Appendix F:
Assessment of the Condition State of Existing Tide Gates, Pump Stations and Berms in Little Ferry, Moonachie and Hackensack

The towns of Little Ferry, Moonachie and Hackensack have a long history of flooding. Beginning in the late 1600s, residents found ways to manage flooding and salt contamination from tides by digging ditches and constructing gates. The construction of canals began in the early 1900s by the Mosquito Commission, which was charged with the responsibility of preventing standing water as a mosquito control strategy. This effort resulted in the development of a complicated network of "legacy" berms, canals and ditches that, to a limited degree, continue to serve as flood control structures. The average elevation of the berms in Little Ferry, Moonachie and Hackensack is 5 feet above sea level (North American Vertical Datum of 1988 or NAVD 88). These berms and flood control structures such as tide gates are located on both private and public properties. Those structures in Little Ferry, Moonachie and Hackensack towns are shown in Figure 1 and detailed information is provided in Table 1. Figure 2 is a map developed in 1934 showing the area with constructed berms. The following sections describe condition states of flood controlling structures listed in Table 1 (DePeyster Creek Pump Station and Tide Gate, Losen Slote Tide Gate and Pump Station, Teterboro Pump Station, Willow Lake Pump Station, West Riser Tide Gate and Mosquito berms).

Figure 1 Map of Tide Gates, Pump Stations and Berms in Little Ferry, Moonachie, Lincoln Place, and Hackensack

Table 1 Location information of Tide Gates, Pump Stations and Berms in Little Ferry, Moonachie and Hackensack

#	Name	Elevation (NAVD88)	Latitude	Longitude	Location
1	DePeyster Creek Pump Station and Tide Gate- Protect Little Ferry	2.1ft-4.0ft	+ 40° 50' 30.52"	-74° 2' 3.21"	At the end of Dietrich Street
2	Losen Slote Tide Gate and Pump Station- Protect Little Ferry and Moonachie	6.1ft-8.0ft	+ 40° 49' 45.60"	-74° 2' 17.15"	Inter section of Empire Blvd and State street
3	Teterboro Pump Station- Protect Teterboro Airport up to 4'of of storm surge	N/A	+40° 51' 7.17"	-74° 4' 13.04"	Industrial Ave
4	Willow Lake Pump Station-- Protect Little Ferry	4.1ft-6.0ft	+40° 50' 51.73"	-74° 2' 5.09"	Willow Lake, Little Ferry
5	West Riser Tide Gate- Protect Moonachie and Teterboro Airport up to 4' of storm surge	2.1ft-4.0ft	+40° 50' 16.43"	-74° 4' 34.06"	At the end of Purcell Ct
6	Lincoln Place storm water pump station		+40°50'25.0"	-74°03'06.1"	30-48 Diamond Way, Moonachie, NJ 07074
7	Mosquito Wall- Protect Little Ferry and Moonachie	Average 5.0ft	+40° 50' 6.23"N +40°49'46.12"N	-74° 2' 0.45"E -74° 2' 28.95"E	Losen Slote Tide Gate and Pump station to Empire Blvd.(Figure 2)

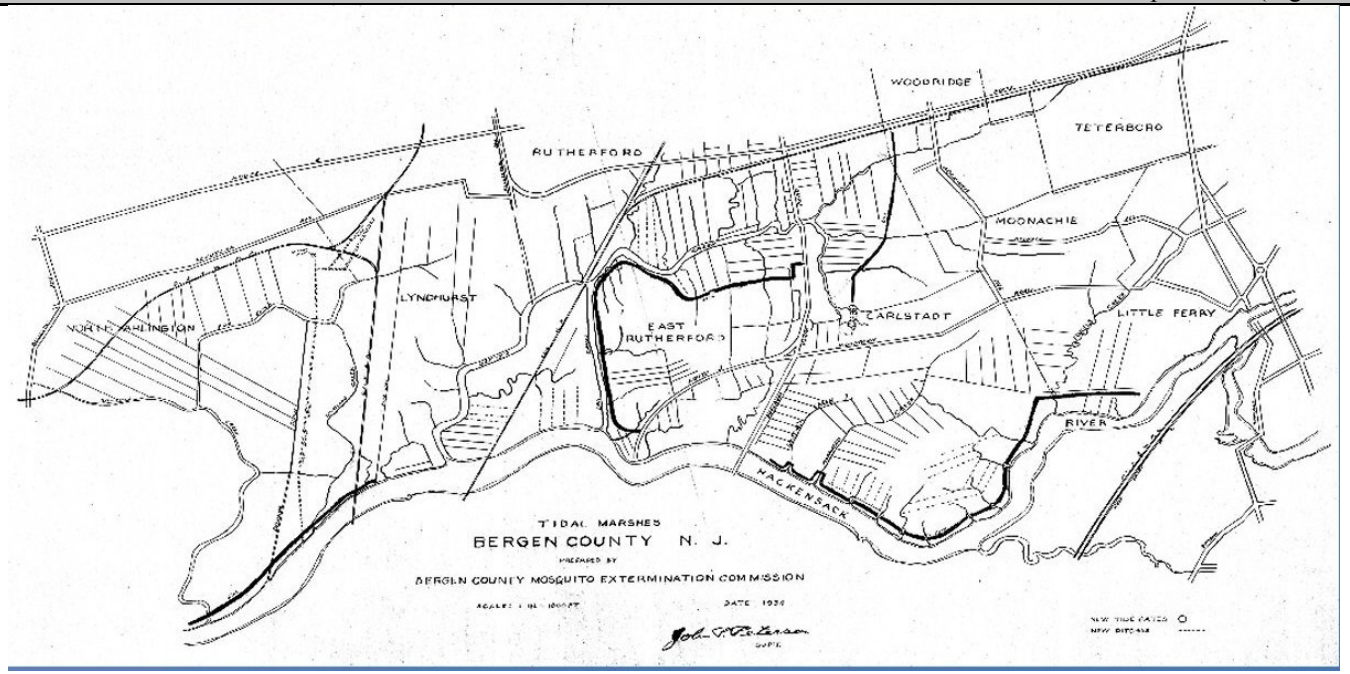

Figure 2 Map of the area with constructed Berms in Dark lines (From 1934)

DePeyster Creek Pump Station and Tide Gate

The DePeyster Creek Pump Station and Tide Gate protect the land mass in Little Ferry bounded by Mehrhof Road, Washington Avenue, Industrial Avenue and Dietrich Street from daily tidal surges of Hackensack River. The Hackensack River has a mean high water spring (MHWS) elevation of 2.6 feet (NAVD88), which is upstream of the confluence point with DePeyster Creek. The ground elevation is around 4 feet (NAVD88) throughout the area protected by the DePeyster Creek Pump Station and Tide Gate. In a 25-year storm event, the water surface elevation is 6.2 feet (NAVD88), per FEMA's 2005 FIS. The DePeyster Creek Pump Station at the end of Dietrich Street has been completely refurbished around 2006 and is now in good working condition. During high intensity storm events, the drainage ditch leading to the DePeyster Creek Pump Station overflowed due to the lack of the pump station's capacity. Since there is no storm-water sewer system in the local streets, once the drainage ditch overflows in the vicinity of Hartwick Street excess water has nowhere to go and floods the surrounding properties. According to a hydrologic and hydraulic analysis of the watershed completed by Mianecki Consulting Engineers (NJMC 2006), the new pump station is unable to empty the projected peak flows from a two-year storm event. During larger storm events, it is likely that the pump station will be inundated and that the upstream channel will back-up into the residential neighborhood. The New Jersey Meadowlands Commission (NJMC) recommends that a hydrologic and hydraulic analysis be prepared that analyzes the need for an additional pump system to adequately discharge the 25-year storm during mean high water (MHW) conditions. The New Jersey Hackensack Meadowlands Floodplain Management Plan recommends that this study forms the basis for the construction of an additional pump system. The NJMC also recommends that access to the upstream trash rack be improved and replaced. The cost of this upgrades are estimated to cost $1.5M. The Little Ferry Department of Public Works employees should be able to clean off the rack via a pathway. The NJMC has accepted the 25-year flood elevation (4.1 feet NAVD88) determined by the report. Water above this elevation leaves the watershed and enters the Losen Slote system (Extracted from NJMC, 2003 and 2006). Figures 3-6 show photos of the pump station and gates confirming the good condtion state of the sytem though it is inadequate to handle a 25 year storm event.

Figure 3 Outfalls of DePeyster Creek Pump Station (NJMC 2006)

Figure 4 Upstream of the intake to the DePeyster Pump Station (NJMC 2006)

Figure 5 DePeyster Pump Station (NJMC 2006)

Figure 6 Downstream of the DePeyster Pump Station **(NJMC 2012)**

Losen Slote Tide Gate and Pump station

The Losen Slote creek begins outside of the HMD in Little Ferry, and runs along the border of Little Ferry and Moonachie, then along the border of Little Ferry and South Hackensack, before it outlets into the Hackensack River in Bergen County. The Losen Slote Creek (also known as Eckles Creek) is not influenced by tidal waters due to a tide gate located near its outlet into the Hackensack River. The original tide gate was installed by the Bergen County Mosquito Commission, sometime around 1921. The creek receives freshwater inputs from surrounding areas. There are freshwater meadows and forested wetlands located along the banks.

In 1999, after years of repeated flooding, Little Ferry replaced the wooden tide gate with a modern high capacity pumping station and a gate. The Losen Slote station with its three 150 horsepower pumps can now remove 129,000 gallons per minute. The $2 million facility is equipped with an emergency diesel generator that self-tests monthly, to ensure the pumping system will continue to operate even if there is a power failure. Pumps are submersible, ensuring the protection of them in a major flood event but not from storm surge such as that from Sandy with salt water. The pumping station went on line in July, 1999, just in time to defend the community against the flood waters unleashed by Hurricane Floyd. Residents were understandably concerned when Hurricane Floyd put the new pumping station to the test. The new system performed beyond expectations and vulnerable residential areas were spared of flooding. The condition of the Losen Slote Tide Gate is listed as “excellent” condition and is “fully functional” in the last annual NJMC inspections. However, the station is underperforming as debris clogs the pumps during storms. Before storms, the Borough proactively cleans the station to remove debris from tidal and fluvial water flows that settles at the station’s pumps. By installing an automatic self-cleaning grate system, the Borough will be able to remove additional storm water out of the Borough’s boundaries faster and more efficiently than before (Extracted from FEMA 1999 and NJMC, 2006). Figures 7-9 show photos of the pump station and gates confirming the good condtion state of the sytem though it is inadequate the handle 25 year storm event.

Figure 7 Losen Slote Creek Pump Station (FEMA 1999)

Figure 8 View of trash racks at in-take structure (NJMC 2006)

Figure 9 Upstream view from the pump station (NJMC 2006)

Willow Lake Pump Station

The Willow Lake pumping station is located within Willow Lake Park. The Willow Lake Pump Station is responsible for moving water out of Willow Lake into the Hackensack River. The Willow Lake acts as the storm water detention basin for numerous residential areas. Water from the surrounding area drains into the Lake and is pumped out of the Borough by the local pumping station. The flooded area not only impacts local EMS and traffic but also negatively impacts two Bergen County roadways. The localized flooding is caused by tidal and fluvial events.

The Lake does not have the capacity to handle the most recent tidal and fluvial storms. The increased water volume has resulted in this vital area being under water for days when the rest of the Borough is dry. Hence it is suggested to dredge and expand the existing Lake to handle the increased water volume that the last storms. It is also suggested that a backup generator be installed at the Willow Lake Pump Station. During Hurricanes Irene and Sandy, the Station failed and the Lake had to be pumped by fire hoses and external pumps. These secondary and last ditch efforts to remove water from the Lake to alleviate localized flooding cannot compare to the capability of the Pump Station in moving of storm water with a back-up generator. Figure 10 show a photo of Willow Lake pump station, which can be rated as in poor condition state without a backup generator.

Figure 10 Willow Lake Pump Station

Teterboro Pump Station

In 1906, Mr. Walter C. Teter built drainage ditches. As the area developed, the need for a pump station to pump storm water from the lower riser ditch to the upper ditch on the west side became apparent. This pumping station handles the storm water for Teterboro and portions of the greater surrounding drainage area. This region is low-lying and flows to downstream tide gates along Berry's Creek West Riser Ditch, which serve to help isolate this area from tidal flooding. Due to the low-lying grades at the tidal barrier, the only way for water to leave Teterboro is by pumping. The original pump house was built in 1917 and upgraded in 1952. The 2 1/2 acre site containing three pump stations, Teterboro DPW yard, and three airport hangers, (originally owned by The Port Authority) was deeded to Teterboro in the 1960s. In 1995, the Port Authority did the preliminary storm water study to assess the Airport needs, followed by a comprehensive study in 2001. This study determined that both the on-airport drainage system and the Borough's pump station were inadequate to handle a five-year storm which is the FAA's design standard for airports. The Port Authority planned to upgrade their on-airport drainage system. As part of the upgrades, the Port Authority considered installing a new pump station on airport property. However, the Borough and the Port Authority eventually decided to combine their problems and resources. At this time all storm water would continue to be pumped through the inadequate Borough pump stations. The Port Authority provided $6.3M to the Borough to fund the new pump station. After the necessary studies, design, regulatory approvals, permits and engineering, to include the NJ Meadowlands Commission, NJDEP, etc., construction began. Contaminated areas were capped to prevent contact with historic fill material. The Port Authority ended their airport drainage upgrade with a 66-inch storm drain exiting the airport at Industrial Avenue. An existing 48-inch storm drain collects drainage from areas along Industrial Avenue extending towards Rt. 46. Both systems connected at Industrial Avenue and Vincent Place to a new 96-inch storm drain that flows to the wet-well of the new pump station. This new $5M stormwater pumping station was a combined effort of The Port Authority of New York and New Jersey and the Borough to complete the redevelopment of a Department of Public Works (DPW) site by consolidating three aging stormwater pumping stations into a more robust facility, while making way for much-needed residential space. This project achieved goals to provide improved stormwater management, new townhome properties and significant open space for the Borough of Teterboro’s residents. To support the facility, 88 steel "H" piles were driven into the underlying clay soil (some down to 200'), while weight-compensating fill was used to offset the weight on the large diameter reinforced concrete pipe storm sewer. This upgraded facility became operational in February 2007. The new 175-cubic-feet-per-second (CFS) stormwater pumping station uses six, 6-foot diameter Archimedes screw pumps. This design is easier to construct, maintain and operate than typical vertical pumps. The Archimedes screw pumps pull water from the lower riser ditch wet-well (open channel), lifting the water 110 feet to the upper ditch which flows by gravity towards Berry's Creek (Extracted from Gazette, 2008 and Dewberry, 2008). However, this system can only handle floods up to an elevation of 4 ft as West Riser Tide Gate is only 4 ft above the mean sea level. The West Riser Tide Gate is currently being replaced by a new gate. However, since there is no pump station at this gate there is a $5M proposal to pipe storm-water from the Teterboro Pump Station Downstream past the West Riser Tide Gate. Figure 11 show a photo of this pump station, since it is newly built, it is in good condition state.

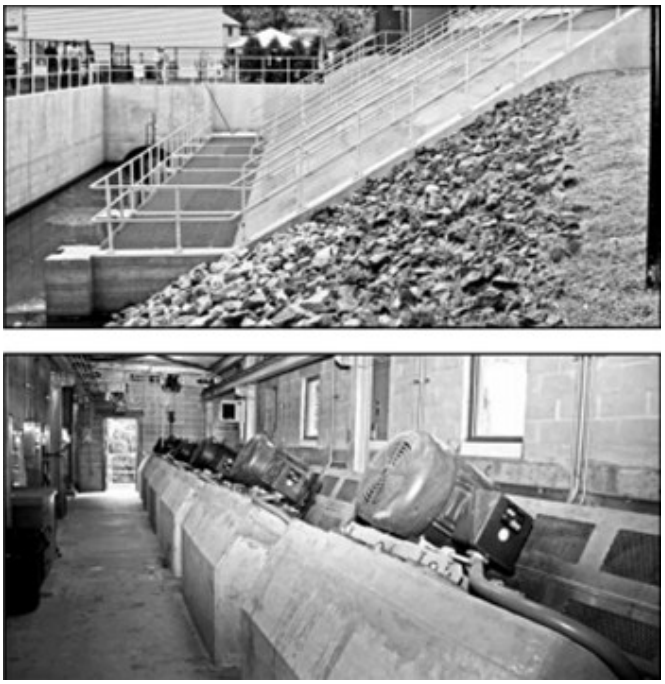

Figure 11 Teterboro Pump Station (Gazette, 2008)

Lincoln Place stormwater pump station

The Lincoln Place pumps station is located at 30-48 Diamond Way, Moonachie, NJ. It was proposed and developed as a solution for the flooding in the neighborhoods closer to the Teterboro Airport. The drainage system is directed towards the pump station. The drainage system accumulates the precipitation from the surrounding residential area which is directed to the pump station via the rainwater drainage system. In the 2010 municipal budget, the Borough Council allocated funds to upgrade Lincoln Place Pump Station. The Lincoln Place redesign project, which has been the focal point of studies, workshops and special meetings, was funded through various departments for a total cost of $605,000. The cost for the pump is $400,000. The pump station was renovated in 2013 adding two 6000 GMP pumps with an additional duty point of 4000 GPM. The renovations equipped the pumping station with capacity to handle even a rain intensity of 6 inch per hour. However, the pumping station does not have a backup generator.

Figure 12: Lincoln Place stormwater pump station (courtesy Google maps)

Figure 13: Lincoln Place stormwater pump station (courtesy Google maps)

Figure 14: Lincoln Place stormwater pump station Arial view (courtesy Google maps)

ACTION PLAN FOR PUMP STATIONS

Under the short term solutions improving the existing pump station would provide the best cost benefit ratio. The capacity of the pump station can be increased to handle the precipitation from a major storm. Our analysis shows that most of the pump stations have inadequate pumping capacity for a significant flood event. Hence, improvement of the pump station pumping capacities will help to eradicate flooding behind the tide protection barriers. The analysis of the existing pumping systems indicates that they are resilient to handle small storm events whereas almost all of them are unable to handle 25 year storm event. However, the Sandy created a +100 year storm event which needs significant measures to manage the flooding. The improvements of the pump stations include the improvement and updating the tidal gates and increasing their surge heights. These will allow the existing system to handle a storm with a 25 year return period.

#	Name	Current Pump condition	Requirement for improvement
1	DePeyster Creek Pump station and Tidal gauge	The DePeyster Creek Pump Station at the end of Dietrich Street has been completely refurbished around 2006 and is now in good working condition. The station has three 15 Hp, 1100GPM pumps	The system is inadequate to handle a 25 year storm event.
2	Losen Slote Tide Gate and Pump station	The pump performed beyond expectations during the Hurricane Floyd. NJMC inspections listed it as a pump station in excellent condition. The station consists of 3 150Hp 43000 GPM pumps	The system is inadequate to handle a 25 year storm event.
3	Teterboro Pump Station	175 cubic feet per second storm water pump station utilizing six-foot diameter Archimedes screw pumps. The water is pumped to an upper ditch 110 feet from the pump level, which flows by gravity towards Berry's Creek.	The system can only handle a flood up to 4'. Hence needed to be reanalyzed for an upgrade in the system
4	Lincoln Place storm water pump station	With the repairs and renovations the pump station will carry two pumps each with a capacity of 6000 GPM with an additional duty point of 4000 GMP.	Enough capacity for a major storm up to an intensity of 6" per hour. However, it needs a backup generator.
5	Willow Lake Pump Station	The Willow Lake Pump Station is responsible for moving water out of Willow Lake into the Hackensack River. The pump station is in poor condition. The station has two 50Hp with 5500 GPM pumps.	Need to increase the capacity of the pumps and need to add a backup generator.

As shown in the table above, it is clear that most of the pumping stations are unable to handle a storm event with a 25 year return period. It is clear from the above table that most of the pumps require higher pumping capacities; hence it is necessary to address the issue and increase the pumping capacities of the pump stations.

Following table illustrates the estimated costs for the required modifications for the pump station.

#	Name	Suggested alternatives	Estimated cost
1	DePeyster Creek Pump station and Tidal gauge	• Upgrade Pump Station to Handle 25 Year Storm Event	$1,500,000.00
2	Losen Slote Tide Gate and Pump station	• Automatic self-cleaning grating system • Upgrade Pump Station to Handle 25 Year Storm Event	$400,000.00 $1,500,000.00
3	Teterboro Pump Station	• Pipe Storm water from Teterboro Pump Station Downstream Past West Riser Tide Gate	$5,000,000.00
4	Lincoln Place storm water pump station	• Backup generator	$250,000.00
5	Willow Lake Pump Station	• Trailer Mounted or Permanent Generators to Allow for Continued Operations During Storm Events • Automatic self-cleaning grating system • Upgrade Pump Station to Handle 25 Year Storm Event • Dredging and Expansion	$150,000.00 $400,000.00 $1,500,000.00 $1,500,000.00

West Riser Tide Gate

The West Riser is among almost three dozen tide gates built decades ago, mostly by private businesses in the Meadowlands, to keep floodwaters out of their properties. The tide gate on Berry's Creek keeps the tide from flooding the west side of Teterboro and adjacent portions of Moonachie and Hasbrouck Heights. Routine cleaning helps keep the gates operating properly. The timber gates shown in Figures 13-15 will be replaced with metal flap gates. The new gate includes a trash rack system would alleviate the collection of debris. The $1.1 million overhaul of the West Riser Tide Gates along Berry's Creek will allow water from heavy rains and tides to flow into marshlands rather than parking lots and runways. Work on the new tide gate is expected to be completed in early 2014. It has a new foundation to hold four new tide gates, a trash rack and a catwalk for maintenance and inspection access. Bergen County has agreed to maintain the new tide gate in perpetuity. Although the project was being designed as early as 2006, it had been on hold until recently, when contaminated sediment was dredged from Berry's Creek, a Superfund site that had some of the highest levels of mercury of any freshwater system in the United States. Because Teterboro Airport is a prime beneficiary of a working tide gate, its owner, the Port Authority of New York and New Jersey, is contributing $552,000 to the project. The new tide gate will help protect the homes and businesses of South Bergen while also protecting Teterboro Airport. A fully functioning West Riser would not likely have made much of a difference during Superstorm Sandy. The tide gate is almost 4 feet high, but the wall of water that inundated the Meadowlands and caused heavy damage in Little Ferry and Moonachie reached 8.6 feet high, according to data from the Meadowlands Environmental Research Institute. Figures 12-16 shows photos of this gate, in poor condition state but will be replaced soon.

Figure 15 Upstream of West Riser Tide Gate **(NJMC 2006).**

Figure 16 Looking Upstream of West Riser Tide Gate **(NJMC 2006).**

Figure 17 Looking Upstream of West Riser Tide Gate**.**

Figure 18 Looking Downstream of West Riser Tide Gate.

Figure 19. Downstream of West Riser Tide Gate.

Mosquito Berm

In the Meadowlands District a berm is a raised ridge of earth that results from excavating drainage ditches as a mosquito control strategy to prevent standing water in low-lying areas. Earthen berms also prevent waters from high tides reaching and ponding in the low lying meadows. Between 1913 and the late 1970's hundreds of miles of ditches were dug in the vicinity of the towns of Carlstadt, Little Ferry and Moonachie and the average berm height was about 5 feet above sea level. Older berms are simple earthen barriers made by hand that date back more than 100 years. Around 1930 several berms were built for mosquito control or agricultural purposes and shown in Figure 2. More berms were built in 2010 as part of a project that has turned a former dumping ground west of the New Jersey Turnpike and north of MetLife Stadium into a tidal wetland with vegetation and wildlife. The company that finished building the berm and is responsible for maintaining it, the berm was built primarily to control the movement of tidewaters in and out of the wetlands area and not for flood protection.

In total here are more than 28 miles of berms along ditches throughout the Meadowlands District. The average elevation of berms in the District is 5 feet above sea level (North American Vertical Datum of 1988 or NAVD 88). Ownership and responsibility for the maintenance of berms and tide gates varies accordingly and can be difficult to establish. There are no records of these berms, including when and how they were built. Also there is no one owner of these berms and no one including New Jersey Department of Environmental Protection is regulating them.

Until super storm Sandy, this berm system protected the residential and industrial areas of these towns from the highest of the high tides. Sandy's sea surge measured 8.5 to 9.5 feet and overtopped all existing berms. The Meadowlands Environmental Research Institute (MERI)-Geographical Information Systems (GIS) team has embarked in a project to precisely map the location and the elevation of all legacy berms in these low lying towns using LIDAR, Hyperspectral Remote Sensing and digital terrain models. Specifically, identify "soft edges", i.e. berms that are less than 5 feet in elevation, within the more than 100 miles of berms and elevated area, and locate areas and neighborhoods most at risk from sea surge flooding.

Berms failed from storms are usually repaired, which is a recurring problem. Hence NJMC is proposing to elevate, restore and replace berms in the District to approximately 6 feet above sea level. Lands in the District are protected from normal flooding by a variety of barriers, including berms, roadways, roadway and railway embankments and other flood control structures. Protection of the District from tidal flooding is limited by the lowest point of these barriers. In other words, the berm system is only as strong as its lowest point since the water will always find the lowest point of entry. Thus, raising the berms requires a detailed, coordinated approach throughout the entire District. When raising the elevation of the berms, consideration must be given to mitigate, through tide gates and pump stations, any potential flooding caused by the trapping of storm-water behind the berms (a "bathtub effect"). NJMC recommends raising those berms to an elevation of 6 feet above sea level to protect against the normal tidal fluctuations but not against a sea surge like the one caused by Hurricane Sandy**.**

Figure 20 Google Earth Photo of portion of Mosquito Berm

Figure 21 Typical View of the Berm with two Layers (AP Photo/Mel Evans)

Figure 22 View of the failed two layer Berm due to Sandy (AP Photo/Mel Evans)

Figure 23 Close-up View of the Berm with a failed section due to Sandy (AP Photo/Mel Evans)

Figure 24 Close-up View of the Berm with a failed section due to Sandy (AP Photo/Mel Evans)

Figure 25 The Berm made of soil (AP Photo/Mel Evans)

Figure 26 Failed Berm cleared of stone due to Sandy (NorthJersey.Com Meghan Grant)

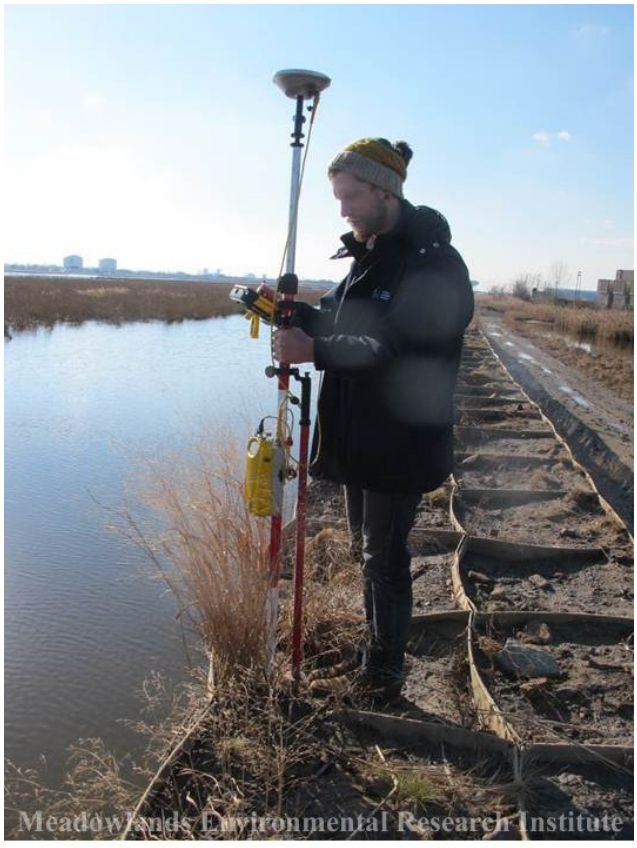

Figure 27 Failed Berm partially cleared of stone due to Sandy (MERI, 21012)

Figure 28 A section of intact Berm after Sandy

Figures 17-25 show the poor condition state of most of berms in Meadowlands. The existing system consist of earth filled (Figure 22) as well as stone filled metal wire construction using approximately 3 ft x 3 ft X 3 ft metal wire cages (Figures 23-25). In some locations a single layer system with two of these metal wire cages next to each other (Figures 23-24) formed the berm, while in other locations a two layer berm system with two of these metal wire cages on top of three cages (Figures 18-21) formed the berm. These poorly constructed berms are inadequate to protect the area from recurring floods and must be repaired after each major storm event.

One of the flood protection systems that NJIT proposes aligns very closely with these berms and hence should be given serious consideration rather than raising the height of berms to 6' at a cost of over $20M. Also, the feasibility of constructing three layer berms with two of those stone filled metal wire cages on top of three cages and those three on top of four stone filled metal wire cages should be evaluated.

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