Randall's Island and Effectiveness of Constructed Freshwater Wetland on Water Quality Improvement

By

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Abstract

This study investigates a constructed wetland located on Randall's Island located in the center of the island near the water treatment facility and fields. The constructed wetland's purpose is to remove non-point and other pollutants that run-off into the wetland. It works also as a secondary filtration site for a portion of the effluent coming from the water treatment facility before the treated water passes into the East River. The study to determine the effectiveness of the Constructed Wetland showed that NTU and DO decreased as the water moved from the entrance to the wetland toward the outflow into the surrounding environment which could point to not filtering out all pollutants. More data collection is needed to form more solid conclusions about the water quality and surrounding environment health on Randall's Island and if the wetland is improving them. After more research is done to determine if pollutants are actually being removed in large enough quantities it also might be advantageous to look into changing the system to a vertical flow constructed wetland for increased success of water filtration.

Introduction

Randalls/Wards Island Wetland History

Wetlands in the United States make up 5.5 percent of land cover in the contiguous states. An estimated 95% of these wetlands are freshwater while the remainder are marine or estuarine. Natural stressors such as erosion, drought, sea level rise and fall, storm events, and land subsidence can cause the loss of wetland habitat. However, the majority of loss of wetlands is caused by human activities. Climate change and the increased storm intensity that comes with it, along with rapid human growth causes wetlands, streams, rivers, etc. within urban centers to see increased non-point pollution during these, now more frequent, storm events. Wetlands are now also being drained and filled for agriculture and development purposes limiting the ability of wetlands to filter out pollution from our waterways etc. Wetlands act as habitat, buffer for erosion and flooding, and act as key links in global water cycles. Wetland root systems and soil filter pollutants, naturally improving water quality. The plant growth in wetlands also acts as sinks for atmospheric carbon and other chemicals (EPA. Wetlands, 2020).

The condition of wetlands can be affected by different stressors both physical, chemical, and biological. Storm events, sea level change, and agricultural and forestry practices can increase sedimentation and erosion. Modification of landscape by human intervention for pipes and channels etc. can alter the type of wetland, elevation and hydrology of wetland. Groundwater and surface water amount can also affect flow of water into and within the wetland(s). Pollutants within the water following into the wetland can be toxic to organisms as well as accumulate within the sediment.

Non-point Source Pollution

“The term "nonpoint source" is defined as any source of water pollution that does not meet the legal definition of "point source" in section 502(14) of the Clean Water Act: The term "point source" means any discernible, confined and discrete conveyance, including but not limited to any pipe, ditch, channel, tunnel, conduit, well, discrete fissure, container, rolling stock, concentrated animal feeding operation, or vessel or other floating craft, from which pollutants are or may be discharged. This term does not include agricultural storm water discharges and return flows from irrigated agriculture. (EPA, 2020)” Nonpoint Source Pollution comes generally from land runoff, precipitation, atmospheric deposition, drainage, seepage, and or hydraulic modification. This also means that unlike pollution from industrial sources nonpoint source pollution comes from a combination of diffuse sources. This pollution is caused by storm events or melt picking up pollutants as it flows into different waterways/bodies of water. This pollution is

usually from fertilizers, herbicides, oil, grease, toxic chemicals, sediment, acid drainage, road salts, bacteria, excess nutrients, animal waste, human waste (septic waste), atmospheric deposition, and hydromodification (EPA, 2020). Urban stormwater runoff mitigation has prominently been done with detention basins and or retention ponds.

Heavy metals such as Zn, Cu, Cd, Cr, and Pb are released from contaminated sediments into the water occur during storm events and the rates of release can be affected by multiple conditions. The heavy metal release rates were much greater in low pH conditions (4-7) compared to high pH conditions (8-10) heavy metal release rates were increased at temperatures between 30-35°C compared to speed of the release rates at lower temperatures. Flow rate within the body of water/location in question can affect the release of heavy metals. Showing that flow rate significantly affected release of Zn, Pb, and Cr, while also showing slight effects on the concentrations of Cu and Cd (Li, et al., 2013).

Pollutant removal from wastewater is the most cost effective and environmentally sustainable when the treatment(s) use biological treatment processes. This can be through assimilation, biodegradation, metabolism, absorption, flocculation, precipitation, and ion exchange. These treatments during the waste water filtering through a wetland thanks to common plants and microorganisms within the wetland that remove pollutant loads from wastewater. Common reeds that are commonly planted in constructed wetlands are used for nutrient uptake from domestic wastewater, helping purification of wastewater. Constructed Wetlands also have low costs of creation and operation which could be of great use to convince municipalities to implement more water quality control treatments to help alleviate conventional wastewater treatment overflow, etc. (Scholz, M. (n.d.), Pollutant Removal)

Point Source Pollution

In addition to the above non-point pollutants, two major classes of pollutants are often closely associated with point-sources such as wastewater treatment facilities. The first of these is nitrate and nutrient levels. Excess levels of nutrients can lead to excessive plant growth. Once these plants start to die the decomposition of the large masses and plants and algaes leads to anoxia and eutrophication (NOAA, 2019). In high levels excessive nutrients can become toxic to humans and other life.

Presence of *E. coli* can be a factor if high levels of human and or animal waste are present in a particular water body (LCRA, 2021). *E. coli* and bacterial pathogens can come from water passing out of wastewater treatment plants such as the one on Randall's Island that uses the constructed wetland as a secondary filtering stage. The

presence of *E. coli* and other pathogens with uropathogenic properties seem to survive the treatment stages within sewage treatment plants. The high percentage of environmental *E. coli* in water around the world near sewage treatment plants also suggest that this bacteria may have been from effluent from these treatment plants and other non-point sources for runoff (Anastasi E. M. et. al., 2012).

pH of the water is a key indicator of water quality. Auto exhaust, and other pollutants can cause drops in pH. Spills from agricultural runoff, sewer overflow, and other runoff can also change pH levels. Extreme pH values on either end of the spectrum can be lethal to most organisms. Expected levels for a stream, freshwater small body of water, etc. can be anywhere between 6.5 to 9.0 (LCRA, 2021). Finally, separate from either source of pollution, invasive species can alter composition of wetlands, deter native plants from growth, deter native species from feeding, etc. It can also affect food pyramids, and landscape diversity. Wetland loss can mount stress on the remaining wetlands forcing this excess of pollutants from surface waters, etc. to concentrate and be forced through the now smaller and less capable wetlands. This decreases overall habitat, landscape diversity, and connectivity between natural ecosystems and aquatic resources. All these condition changes can contribute to habitat type change and community structure change that can have major ecological effects (EPA. Wetlands, 2020).

At two sites in London where urban runoff treatment wetlands have been constructed it has been shown that during storm events there is an increase of efficiency with removal of urban pollutants from runoff and other non point source pollution entering the wetland(s). During dry weather efficiency of the wetlands varies greatly. During storm events heavy metals increase in mean values of removal efficiency as well as for suspended solids and removal of biological oxygen demand also increases during storm events (Scholes, L. N. L. et al., 1999). Constructed wetlands have been shown to filter water passing through them with a similar ability to natural wetlands. A study on an agricultural area wetland, over the course of two years, was shown to reduce phosphorus levels by close to 60% and nitrate levels to 40%. These constructed wetlands could also act as buffer zones filtering out runoff from agriculture, roadways, impervious surfaces, etc. (The Ohio State University, Wagner, H., 2005) This shows that these constructed wetlands can significantly reduce fertilizers and other types of chemical pollutants. They can also become sinks for nutrients like phosphorus that could possibly later be used for agricultural use.

Constructed wetlands can be a low cost, efficient way to clean non-point wastewaters (drainage, agricultural, landfill leachates, chemicals, industrial, etc.) These wetlands as well as natural wetlands act as buffer zones for the surrounding water bodies and as a polishing stage for effluents from wastewater treatment plants before

reaching the receiving water way. Traditional wastewater treatment facilities have issues removing several xenobiotic organic compounds (pesticides, pharmaceutical residues, etc.) and this contaminates these receiving bodies of water. The addition of constructed wetlands to be used as living filters for the purification of the water after initial filtration makes it so these contaminants that are usually left behind are removed before being released into surrounding water bodies (Dordio, A. et al., 2008).

Hydrology

There are different types of constructed wetlands such as horizontal subsurface flow constructed wetlands and vertical flow constructed wetlands. Vertical flow constructed wetlands are planted filter beds with drainage at the bottom. The wastewater is then mechanically released in selected amounts onto the surface of the wetland. The water then flows down through the matrix filter created by the plants and soil into the bottom of the basin to collect in a drainage pipe and then is ported to other locations (bodies of water, irrigation, etc.) horizontal subsurface flow constructed wetlands are large gravel and sand filled basins with wetland vegetation and as water flows through filter material removing particles and microorganisms from vegetation degrade the organic waste(s). The horizontal and vertical flow constructed wetlands can be paired together with a primary treatment water system that is already in place to have higher quality effluent with less pollutant release when it passes through these wetland features (SSWM, Vertical Flow Constructed Wetland).

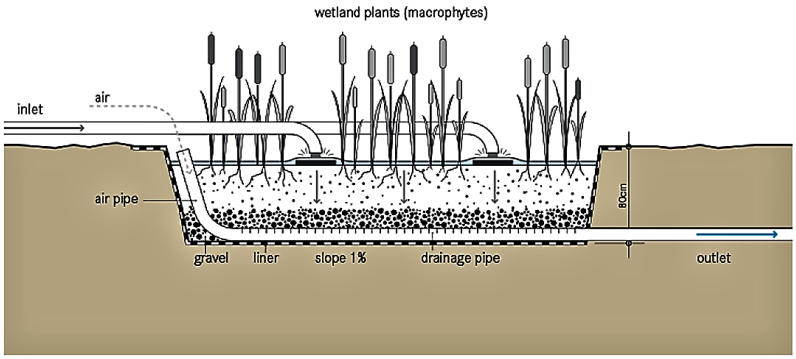


Figure 1. Schematic of the Vertical Flow Constructed Wetland. Source: TILLEY et al. (2014).

There are three main processes that constructed wetlands do to improve water quality: sediment trapping, excess nutrient removal, chemical removal and

detoxification. When water enters a wetland, the water flows through the native vegetation reducing the velocity of the flow, allowing suspended material in the water to settle to the wetland's surface. The roots of wetland plants can help trap accumulated sediment and pollution. 90 percent of the sediments that are present in runoff or in streamflow can be removed if the water passes through the wetland. Pollutants, such as heavy metals, are attached to soil particles, and the retention of these particles in wetlands further improves water quality due to this removal of pollutants like heavy metals clinging to these particles (VT.DEC. Wetland Functions and Values).

In New York State, because of years of not fully understanding the benefits of wetlands, almost half of the historic wetlands in the state have been lost due to filling and drainage. This creates a reason for the construction of man-made wetland features. Constructed wetlands can have functions and benefits for surrounding waterways/ bodies of water such as: flood and storm water control, surface and groundwater protection, erosion control, pollution treatment, nutrient cycling, fish and wildlife habitat, and public use! (NYS. DEC. Freshwater Wetlands Program).

This study focused on a constructed freshwater wetland located on Randall's Island; an island located between the Harlem River and the East River. Randall's Island is 516 acres in total conjoined with Ward's Island. The constructed wetland was planned as well as initial construction starting in October of 2006. This particular construction featured a horizontal subsurface flow regime. This wetland filters water coming from rain, stormwater runoff, groundwater, and the water treatment plant. This filtering is extremely helpful for secondary and primary filtration before water is passed into the surrounding environment. The wetland also provides critical habitat for breeding of butterflies, dragonflies, damselflies, and for migratory habitat for many bird species (Randall's Island Park Alliance, 2017). There are many water quality indicators that are essential for determining the overall health of a body of water. Dissolved oxygen, temperature, total dissolved solids, and total suspended solids, are four key parameters that can be affected as water moves through a horizontal subsurface flow wetland.

Dissolved Oxygen (DO) is crucial for supporting both plant and animals within a system and pollution (Nonpoint-Source pollution) has been shown to decrease DO harming wildlife and aquatic organisms. This decrease can come from runoff, sewage, leaf litter decomposition, grass clipping decomposition (with presence of pesticides, etc.) Expected Levels of DO according to the LCRA and Colorado River Watch Network is between 4.0mg/L to 12.0mg/L (LCRA, 2021).

Water temperature can be a key indicator for overall health of a water body. Aquatic plants and animals are dependent on certain temperature ranges. Temperature can also affect DO levels, types of plants and animals that will be present, as well as the

ability of the organisms present to either defend and or adapt to pollution, disease, and or parasites. Unexpected temperature change could be caused by discharge from urban sources, groundwater inflows, etc. Normal seasonal range for water temperature in lakes and streams is between 22-35°C between May and October and 2-27°C between November and April (LCRA, 2021).

Conductivity, a measure of total dissolved solids, can also be a major factor in water quality. This can be affected by dissolved solids and suspended solids such as chloride, sulfate, calcium, others. High readings can come from industrial pollution, urban runoff, and extended periods of dry and low flow conditions can contribute to total dissolved solids, and conductivity to increase (LCRA,2021).

Water clarity can be a major factor in water quality as well as being a direct effect on aquatic flora and fauna present in a wetland. Transparency/clarity of the water is showing a low amount of total suspended solids within the water. These suspended particles impact turbidity (NTU) which is the water appearing cloudy or murky. This is either from suspended solids or dissolved solids from pollutants and or other substances. The higher amount of these particles the more light is scattered making it harder for the light to penetrate deeper into the water column because of the decrease in clarity. Water quality management agencies have established a series of maximum turbidity standards for different water body classifications that support different designated uses to put controls on water quality. These classifications are: class 1B (drinking water)/10 NTU, class 2A (cold water fishery, all recreation)/10 NTU, class 2B (cool/warm water fishery, all recreation)/25 NTU, and class 2C (indigenous fish, most recreation)/25 NTU (Minnesota Pollution Control Agency, 2021).

Methods

To gather data on if the constructed freshwater wetland on Randall's Island functions to improve water quality by removing pollutants, sediment, etc. from the water. Data collection occurred at multiple sites within the wetland using a YSI multimeter to test for Total Dissolved Solids, Turbidity (NTU), Temperature, and Dissolved Oxygen. This testing all had to be done when there was enough water present in the wetland to fully submerge the sensors on the YSI machine. To do this consistently testing had to occur during a rain event or while snowmelt is occurring. This testing can then help determine if the horizontally constructed freshwater wetland is filtering out non-point source pollution and other runoff pollution as well as the effectiveness of the filtering.

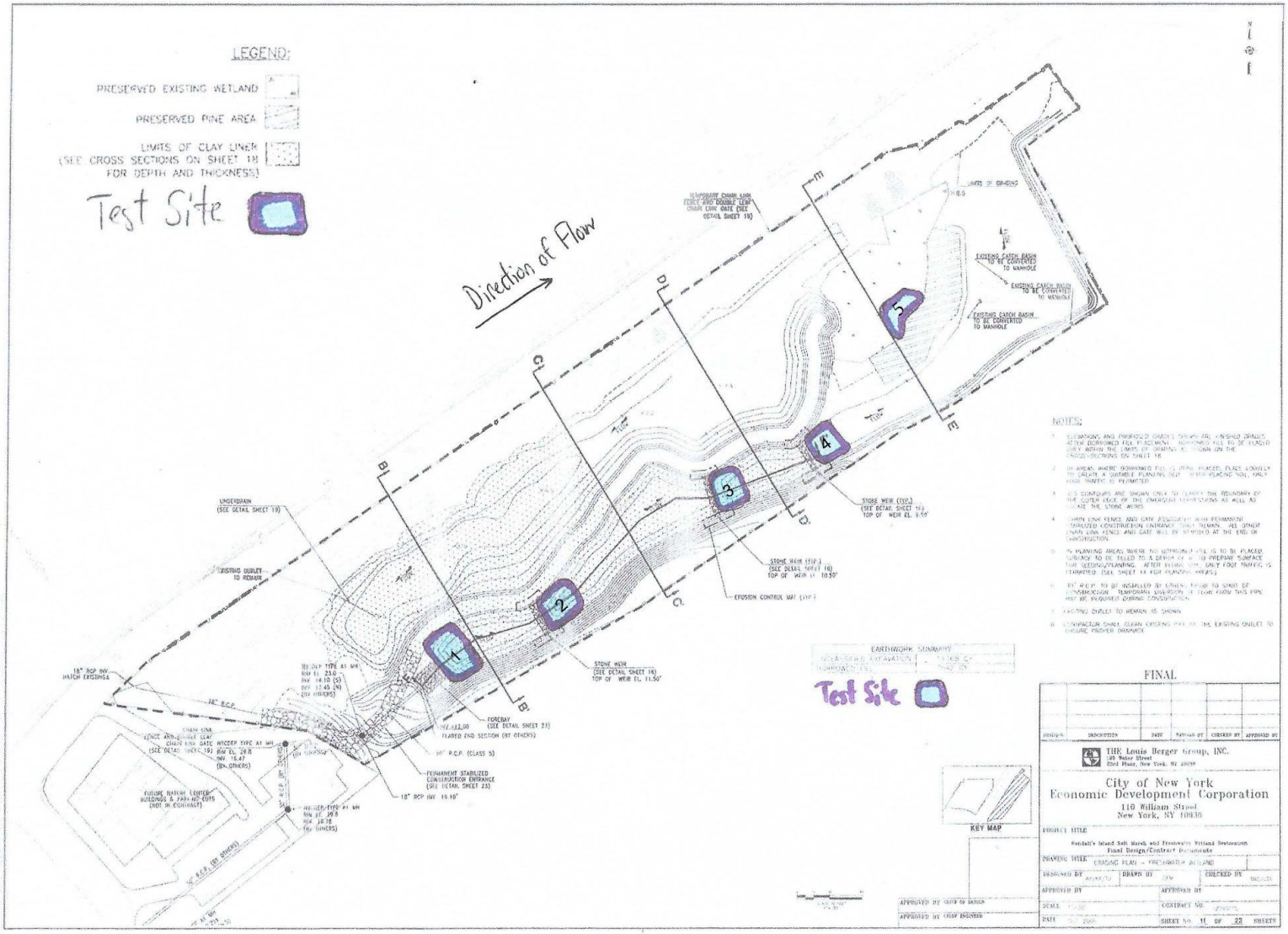

LEGEND:
PRESERVED EXISTING WETLAND
PRESERVED PINE AREA
LIMITS OF CLAY LINER (SEE CROSS SECTIONS ON SHEET 18 FOR DEPTH AND THICKNESS)
Test Site
Direction of Flow
NOTES:
EARTHWORK SUMMARY
Test Site
KEY MAP
FINAL
THE Louis Berger Group, INC.
City of New York
Economic Development Corporation
110 William Street
New York, NY 10038
Randall's Island Salt Marsh and Freshwater Wetland Restoration
Final Design/Contract Documents
GRADING PLAN - FRESHWATER WETLAND
SHEET NO. 11 OF 23 SHEETS

Figure 2. Constructed freshwater wetland site locations with location of preserved natural wetland, constructed, etc. This map was altered from an original planning map for the Randall's Island saltmarsh and freshwater restoration project by the City of New York Economic Development Corporation.

PLANTING TABLE

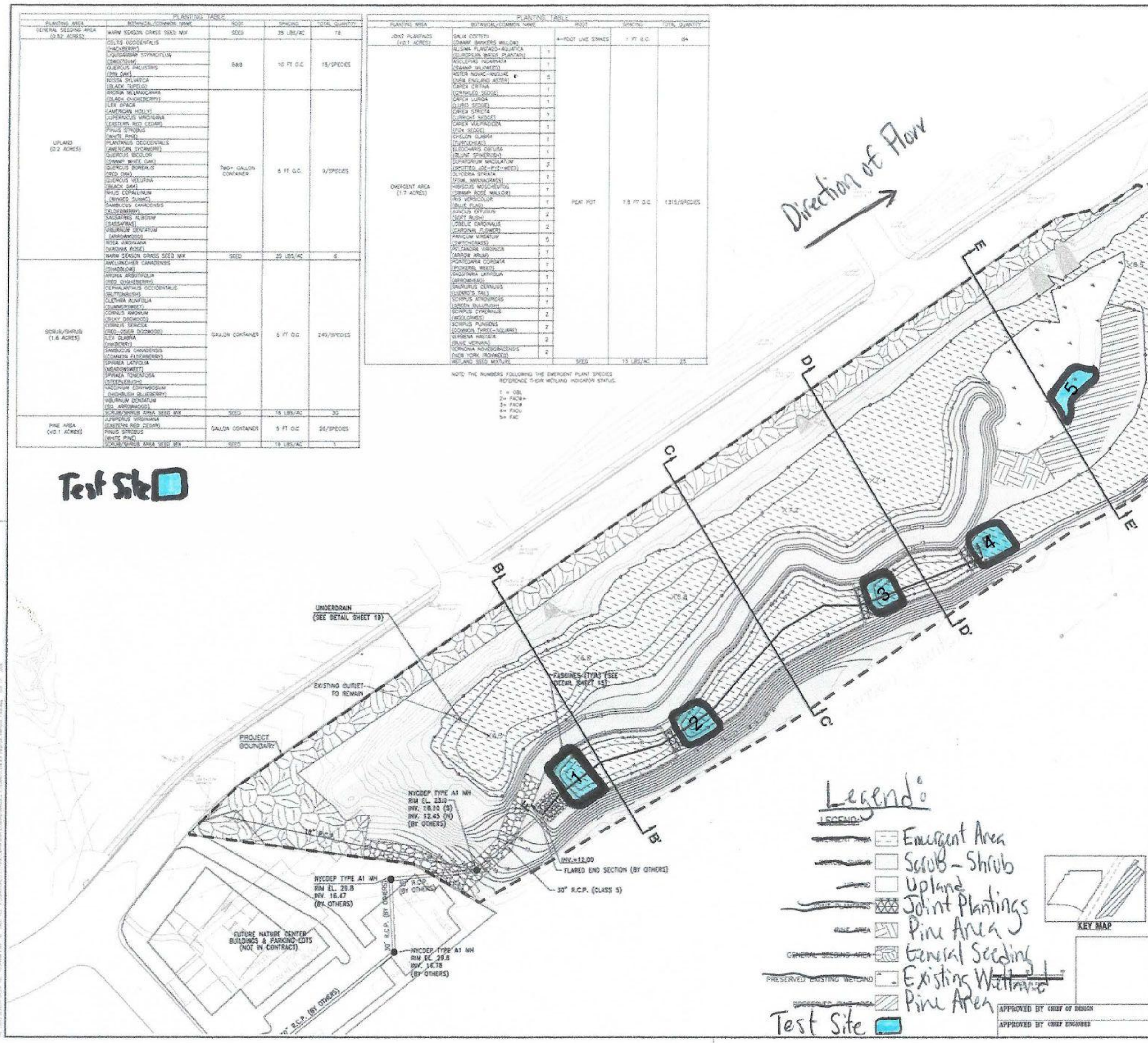
PLANTING AREA	BOTANICAL/COMMON NAME	ROOT	SPACING	TOTAL QUANTITY
GENERAL SEEDING AREA (0.52 ACRES)	WARM SEASON GRASS SEED MIX	SEED	35 LBS/AC	18
UPLAND (0.2 ACRES)	CELTIS OCCIDENTALIS (HACKBERRY)	B&B	10 FT O.C.	16/SPECIES
	LIQUIDAMBAR STYRACIFLUA (SWEETGUM)			
	QUERCUS PALUSTRIS (PIN OAK)			
	NYSSA SYLVATICA (BLACK TUPELO)			
	ARONIA MELANOCARPA (BLACK CHOKEBERRY)	TWO- GALLON CONTAINER	8 FT O.C.	9/SPECIES
	ILEX OPACA (AMERICAN HOLLY)			
	JUNIPERUS VIRGINIANA (EASTERN RED CEDAR)			
	PINUS STROBUS (WHITE PINE)			
	PLANTANUS OCCIDENTALIS (AMERICAN SYCAMORE)			
	QUERCUS BICOLOR (SWAMP WHITE OAK)			
	QUERCUS BOREALIS (RED OAK)			
	QUERCUS VELUTINA (BLACK OAK)			
	RHUS COPALLINUM (WINGED SUMAC)			
	SAMBUCUS CANADENSIS (ELDERBERRY)			
	SASSAFRAS ALBIDUM (SASSAFRAS)			
	VIBURNUM DENTATUM (ARROWWOOD)			
	ROSA VIRGINIANA (VIRGINIA ROSE)			
	WARM SEASON GRASS SEED MIX	SEED	35 LBS/AC	6
SCRUB/SHRUB (1.6 ACRES)	AMELANCHIER CANADENSIS (SHADBLOW)	GALLON CONTAINER	5 FT O.C.	240/SPECIES
	ARONIA ARBUTIFOLIA (RED CHOKEBERRY)			
	CEPHALANTHUS OCCIDENTALIS (BUTTONBUSH)			
	CLETHRA ALNIFOLIA (SUMMERSWEET)			
	CORNUS AMOMUM (SILKY DOGWOOD)			
	CORNUS SERICEA (RED-OSIER DOGWOOD)			
	ILEX GLABRA (INKBERRY)			
	SAMBUCUS CANADENSIS (COMMON ELDERBERRY)			
	SPIRAEA LATIFOLIA (MEADOWSWEET)			
	SPIRAEA TOMENTOSA (STEEPLEBUSH)			
	VACCINIUM CORYMBOSUM (HIGHBUSH BLUEBERRY)			
	VIBURNUM DENTATUM (SO. ARROWWOOD)			
	SCRUB/SHRUB AREA SEED MIX	SEED	18 LBS/AC	30
PINE AREA (<0.1 ACRES)	JUNIPERUS VIRGINIANA (EASTERN RED CEDAR)	GALLON CONTAINER	5 FT O.C.	26/SPECIES
	PINUS STROBUS (WHITE PINE)			
	SCRUB/SHRUB AREA SEED MIX	SEED	18 LBS/AC	1

PLANTING TABLE

PLANTING AREA	BOTANICAL/COMMON NAME		ROOT	SPACING	TOTAL QUANTITY
JOINT PLANTINGS (<0.1 ACRES)	SALIX COTTETI (DWARF BANKERS WILLOW)		4-FOOT LIVE STAKES	1 FT O.C.	84
EMERGENT AREA (1.7 ACRES)	ALISMA PLANTAGO-AQUATICA (EUROPEAN WATER PLANTAIN)	1	PEAT POT	1.8 FT O.C.	1315/SPECIES
	ASCLEPIAS INCARNATA (SWAMP MILKWEED)	1			
	ASTER NOVAE-ANGLIAE (NEW ENGLAND ASTER)	5			
	CAREX CRINITA (CRINKLED SEDGE)	1			
	CAREX LURIDA (LURID SEDGE)	1			
	CAREX STRICTA (UPRIGHT SEDGE)	1			
	CAREX VULPINOIDEA (FOX SEDGE)	1			
	CHELON GLABRA (TURTLEHEAD)	1			
	ELEOCHARIS OBTUSA (BLUNT SPIKERUSH)	1			
	EUPATORIUM MACULATUM (SPOTTED JOE-PYE-WEED)	3			
	GLYCERIA STRIATA (FOWL MANNAGRASS)	1			
	HIBISCUS MOSCHEUTOS (SWAMP ROSE MALLOW)	1			
	IRIS VERSICOLOR (BLUE FLAG)	1			
	JUNCUS EFFUSUS (SOFT RUSH)	2			
	LOBELIE CARDINALIS (CARDINAL FLOWER)	2			
	PANICUM VIRGATUM (SWITCHGRASS)	5			
	PELTANDRA VIRGINICA (ARROW ARUM)	1			
	PONTEDARIA CORDATA (PICKERAL WEED)	1			
	SAGITARIA LATIFOLIA (ARROWHEAD)	1			
	SAURURUS CERNUUS (LIZARD'S TAIL)	1			
	SCIRPUS ATROVIRENS (GREEN BULLRUSH)	1			
	SCIRPUS CYPERINUS (WOOLGRASS)	2			
	SCIRPUS PUNGENS (COMMON THREE-SQUARE)	2			
	VERBENA HASTATA (BLUE VERVAIN)	2			
	VERNONIA NOVEBORACENSIS (NEW YORK IRONWEED)	2			
	WETLAND SEED MIXTURE		SEED	15 LBS/AC	25

NOTE: THE NUMBERS FOLLOWING THE EMERGENT PLANT SPECIES REFERENCE THEIR WETLAND INDICATOR STATUS.

1 = OBL
2= FACW+
3= FACW
4= FACU
5= FAC



NOTES:

1. ELEVATIONS AND PROPOSED GRADES SHOWN ARE FINISHED GRADES AFTER BORROWED FILL PLACEMENT. SEE SHEET 18 FOR BORROWED FILL DEPTHS.
2. TEMPORARY CONSTRUCTION ENTRANCE SHOWN ON SHEET 22 TO BE REMOVED PRIOR TO PLANTING.
3. GENERAL SEEDING AREA SHALL ONLY BE SEEDED IF VEGETATION IS DISTURBED.
4. PLANTING IN THE FRESHWATER WETLAND AREA SHALL BE DONE UNDER THE DIRECT SUPERVISION OF THE SITE SUPERVISOR. THE SITE SUPERVISOR MAY DIRECT THAT CERTAIN PLANTS BE PLACED IN SPECIFIC LOCATIONS WITHIN THE PLANTING AREAS.
5. ONLY OUTSIDE BOUNDARY OF WATERFOWL BARRIER SHOWN. FOR INSTALLATION OF INNER CELLS, SEE DETAIL SHEET 15 AND CONSTRUCTION SPECIFICATIONS.
6. SITE SUPERVISOR WILL DIRECT LOCATION OF SHRUBS PLANTED ATOP THE BERM LOCATED IN THE CENTER OF THE SITE TO ALLOW FOR PEDESTRIAN TRAFFIC.

FINAL

REVISION	DESCRIPTION	DATE	REVISED BY	CHECKED BY	APPROVED BY

APPROVED BY CHIEF OF DESIGN

APPROVED BY CHIEF ENGINEER

THE Louis Berger Group, INC.
180 Water Street
23rd Floor, New York, NY 10038

City of New York
Economic Development Corporation
110 William Street
New York, NY 10038

PROJECT TITLE
Randall's Island Salt Marsh and Freshwater Wetland Restoration
Final Design/Contract Documents

DRAWING TITLE PLANTING PLAN – FRESHWATER WETLAND

DESIGNED BY AY/KA/TD	DRAWN BY CEM	CHECKED BY AMS/JTA
APPROVED BY	APPROVED BY	
SCALE 1"=30'	CONTRACT NO. 12390015	
DATE OCT. 2006	SHEET NO. 14 OF 23 SHEETS	

Figure 3. Constructed freshwater wetland site locations with a list of plants/material within the wetland. This map was altered from an original planning map for the Randall's Island saltmarsh and freshwater restoration project by the City of New York Economic Development Corporation.

The constructed wetland at Randall's Island is broken up into multiple habitat types consisting of a few constructed features: a general seeding area of grass (warm season grass mix), a upland area consisting of 18 species of native trees (deciduous), a scrub/shrub brush type area consisting of 13 species, and a final pine area consisting of 3 species of native trees (coniferous). The list of the planting area, the botanical/common names of the species, the root types of the plants, spacing, and total quantities are all listed within Table(s) 1-3. The remaining parts of the habitat are a small existing portion of the wetland and a small existing pine area that are in the E section of Figure(s) 2-3.

PLANTING TABLE

PLANTING AREA	BOTANICAL/COMMON NAME	ROOT	SPACING	TOTAL QUANTITY
GENERAL SEEDING AREA (0.52 ACRES)	WARM SEASON GRASS SEED MIX	SEED	35 LBS/AC	18
UPLAND (0.2 ACRES)	CELTIS OCCIDENTALIS (HACKBERRY)	B&B	10 FT O.C.	18/SPECIES
	LIQUIDAMBAR STYRACIFLUA (SWEETGUM)			
	QUERCUS PALUSTRIS (PIN OAK)			
	NYSSA SYLVATICA (BLACK TUPELO)			
	ARONIA MELANOCARPA (BLACK CHOKEBERRY)	TWO– GALLON CONTAINER	8 FT O.C.	9/SPECIES
	ILEX OPACA (AMERICAN HOLLY)			
	JUPERNICUS VIRGINIANA (EASTERN RED CEDAR)			
	PINUS STROBUS (WHITE PINE)			
	PLANTANUS OCCIDENTALIS (AMERICAN SYCAMORE)			
	QUERCUS BICOLOR (SWAMP WHITE OAK)			
	QUERCUS BOREALIS (RED OAK)			
	QUERCUS VELUTINA (BLACK OAK)			
	RHUS COPALLINUM (WINGED SUMAC)			
	SAMBUCUS CANADENSIS (ELDERBERRY)			
	SASSAFRAS ALBIDUM (SASSAFRAS)			
	VIBURNUM DENTATUM (ARROWWOOD)			
	ROSA VIRGINIANA (VIRGINIA ROSE)			
	WARM SEASON GRASS SEED MIX	SEED	35 LBS/AC	6
	AMELIANCHIER CANADENSIS			

Table 1. Planting table for upland area of the constructed wetland. This planting table was taken from the construction map from figure #3 (City of New York Economic Development Corporation).

SCRUB/SHRUB (1.6 ACRES)	AMELIANCHIER CANADENSIS (SHADBLOW)	GALLON CONTAINER	5 FT O.C.	240/SPECIES
	ARONIA ARBUTIFOLIA (RED CHOKEBERRY)			
	CEPHALANTHUS OCCIDENTALIS (BUTTONBUSH)			
	CLETHRA ALNIFOLIA (SUMMERSWEET)			
	CORNUS AMOMUM (SILKY DOGWOOD)			
	CORNUS SERICEA (RED-OSIER DOGWOOD)			
	ILEX GLABRA (INKBERRY)			
	SAMBUCUS CANADENSIS (COMMON ELDERBERRY)			
	SPIRAEA LATIFOLIA (MEADOWSWEET)			
	SPIRAEA TOMENTOSA (STEEPLEBUSH)			
	VACCINIUM CORYMBOSUM (HIGHBUSH BLUEBERRY)			
	VIBURNUM DENTATUM (SO. ARROWWOOD)			
	SCRUB/SHRUB AREA SEED MIX	SEED	18 LBS/AC	30
PINE AREA (<0.1 ACRES)	JUNIPERUS VIRGINIANA (EASTERN RED CEDAR)	GALLON CONTAINER	5 FT O.C.	26/SPECIES
	PINUS STROBUS (WHITE PINE)			
	SCRUB/SHRUB AREA SEED MIX	SEED	18 LBS/AC	1

Table 2. Planting table for scrub/shrub and pine area(s) of the constructed wetland. This planting table was taken from the construction map from figure #3 (City of New York Economic Development Corporation).

PLANTING TABLE					
PLANTING AREA	BOTANICAL/COMMON NAME		ROOT	SPACING	TOTAL QUANTITY
JOINT PLANTINGS (<0.1 ACRES)	SALIX COTTETII (DWARF BANKERS WILLOW)		4–FOOT LIVE STAKES	1 FT O.C.	84
EMERGENT AREA (1.7 ACRES)	ALISIMA PLANTAGO–AQUATICA (EUROPEAN WATER PLANTAIN)	1	PEAT POT	1.5 FT O.C.	1315/SPECIES
	ASCLEPIAS INCARNATA (SWAMP MILKWEED)	1			
	ASTER NOVAE–ANGLIAE (NEW ENGLAND ASTER)	5			
	CAREX CRITINA (CRINKLED SEDGE)	1			
	CAREX LURIDA (LURID SEDGE)	1			
	CAREX STRICTA (UPRIGHT SEDGE)	1			
	CAREX VULPINOIDEA (FOX SEDGE)	1			
	CHELON GLABRA (TURTLEHEAD)	1			
	ELEOCHARIS OBTUSA (BLUNT SPIKERUSH)	1			
	EUPATORIUM MACULATUM (SPOTTED JOE–PYE–WEED)	3			
	GLYCERIA STRIATA (FOWL MANNAGRASS)	1			
	HIBISCUS MOSCHEUTOS (SWAMP ROSE MALLOW)	1			
	IRIS VERSICOLOR (BLUE FLAG)	1			
	JUNCUS EFFUSUS (SOFT RUSH)	2			
	LOBELIE CARDINALIS (CARDINAL FLOWER)	2			
	PANICUM VIRGATUM (SWITCHGRASS)	5			
	PELTANDRA VIRGINICA (ARROW ARUM)	1			
	PONTEDARIA CORDATA (PICKERAL WEED)	1			
	SAGGITARIA LATIFOLIA (ARROWHEAD)	1			
	SAURURUS CERNUUS (LIZARD'S TAIL)	1			
	SCIRPUS ATROVIRENS (GREEN BULLRUSH)	1			
	SCIRPUS CYPERINUS (WOOLGRASS)	2			
	SCIRPUS PUNGENS (COMMON THREE–SQUARE)	2			
	VERBENA HASTATA (BLUE VERVAIN)	2			
	VERNONIA NOVEBORACENSIS (NEW YORK IRONWEED)	2			
	WETLAND SEED MIXTURE		SEED	15 LBS/AC	25

Table 3. Planting table for emergent area within the constructed wetland. This planting table was taken from the construction map from figure #3 (City of New York Economic Development Corporation).

Figure 3 details the step-pool construction style of the wetland. Within the Wetland there are stone walls with reinforcement made of chicken wire separating the sections of the wetland, acting as parts of the water filtration process, as well as decline in height of each of the stepped pools being demarcated by those stone walls. These stone walls and demarcation of the stepped declines are marked B-E on figures 1 and 2.

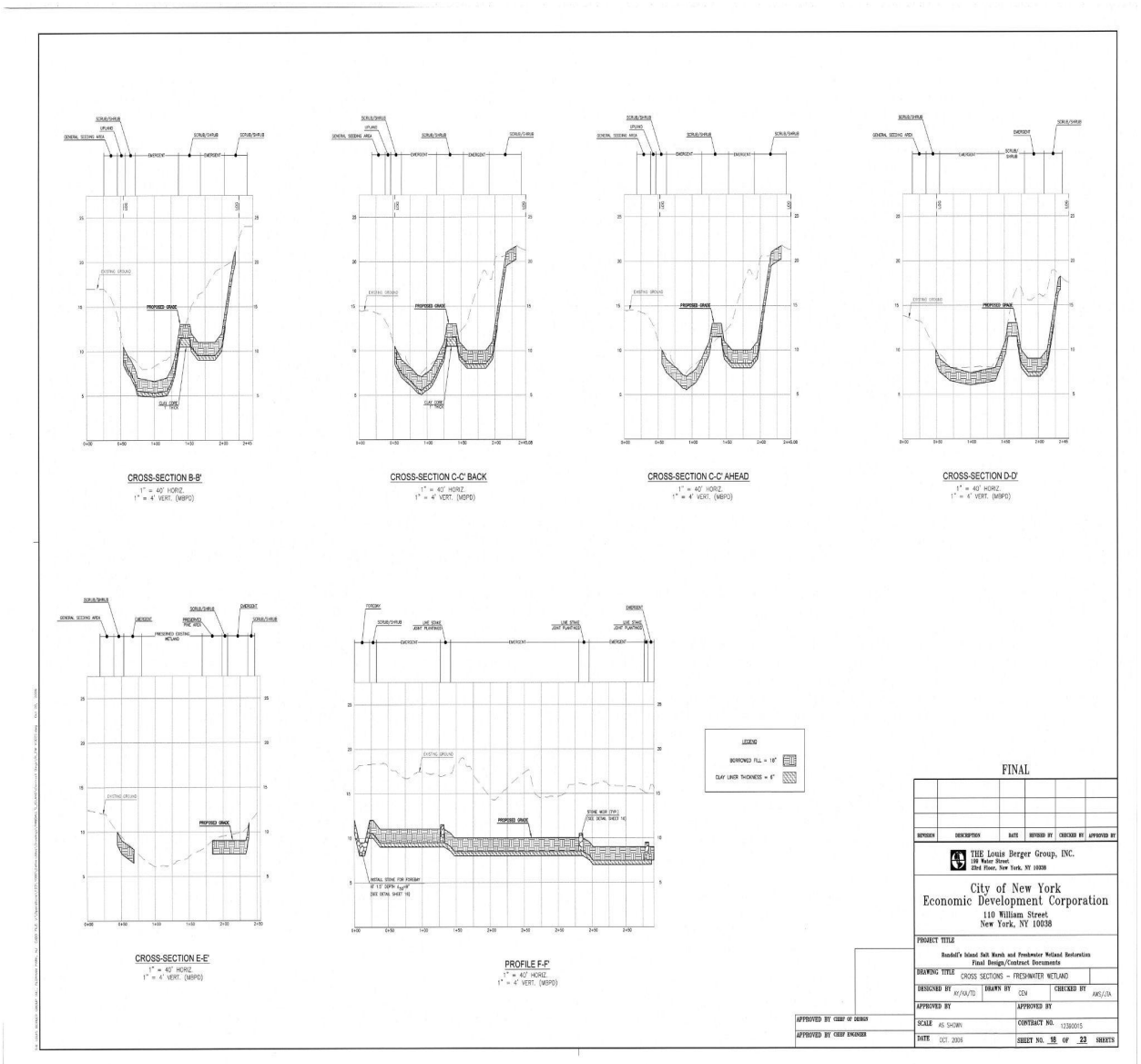


Figure 3. Depth mapping of constructed freshwater wetland. Created for the Randall's Island saltmarsh and freshwater restoration project by the City of New York Economic Development Corporation.

Timing of Sampling/Testing

_____From February 23rd to May 6th eight storm events were recorded and data collected using the YSI meter never after rainfall subsided. The intensity and duration of the storm events were all different; but all storm events filled the freshwater wetland. These samples were taken from five site locations (see Figure 1&2.) throughout the wetland following the flow of the water through the wetland to be able to see the difference in water "quality" content as it flowed through the Freshwater Wetland. The storm events occurred on: February 23rd, February 27th, March 1st, March 28th, April 11th, April 15th, April 25th, and May 6th.

Equipment

At each of the 5 sample sites at the Randall's Island Freshwater Wetland a YSI ProDSS Multiparameter Digital Water Quality Meter was used to test for temperature, total dissolved solids, dissolved oxygen (DO), salinity, conductivity, and turbidity. These field samples were all collected during storm events. The YSI meter uses multiple sensors to determine the content and "quality" of the water as it passes by the 5 sample sites dispersed throughout the Freshwater Wetland. These sensors are: four nickel electrode cell for conductivity, nephelometric - optical for turbidity, optical luminescence for dissolved oxygen, thermistor for temperature, and for total dissolved solids (TDS) it is calculated from conductivity and temperature, and for total suspended solids (TSS) it is correlated from turbidity field measurements and lab TSS measurements from grab samples. (ProDSS Multiparameter Digital Water Quality Meter)

Results

Dissolved oxygen average measurements decreased as water flowed through each of the 5 sampling sites. At sites #1-5 on day 1 DO was 10.89mg/L, 4.75mg/L, 8.78mg/L, 8.17mg/L, and 10.41mg/L. At sites #1-5 on day 8 DO was and at day 8 had DO values of 9.99mg/L, 8.95mg/L, 7.06mg/L, 7.1mg/L, and 4.31mg/L.

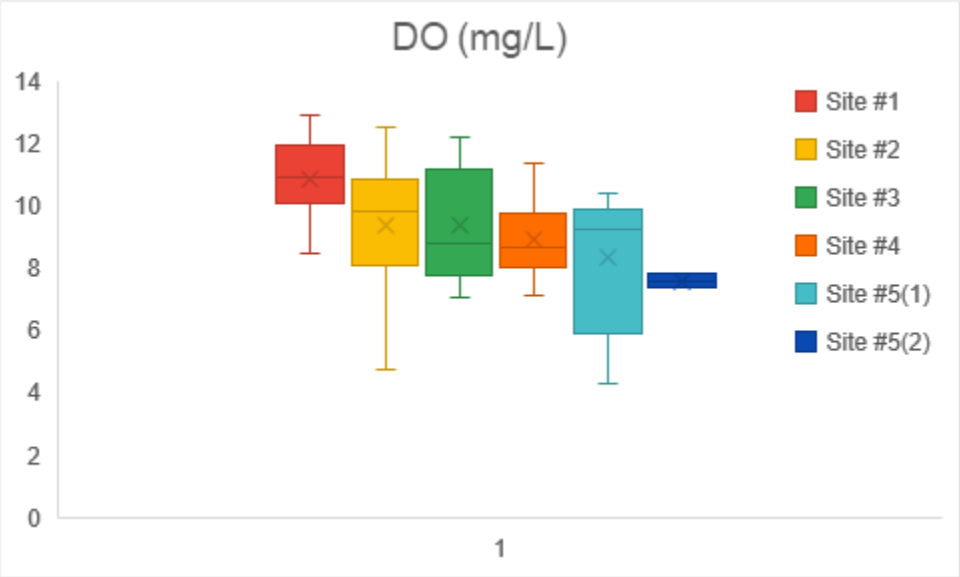


Figure 4. Average DO (mg/L) at each of the 5 collection sites shown as box and whisker plots. Site #5(2) only accounted for day 6 and 7 of the collection(s).

Total dissolved solid average measurements increased from site #1-4 and then from site #4-5 and 5(2) seeing decrease in TDS mg/L. At sites #1-5 on day 1 TDS was 1965.564mg/L, 20139.842mg/L, 4869.405mg/L, 5478.559mg/L, and 2593.555mg/L. At sites #1-5 on day 8 TDS was 172.658mg/L, 184.287mg/L, 208.971mg/L, 490.568mg/L, and 288.398mg/L.

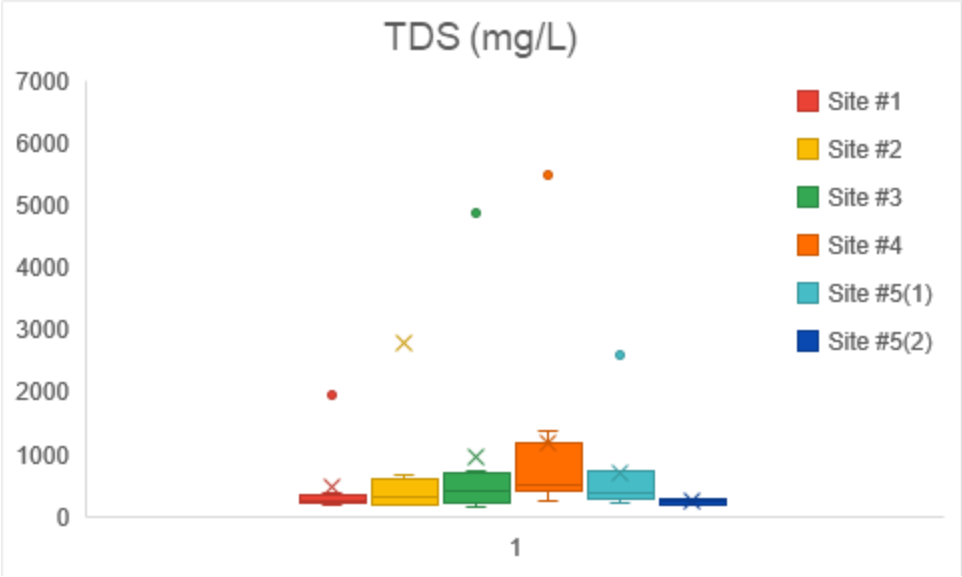


Figure 5. Average TDS (mg/L) at each of the 5 collection sites shown as box and whisker plots. Site #5(2) only accounted for day 6 and 7 of the collection(s). The y-axis scale has been changed to make viewing the data possible. There was a outlier of 20,139.842mg/L that was cut off for TDS site #2 because of the scale change.

Temperature average measurements seem to stay at a consistent level with slight increase from site #1-4 and slight decrease from site #4-5 and 5(2). At sites #1-5 on day 1 the temperature was 5.4°C, 5.5°C, 0.8°C, 3.8°C, and 5.4°C. At sites #1-5 on day 8 the temperature was 13.1°C, 13.7°C, 13.9°C, 15°C, and 14.2°C.

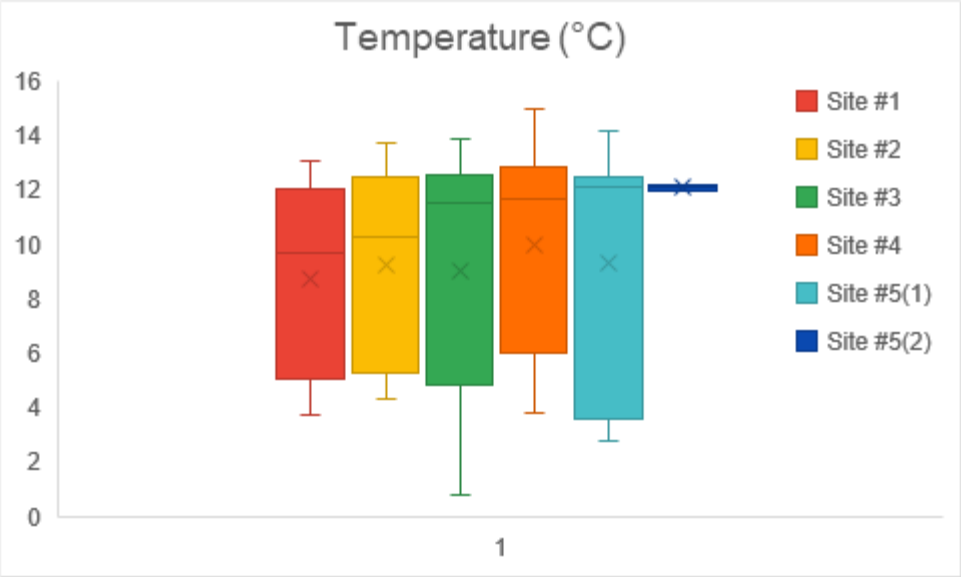


Figure 6. Average temperature (°C) at each of the 5 collection sites shown as box and whisker plots. Site #5(2) only accounted for day 6 and 7 of the collection(s).

Turbidity(NTU) average measurements increased from site #1-2 and then from site #2-5 and 5(2) seeing a decrease in NTU. At sites #1-5 on day 1 NTU was 15.6, 71.2, 9.1, 6.2, and 15.7. At sites #1-5 on day 8 NTU was 6.86, 61, 46.3, 9.7, and 10.4.

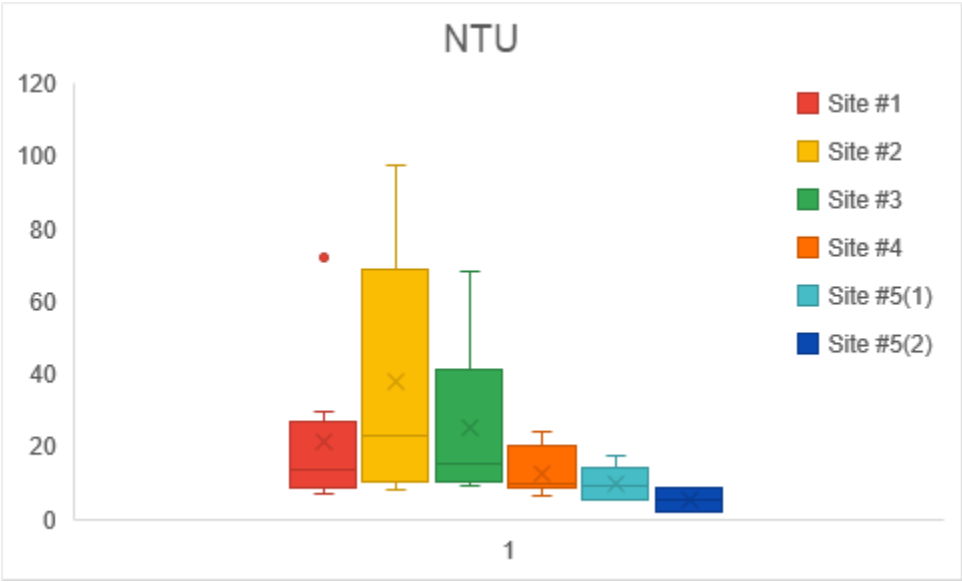


Figure 7. Average NTU at each of the 5 collection sites shown as box and whisker plots. Site #5(2) only accounted for day 6 and 7 of the collection(s).

Discussion

These results were not conclusive to point toward a significant pattern emerging and likely needs more data collection and or a fixed monitoring station to improve ability to determine if the constructed wetland on Randall's Island is actually reducing pollutants etc. from reaching the waterways around the wetland. This was shown in the statistical analysis of the data through paired t-tests for each of the testing parameters. This was to run a paired t-test on the values of site #1 versus site #5 to determine if the value change(s) from the water inflow to the water outflow are significant. The t-test for temperature had p-levels of: P(T<=t)one-tail 0.180665733 and P(T<=t)two-tail 0.361331466. These p-values for temperature are both over 0.05 showing they are not statistically significant. The t-test for TDS had p-levels of: P(T<=t)one-tail 0.011311979 and P(T<=t)two-tail 0.022623958. These p-values for TDS are both less than or equal to 0.05 making these values statistically significant. The t-test for DO had p-levels of: P(T<=t) one-tail 0.008494517 and P(T<=t)two-tail 0.016989033. Both of the DO p-values are less than or equal to 0.05 making these values statistically significant. This means more data collection is needed to get more information on DO and TDS. The t-test for NTU had p-levels of: P(T<=t)one-tail 0.100690324 and P(T<=t)two-tail 0.201380648. These p-values for NTU are both over 0.05 showing they are not statistically significant. The temperatures seem to range too widely to show a spatial pattern between the temperatures recorded and the locations where each temperature reading was taken.

DO and TDS seem to both suggest that there is a decrease in quality of the water, DO is gradually decreasing as the water passes the step down sections of the wetland. This makes sense as the wetland becomes increasingly still as it flows away from the metal pipe where the water enters the wetland from (besides nonpoint runoff). TDS seem to increase as the test sites move farther away from the entrance of the wetland showing that water clarity and quality is not being significantly improved as it passes through the plants soil and other biological filter material present within the constructed wetland. This is not conclusive though as the number starts to range a little more than is conclusive and more data collection is necessary to confirm this. I was not able to obtain pH levels at each of the sites that were accurate because of slight damage to the sensor on the YSI testing unit. The data collected for TDS showed an increase in mg/L of these dissolved solids as the water passed from site 1-4 and then a decrease from site 4 to site 5 and 5(2). This could be because site 5 and 5(2) (same as site 5 with 8 foot space between) get closer to more aquatic vegetation and or because the section(s) of water passing site 5 and 5(2) was moving slower allowing for the removal of larger qualities of heavy metals suspended within the water flowing through the wetland.

The data collected for Turbidity showed an increase in NTU from site 1-2 and then from site 2-5 and 5(2) there was a sharp decrease to below the readings for site #1. The sharp decrease in turbidity is most likely from the baffling between sections of the constructed wetland that act as extra buffer(s) for particulate matter flowing through the wetland in the water column. This decrease could also be from decrease in flow (speed as well as volume) of the water as it passes through the wetland. Also the aquatic plants and foliage increase in density as well as proximity of the plants aquatic plants and other vegetation from the water in the constructed wetland. Temperature seemed to have a negligible impact on anything.

The turbidity (NTU) and subsequent total dissolved solids (TDS) showed higher levels for the classification of drinking water, cold water fishery/all recreation which is 10 NTU, as well as being higher than the 25 NTU required in some locations during specific testing days to classify as cool/warm water fishery/all recreation and or native fish/most recreation. This is especially apparent when we look at site #2 day 3 where NTU was at 97.6 close to 4 times the classifications limits described. The temperature was within range for the most part for keeping in line with a normal temperature range for between May and October and for between November and April. The expected levels of DO for a stream/river also seemed to be in keeping with the data collected; only having 4 days where a location in the constructed wetland was above the max 12 mg/L. These 4 also were all less than 1 mg/L over the 12 mg/L max.

Conclusion

It seems that there is much more data needed to reach conclusions from analysis of the effectiveness of the constructed wetland. The constructed wetland implemented on Randall's Island for the purpose of secondary filtration of wastewater treatment outflow, as well as non-point (run-off) pollution from the surrounding roads, fields, and other sources of nonpoint pollution on the island, has shown through the small amount of testing done during this study to not be effectively filtering out pollution from the water passing through the constructed wetland. The most significant results came from the DO readings throughout the different test sites; showing overall decrease in DO as the water passed from site 1-5 (site 1 inflow of water, site 5 outflow pipe location). P-values for DO and TDS showing statistical significance also is a prompt for more data collection to confirm this information. There could be improvements in the performance achieved by the wetland from slightly altering the present layout of the constructed wetland on Randall's Island to be changed from a horizontal flow constructed wetland into a vertical flow orientation of the constructed wetland. The vertical flow style of wetland could be more effective at removal of non-point pollution when compared with horizontal flow wetlands. This is due to the dispersal method used to pass the water through the wetlands vegetation, soil, medium, etc. The next steps for the freshwater wetland and the surrounding area would be for further research to take place to form stronger conclusions about the water quality entering and leaving the freshwater wetland on Randall's Island. Then once adequate data has been collected a choice to change to a vertical flow oriented constructed wetland to increase water quality could then be implemented at a later date. As it stands the Randall's Island Constructed Wetland is a great step toward a cleaner environment and better water quality standards Randall's Island and the environment surrounding the island.

Literature Cited

--*Waterfront & Natural Areas*. Randall's Island Park Alliance. (2017, August 7). https://randallsisland.org/visit/waterfront-natural-areas/#:~:text=Many%20different%20types%20of%20plants,referred%20to%20as%20a%20swamp.

--Li, H., Shi, A., Li, M., & Zhang, X. (2013, December 2). *Effect of pH, Temperature, Dissolved Oxygen, and Flow Rate of Overlying Water on Heavy Metals Release from Storm Sewer Sediments*. Journal of Chemistry. https://www.hindawi.com/journals/jchem/2013/434012/.

--ProDSS Multiparameter Digital Water Quality Meter. (n.d.). https://www.ysi.com/prodss.

--*Wetland Functions and Values: Surface and Ground Water Protection*. Wetland Functions and Values: Surface and Ground Water Protection | Department of Environmental Conservation. (n.d.). https://dec.vermont.gov/watershed/wetlands/functions/water-quality.

--The Ohio State University, Wagner, H. (n.d.). Man-Made Wetland's Effectiveness Similar To Natural Marsh. (2005, March 6). https://news.osu.edu/man-made-wetlands-effectiveness-similar-to-natural-marsh/.

--*Freshwater Wetlands Program*. Freshwater Wetlands Program - NYS Dept. of Environmental Conservation. (n.d.). https://www.dec.ny.gov/lands/4937.html.

--Environmental Protection Agency. (2020, October 7). *Basic Information about Nonpoint Source (NPS) Pollution*. EPA. https://www.epa.gov/nps/basic-information-about-nonpoint-source-nps-pollution.

--Vertical Flow Constructed Wetland | SSWM. (n.d.). . https://www.sswm.info/water-nutrient-cycle/wastewater-treatment/hardwares/semi-centralised-wastewater-treatments/vertical-flow-constructed-wetland.

--Scholes, L. N. L., R. B. . Shutes, D. M. Revitt, D. Purchase, and M. Forshaw. 1999. The Removal of Urban Pollutants by Constructed Wetlands During Wet Weather. Water Science & Technology 40:333–340.

--Rossiello, C. 2018, May. “The Effect of Mature Free-Water Surface Flow Wetland Complex on the Quality of Stormwater Runoff Exiting a Suburban Campus”.

--Stodden, L. 2016, May. “Analysis of the Purchase College Storm Water Filtration System”.

--Robinson, S. 2019, May. “An Analysis of the Major Sources of Runoff Pollution on the Purchase College Campus Adjacent to the Western Branch of Blind Brook”.

--Dordio, Ana, et al. 2008 “WETLANDS: WATER “LIVING FILTERS”?” University of Évora, Évora, Portugal.

--Water quality indicators. LCRA. (2021, May 11). https://www.lcra.org/water/quality/colorado-river-watch-network/water-quality-indicators/.

--Environmental Protection Agency. (2020, March 18). Wetlands: What are the trends in the extent and condition of wetlands and their effects on human health and the environment? EPA. https://www.epa.gov/report-environment/wetlands.

--Scholz, M. (n.d.). Pollutant Removal. Pollutant Removal - an overview | ScienceDirect Topics. https://www.sciencedirect.com/topics/earth-and-planetary-sciences/pollutant-removal.

--Anastasi E. M., Matthews B., Stratton H. M., Katouli, M. (2012, August). Pathogenic escherichia coli found in sewage treatment plants and environmental waters. Applied and environmental microbiology. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3406122/.

--Minnesota Pollution Control Agency . (2021, August 11). *Turbidity: Description, Impact on Water Quality, Sources, Measures* . www.pca.state.mn.us. https://www.pca.state.mn.us/sites/default/files/wq-iw3-21.pdf.

--City of New York Economic Development Corporation. (n.d.). Randall's Island Salt Marsh and Freshwater Wetland Restoration Final Design/Contract Documents. *Randall's Island Park Alliance*. Map. (I received this information from Chris Girgenti, director of environmental programs at the Randall's Island Park Alliance.)

--US Department of Commerce, N. O. and A. A. (2019, April 2). *What is eutrophication?* NOAA's National Ocean Service. https://oceanservice.noaa.gov/facts/eutrophication.html.