project Team recommends that an appropriate reuse of this fill, dependent on soils investigations to be conducted, be identified during final design. If feasible, reused fill could elevate areas that experience ponding and localized flooding near Tibbetts Wetland or in community use areas using the excavated soils from the Project.

4 Proposed Conceptual Plan and Cost Estimate

4.1 Design Objectives Met

The 30% design drawings and details in Appendix B are consistent with the Project goals and objectives, and the Project is expected to achieve:

- Potential opportunities for a future connection to the Harlem River;
- Restored wetlands (distinct water storage zones, and more complex, diverse habitat);
- Filtration of sediments and nutrients;
- Enhanced ecological features and plantings;
- Potential tree removals limited and tree protections required;
- Redesigned pathways and alignment with other park improvements;
- Adaptable lake diversion structure; and
- New connection to Broadway sewer.

4.2 Cost Estimate

The Project Team developed cost estimates for the conceptual design alternatives and preferred alternative, and updated costs to reflect the 30% design in Appendix C. Total project costs, for reference purposes only, are anticipated to be $15.5 million in 2025 dollars. Table 9 summarizes the major cost components and estimates for each. As final design advances and required data collection and analyses are completed, the cost estimate for the 30% design may change.

Table 9. 30% Design Cost Estimate Summary

Key Project Components	Estimated Costs
General Requirements	$726,800
Removals, Excavation, Site Work, & Erosion Control	$1,867,300
Utilities—Drainage, Electric, & Water	$254,400
Pathways, Overlook, Boardwalks, & Pavement Restoration	$1,598,900
Lake Outfall, Spillway, & Wetland Outlet	$1,373,100
Connection to Broadway Sewer	$1,866,800
Landscaping & Habitat Restoration	$858,200
Contingency	$2,136,400
Total (in 2016 dollars)	$10,681,900
Total (with escalation, in 2025 dollars)	$15,874,400

Appendix C includes the engineers' estimate for the Project, which was developed based on the following key assumptions:

- Rough order of magnitude (ROM) cost estimate is the Project Team's opinion of the probable cost of construction and is not a price proposal.
- ROM cost estimate is intended to provide a ballpark estimate of the probable costs of construction for project planning purposes. Typical degree of accuracy of estimate is 20 to 25%.
- ROM cost estimate does not include access, staging, geotechnical investigations, or project phasing.
- Build year estimate of 2025 includes annual escalation rate of 4.5%.
- Of estimated grading, 20% will require rock removal and 20% will require hand and/or pneumatic excavation.
- Costs associated with construction access, such as repaving existing pathways that trucks may use, are not included.
- Eight trees will be removed, with a total diameter at breast height (DBH) of 76 inches. Tree restitution onsite will include the planting of 240 saplings and 582 3-inch caliper trees, based on December 2015 tree survey. Restitution costs would be reevaluated according to updated tree survey once design is advanced.
- A vault is noted on the survey drawings, within the new wetland boundary. Removal and relocation of the vault and associated utilities is not included, as it is unknown what the vault contains or its size.

- Dewatering is not included.
- NYC Parks' 2016 Engineer's Estimate was used for costing. For items not listed in the 2016 Engineer's Estimate, recent construction bids for similar projects were used.

5 Potential O&M Requirements

5.1 Plantings

The first one to three years following landscape installation will require the greatest maintenance. During this period, it will be essential that invasive species are controlled and native species established. It is recommended that a maintenance and monitoring contract be established through the construction bid or as a separate contract to ensure that maintenance during this critical period occurs, as well as adaptive management. Adaptive management is an iterative process based on site conditions and site monitoring, allowing early corrective measures to be implemented to direct the Project toward success.

Following the establishment period, invasive species management will need to occur. Currently, *Phragmites australis* (Phragmites) is found on site. However, *Fallopia japonica* (Japanese knotweed) and *Lythrum salicaria* (Purple loosestrife) are common wetland invasive species that may develop onsite. As herbicide application within NYC Parks properties is limited, it is assumed that manual removal will be required. Phragmites, Japanese knotweed, and Purple loosestrife can be controlled through manual means. Phragmites and Japanese knotweed should be cut twice a year, in early and late summer, to limit plant spread through rhizomes and force the plant to expend resources in vegetative regrowth. Purple loosestrife can be removed by pulling or digging out the plants. With any invasive species, early detection and removal is critical. The site should be monitored at least once a year during the growing season to identify potential issues.

5.2 Outlets

Sediment, trash, and debris will need to be removed from the Lake and wetland outlet chambers once every five to ten years. Frequency will be dependent upon the sediment and debris loads within the Lake and wetland. Cleaning frequencies for the proposed Lake outlet are anticipated to be less than the existing outlet based on 30% design (the Lake outlet will draw from the water column, not surface, for example). In addition, the Lake is expected to continue to provide significant pretreatment as sediment would settle out prior to entering the Lake outlet chamber.

Both outfalls will be accessible by vacuum trucks to facilitate maintenance. The 30% design provides truck access to the outlets for maintenance. Final design is needed to prevent vandalism of the outlets, since outlets are currently proposed close to paths for maintenance staff access, and railings may be necessary to assure pathways to outlets are also accessible to park users.

5.3 Boardwalk

Maintenance of the boardwalk will follow NYC Parks' standards based upon the specific material used and path usage. The cost estimate assumed recycled plastic lumber or precast concrete would be used for boardwalk construction. Regular maintenance will include inspections to determine conditions and replacement of damaged sections, as needed.

6 Potential Opportunities for a Future Connection to the Harlem River along the Putnam Greenway

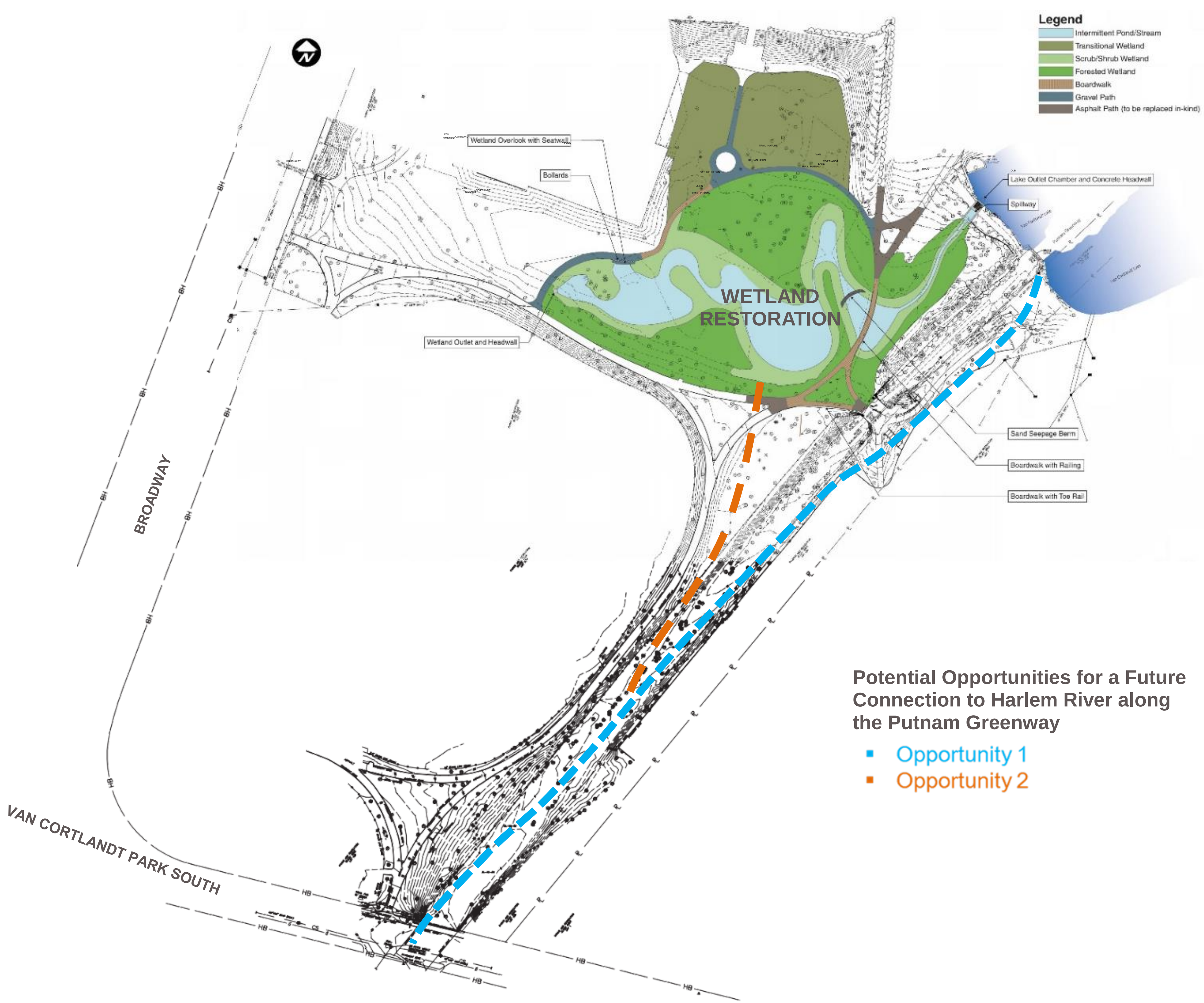
Throughout the development of the Project, opportunities for connecting the Lake and Tibbetts Wetland to the Harlem River along the Putnam Greenway were considered and discussed by NYC Parks and the Project Team. With the 30% design developed for the Project, two opportunities or alignments within the Park were identified for additional feasibility and design evaluations. Several factors including existing elevations for gravity flow to the Harlem River and potential conflicts with pedestrian circulation and trees were considered to identify these opportunites for a future connection. Each opportunity illustrated in Figure 15 would likely involve a combination of piped and surficial flow within the Park due to existing pedestrian connections, utilities, and topographic grade changes.

Starting at the Lake and east of the Putnam Greenway, Opportunity 1 would provide the highest discharge point from the Lake (elevation 15 feet with a channel or pipe bottom around 14 feet) to move flow through a surface stream and/or piped corridor. In contrast, Opportunity 2 would begin with a lower discharge point from the restored wetland west of the Putnam Greenway (proposed wet weather water at elevation 8 feet with a channel or pipe bottom around 7 feet).

While discharging at a lower starting elevation, Opportunity 2 would be a shorter linear run within the Park. The alignment of Opportunity 2 may avoid conflicts presented by Opportunity 1 such as existing/proposed paths, circulation, utilities, adjacent infrastructure, the railroad berm, and existing trees. Opportunity 2 could be piped under pathways to then connect to a linear surface expression or pipe east of the ball fields and downstream to the Opportunity 1 alignment south of the existing parking area.

The potential reduced cost for Opportunity 2 is associated with the alignment west of the Putnam Greenway and fewer impacts to the trails and parking east of the Greenway, the Greenway itself, and the Greenway Bridge. While some impacts from grading or utility realignment would still be expected with Opportunity 2, these are expected to be less than Opportunity 1.

Figure 15. Potential Opportunities for Connection to Harlem River



Opportunity 2 would not allow for as much variability in slopes due to the lower starting elevation and need to keep the channel invert above mean higher high water (MHHW) within the Park. However, tide gates could be considered downstream during future evaluations and design that would allow for a lower elevation within the Park.

The total length of pipe and/or stream corridor required to connect the Lake to the Harlem River would be approximately 8,700 linear feet (depending on where the connection to the Harlem River is made). Both within and beyond the Park, the potential right-of-way for a daylighted system is narrow and serves as a defining constraint on the geomorphology of potential daylighting design. Opportunity 2 would increase use of available space where it exists within the Park, while maintaining the existing Putnam Greenway alignment and potentially extending a surface water feature within the Park. The corridor is particularly constrained looking south of the Park, and may provide few opportunities for public access and use.

Detailed survey of the area east of the Putnam Greenway, including the area between the Greenway and the golf course parking lot, is needed to continue to evaluate opportunities for connecting Tibbetts Brook to the Harlem River. Baseline survey south of the Park, including utility locations, roadways/paths, existing drainage, property boundaries, tree survey, and wetlands is also needed. Evaluation of potential newly-created floodplains, related regulations, and potential impacts on existing adjacent uses and structures outside of the Park is also recommended. These and other uncertainties about downstream constraints such as tidal impacts and sea level rise remain significant at the time of writing this Design Report.

7 Next Steps

Future funding would need to be secured for additional phases of work. Section 3.6 describes the design limitations and data needs to be addressed to advance final design and construction for the wetland restoration. Future connections to the Harlem River would also require substantial data collection and analysis. A daylighted system would need to be engineered for maximum stability given that the flow regime would be dictated by diversions at the Lake and runoff from the Putnam Greenway and adjacent areas that currently experience localized flooding. H&H modeling and also an evaluation of the trade-offs (costs versus benefits) associated with different flows would assist the design of future connections.

As of June 2018, NYC Parks continues to be in negotiations with CSX regarding the potential acquisition of the railroad right-of-way adjacent to Interstate 87. If acquisition is successful, city agencies would need to coordinate agreements for remaining city-owned properties in the proposed daylighting or bypass corridor. The CSX property comprises approximately 60 percent of the length of the potential corridor. Feasibility for use of the remaining properties to establish a connection to the Harlem River is yet to be determined.

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Appendix A

30% Design Concept Rendering

Appendix B

30% Design Drawings and Details

Appendix C

30% Design Conceptual
Cost Estimate

Appendix D

30% Design Issues Log

Appendix E

Community and Stakeholder Engagement Plan

Appendix F

Community and Stakeholder Engagement Presentation

Appendix G

Site Photograph Log

Appendix H

Base Maps