SOUTH JERSEY LEVEE INVENTORY

Levee 13 – Locust Island Levee at Hancocks Bridge, Salem County, New Jersey

November 2010

USDA Natural Resources Conservation Service
Assisting
New Jersey Department of Environmental Protection
Bureau of Dam Safety and Flood Control

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This project was the result of a team effort by many. The primary contributors were:

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Mary Gooch, Program Assistant – Landowner information identification
David Lamm, State Conservation Engineer – Quality assurance of elevation data
Edwin Muniz, Assistant State Soil Scientist – Personal Data Assistant (PDA) Field Inventory program development and conversion to Access Database
Ruben Perez, Irrigation Specialist -Field inventory (September 2009-May 2010)
Mona Peterson, District Conservationist – Landowner outreach
William Skaradek, Resource Conservationist – Field inventory (Jan. 2009 – Sept. 2009)
Mary Beth Sorrentino, District Conservationist – Landowner outreach
Ken Taaffe, South Jersey RC&D Council Coordinator – Local outreach
Pat Walczak, Administrative Assistant – Landowner Information Identification
Greg Westfall, Water Resource Planner – Project Manager and Report Author

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Brenda Evans of the PSEG Estuary Enhancement Program provided information on levees in the vicinity.

The many different levee owners who provided access for the field inventory, some of whom spent their time taking staff to the levee (s) and providing information.

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Executive Summary

The purpose of the South Jersey Levee Inventory was to identify and characterize the location, extent and characteristics of existing levees/dikes in and along the Delaware Bay and lower Delaware River in the South Jersey counties of Cape May, Cumberland, Gloucester and Salem. The South Jersey Levee Inventory was conducted by the USDA Natural Resources Conservation Service under an agreement with the U.S. Army Corps of Engineers, Philadelphia District. Funding was provided by the Bureau of Dam Safety of the New Jersey Department of Environmental Protection. The inventory also attempts to provide an estimate of the amount, type and extent of vulnerability of people and property, including agricultural acreages and businesses, protected by these structures.

The Inventory was divided into two parts, namely the **Field Inventory** and the **Light Detection and Ranging (LiDAR) Analysis**.

The project team made its best effort to identify all significant levees, however, there may be levees that were not identified from these various sources. From an initial 107 “levees”, nearly 18 miles of levees were inventoried. A total of 70 levees were actually identified as, in fact, being levees. Approximately 86 percent of all levees were in Cumberland and Salem Counties.

Levee data recorded included name of structure, inventory date, project location, name, contact information and block and lot for owner/sponsor and operation and maintenance provider. Levee characteristics such as component type, closure structure, length, height, crest width, slope of the protected and waterway sides, name of waterway, levee endpoints, vegetation control, sod cover, erosion, slope stability, settlement, depressions/rutting, cracking, burrowing animal presence, encroachments, culverts, floodgates, pumping stations and closure structures were recorded. These data categories are generally the same as the U.S. Army Corps of Engineers criteria for the National Levee Inventory. No rating was given as to the inherent safety or condition of the levees.

The second component of the South Jersey Levee Inventory was the development of Light Detection and Ranging (LiDAR) information to analyze the length, height and elevation of the levees as well as for identification of the area protected including agricultural land protected, homes/businesses/structures protected, population of area protected and roads, railroads and utilities protected.

The 2010 inventory revealed:

- Nearly 70 percent of the levees are owned by private individuals
- Each of the twenty- two municipalities in the four counties studied have at least one levee

Characteristics observed included:

- Nearly 50 percent of the levees have no vegetation control/management
- Over 20 percent of the levees have less than 50 percent sod cover
- Nearly 24 percent of the levees inventoried have erosion
- Over 19 percent of the levees have unstable or moderately unstable slopes
- Over 35 percent of the levees have some or considerable settlement
- Over 29 percent of the levees have some or considerable depressions
- Some levee cracking was observed in 25 percent of the levees
- Nearly 30 percent of the levees have burrowing animal presence
- Riprap protection was observed on approximately 31 percent of the levees
- Nearly 15 percent of the levees have encroachment by non-levee uses
- Over 3000 structures are identified as being protected by levees in six (of the 70 levees) selected levee locations
- Over 14,000 acres of various land uses are being protected by levees in six (of the 70 levees)selected levee locations
- None of the inventoried levees are accredited as providing sufficient flood control by the Federal Emergency Management Agency and therefore result in those structures being “protected” by the levee as having to have flood insurance
- None of the inventoried levees meet the requirements of the US Army Corps of Engineers for eligibility for their PL-84-99 emergency assistance program in the event of levee failure.
- Some of the levees provide drainage related benefits by controlling tidal inundation of low lying areas as well as limited flood control benefits for the more frequent storm events.
- Characteristics of the levees vary significantly from well maintained structures to those that receive little or no annual maintenance.

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Purpose of Levee Inventory – Why an Inventory?

The purpose of the Levee Inventory is to identify and characterize the location, extent and characteristics of existing levees/dikes in South Jersey and the amount, type and extent of vulnerability of people and property protected by these levees including agricultural acreages and businesses.

Field Inventory Methodology

The field inventory used a systematic approach for determining the location, extent and characteristics of the levees. Air photo interpretation was the primary means used to identify the likely location of levees. Interpretation of 2002 aerial photography was made and suspected levee locations were digitized as line features in an ARC Map environment. Interviews were held with representatives of county planning boards, engineers, mosquito commissions and soil conservation districts as well as with local municipal officials in an effort to "ground truth" local knowledge and experience with levees into the Inventory.

A total of 107 levees were identified and given number identifiers (1-107) using these methods.

Structures were named with the common local name or a nearby geographic feature. The project team made its best effort to identify all significant levees, however, there may be levees that were not identified from these various sources. Figure 2 shows the location of the levees for the four county study area as determined from the 2002 aerial photography and field verification. Figures 3, 4,5, and 6 show the identified levees on a county basis.

As the in-the-field inventory took place, the aerial photo interpreted "levee" features were either verified as an actual levee or categorized as other features. Table 2 shows the categories. Ten "levees" were determined to be dams based on the State Dam Inventory maintained by New Jersey Department of Environmental Protection. Another fifteen were determined to not be a levee or dam once these were assessed in the field. Another four "levees" had been deliberately breached by either New Jersey Department of Environmental Protection Division of Fish and Wildlife or the Public Service Electric and Gas Corporation Estuary Enhancement Program to improve tidal fisheries and wildlife. Another six "levees" had been breached by natural events over time and not repaired. Another two "levees" were actually confined dredged material disposal facilities (Corps of Engineers structures maintained to provide a storage location for the 3.5 million cubic yards annually removed from the Delaware River shipping channel.) Additionally another two "levees" were not accessible because permission from their private landowners could not be obtained.

Publicly owned levees were field inventoried first. Letters to individual private property owners were sent to gain permission to access privately-owned levees. Project team members used Airis, Garmin and Hemisphere Global Positioning System (GPS) units to determine the longitude and latitude of levee endpoints and an Airis and Archer Personal Data Assistants(PDA) to record the description of each of the levees .

Levee characteristics were evaluated using the listed data groups and their associated descriptors shown in Table 3. These characteristics were specifically based on the U.S. Army Corps of Engineers criteria for the National Levee Inventory. Data for each levee was entered into an Excel spreadsheet of these criteria. These data were converted from the Excel spreadsheet to an Access database to permit ready retrieval of customized information.

Levee Locations

Figure 1 shows the 22 municipalities which have levee systems. Table 1 lists the four counties and 22 municipalities. Many of these municipalities are relatively rural and sparsely populated with small budgets for staff, equipment and materials for the needs of levee maintenance and rehabilitation.

Figure 1- Municipalities in Cape May, Cumberland, Gloucester and Salem Counties with Areas Vulnerable to Tidal Flooding

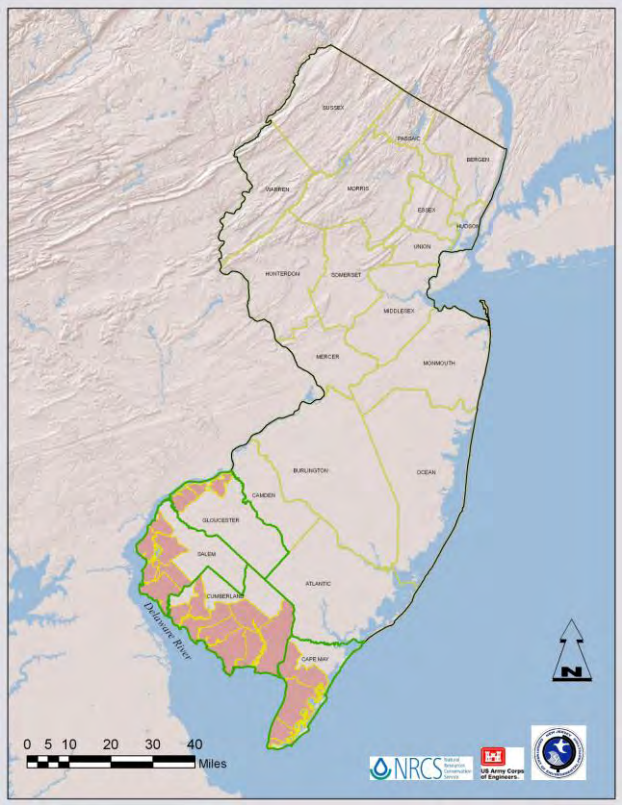


Table 1 – Counties and Municipalities with Levees and Dikes

Counties	Municipalities
Cape May County	Dennis Township
	Lower Township
	Middle Township
Cumberland County	Commercial Township
	Downe Township
	Fairfield Township
	Greenwich Township
	Hopewell Township
	Lawrence Township
	Maurice River Township
	Millville City
	Stow Creek Township
Gloucester County	Greenwich Township
	Logan Township
	West Deptford Township
Salem County	Carneys Point Township
	Elsinboro Township
	Lower Alloways Creek Township
	Mannington Township
	Pennsville Township
	Quinton Township
	Salem City

Figure 2- Levee Locations in South Jersey

Table 2 - Aerial Photo "Levee" Interpretation and Final Feature Category

Aerial Photo "Levee" Identification	Field Inventory Identification						
Original Number of "Levees"	Dam (NJDEP State Dam Inventory)	Not a Levee	Breached (PSEG and NJDEP Division of Fish and Wildlife)	Breached (All Others)	Corps Disposal Facility (CDF)	Inaccessible due to lack of Landowner Permission	Net Number of Levees Inventoried
107	10	15	4	6	2	2	68

Figure 3- Levee Locations in Cape May County

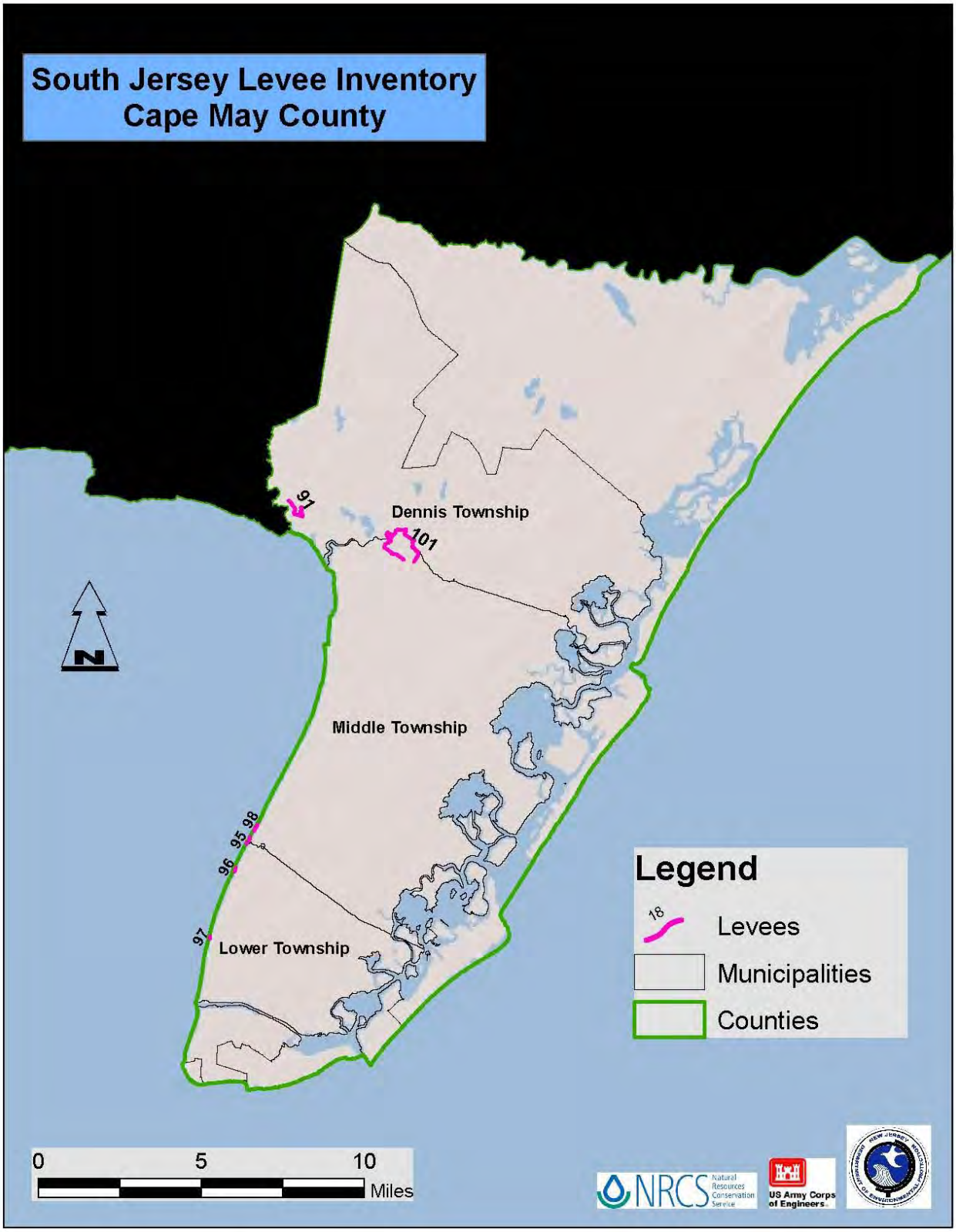


Figure 4- Levee Locations in Cumberland County

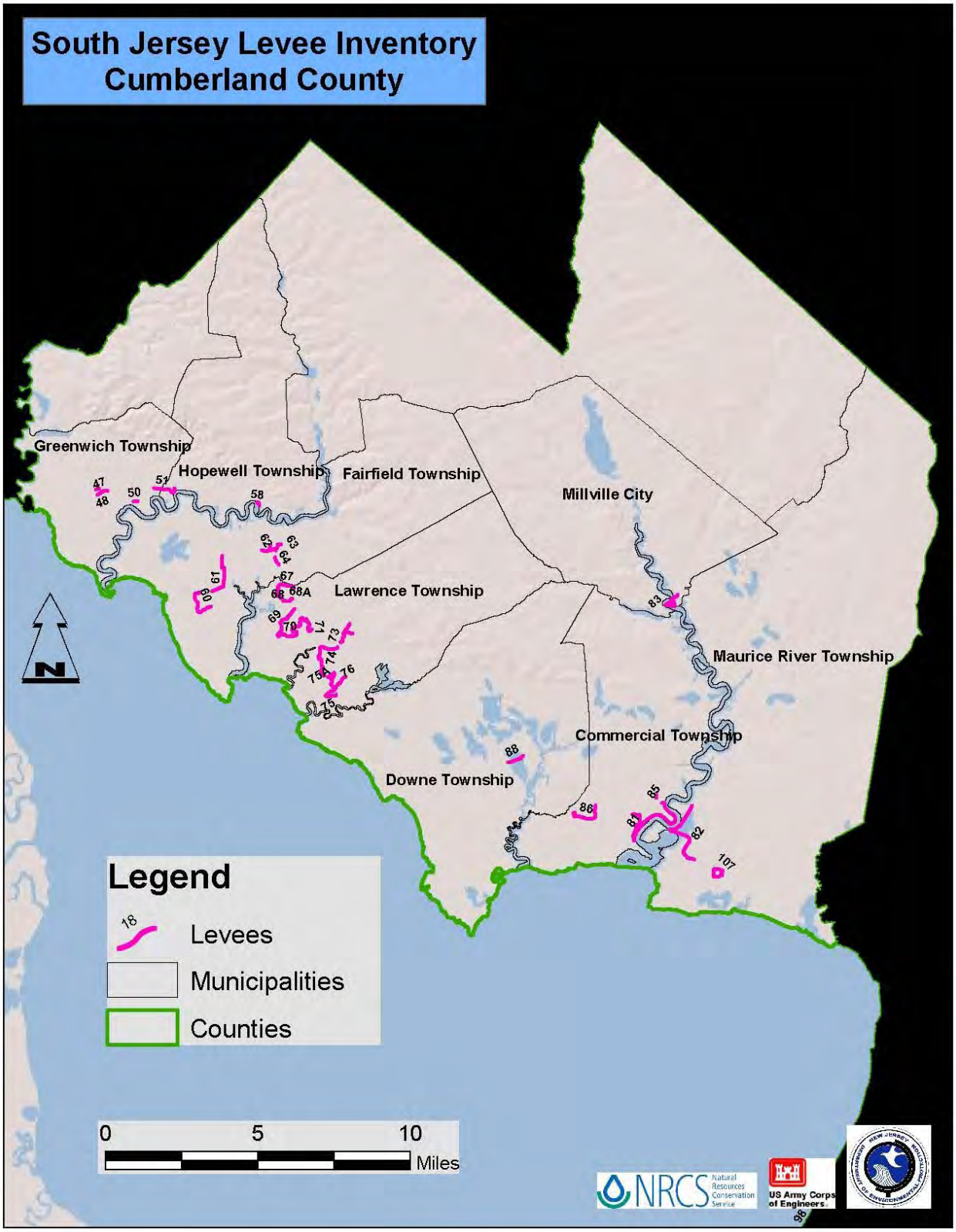


Figure 5 - Levee Locations in Gloucester County

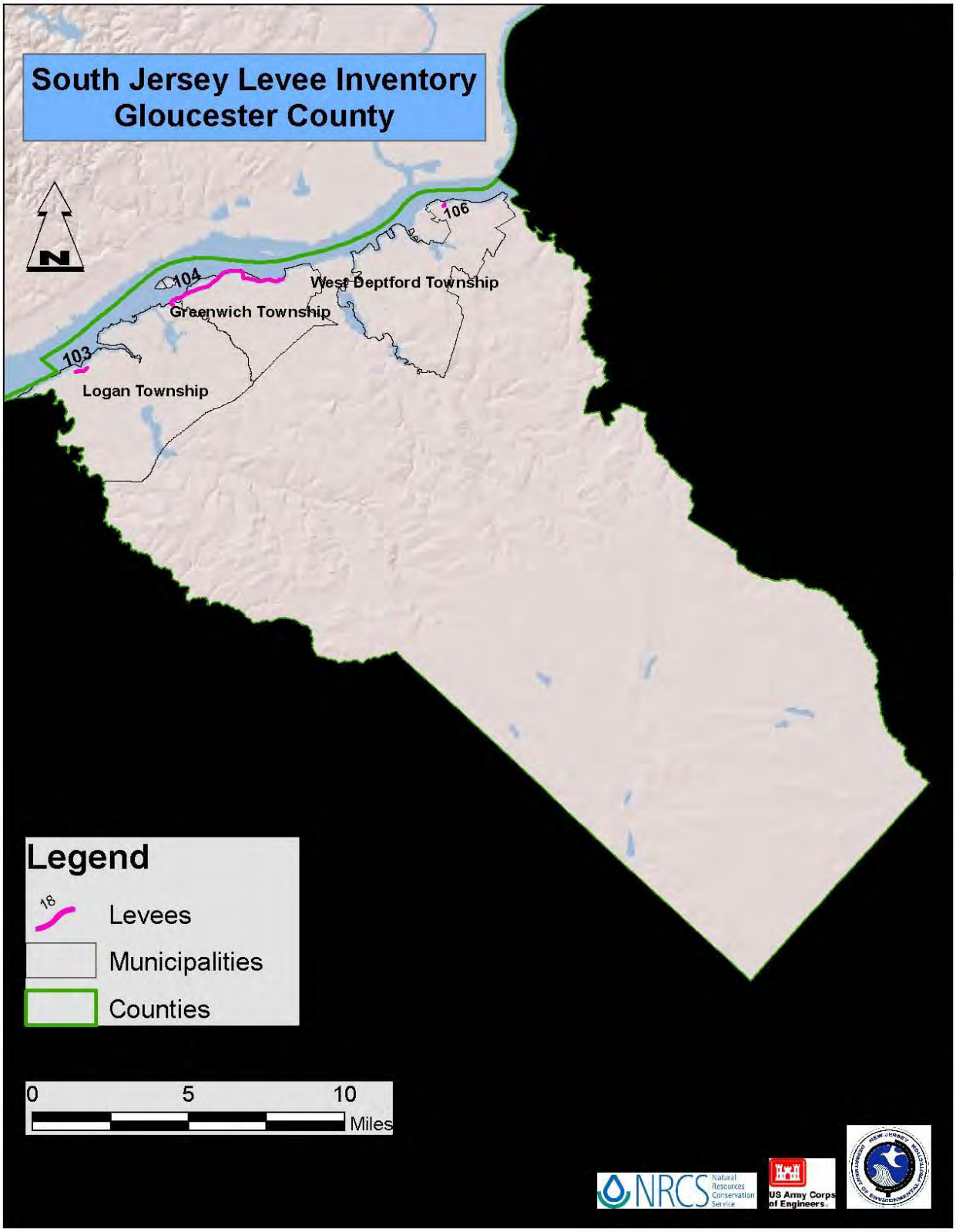


Figure 6- Levee Locations in Salem County

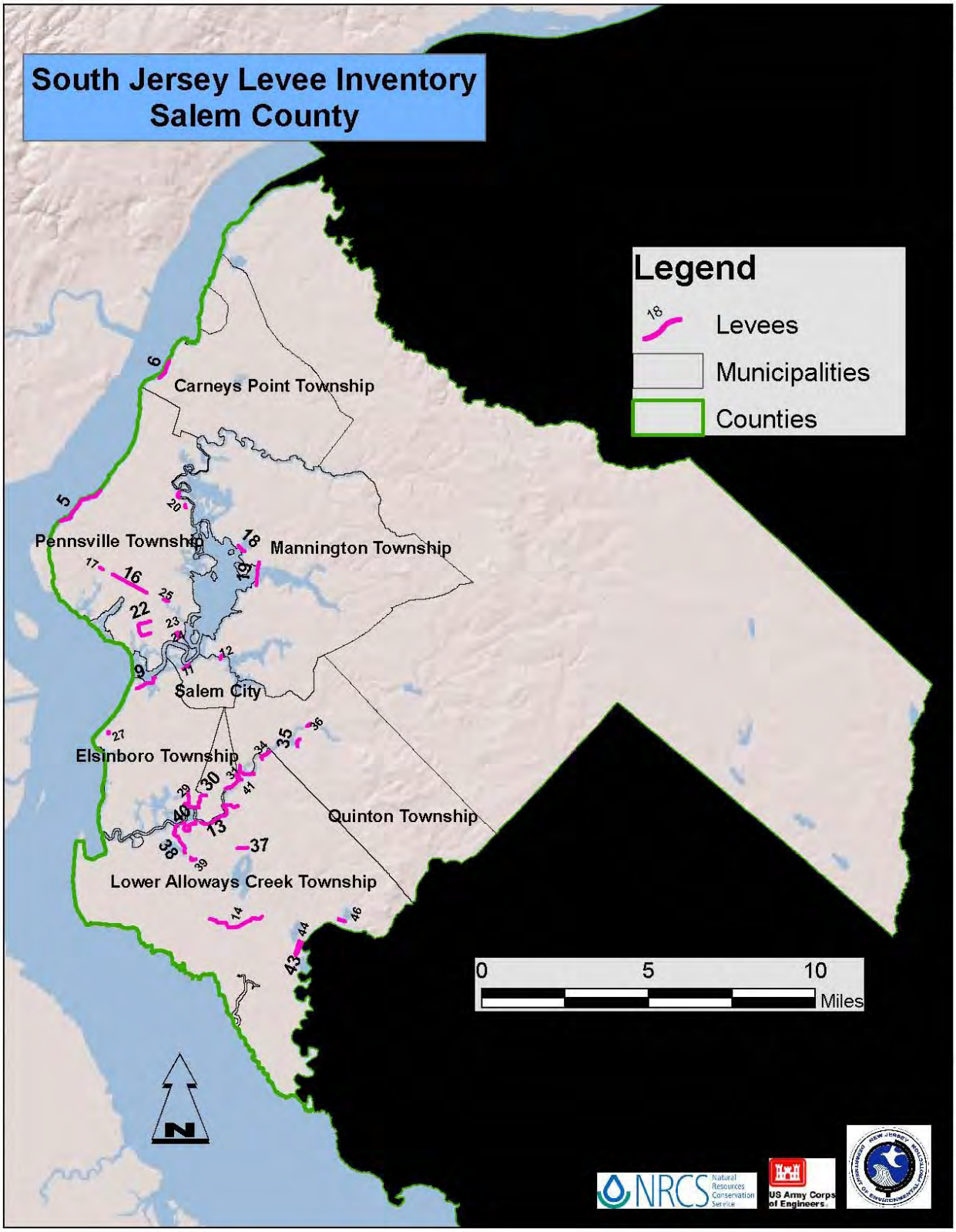


Table 3 - Field Inventory Levee Data Groups and Descriptors Used
(based on US Army Corps of Engineers Criteria for the National Levee Inventory)

Data Group	Descriptor
Name of Structure	
Inventory Date	dd/mo/yr
Project Location	Municipality, County
Owner/Sponsor	
Block and Lot Number	Block #, Lot #
Contact Number	
Contact Address	
Contact Phone	
Contact E-mail	
Operation & Maintenance Provider	
Component Type	Earthen Levee or Floodwall
Closure Structure	Number
Length	Feet
Height	Feet
Crest Width	Feet
Slope Protected Side	Horizontal to vertical (Feet)
Slope River Side	Horizontal to vertical (Feet)

Data Group	Descriptor
Name of Waterway	
Endpoints	Latitude, Longitude
Vegetation Control	Yes or No
Sod Cover	Percent Cover (100-90; 75-90; 50-75; 25-50; 0-25)
Erosion	Yes or No
Slope Stability	Yes or No
Settlement	None, some or considerable
Depressions/Rutting	None, some or considerable
Cracking	None, some or considerable
Burrowing Animal Presence	None, some or considerable
Encroachments	None, some or considerable
Culverts	Number, Type and Est. Size
Floodgates	Number, Type and Est. Size
Pumping Stations	Number
Closure Structures	Number, Type and Est. Size

Associated Characteristics for Selected Field Inventory Data Groups

Vegetation Control

None

Some

Considerable

Sod Cover (Percent)

0 - 25

25 -50

90 – 100

Erosion

Yes

No

Slope Stability

No

Settlement

None

Considerable

Cracking

Some

Considerable

Burrowing Animal Presence

Some

Considerable

Encroachments

Some

Some

Considerable

Riprap/Slope Protection

Considerable

Considerable

Some

Culverts and Floodgates

Rubber-sleeved Floodgate

Rubber-sleeved Floodgate

Improvised Wood Floodgate

Culverts and Floodgates

Valve-Type Floodgate

Stainless Steel Floodgate

Pump Station – Outlet Pipe

Flap-Type Floodgate

Pump Station – Outlet Pipe

Pump Stations

Field Inventory Findings

Data collect is summarized in the following section for the various characteristics shown in Table 3 and photos on the preceding pages. A photo gallery of the various levees visited is included at the end of this report. Levees identified with "no record" include those for which no physical access to the levee was possible. Also, a limited amount of technical data were unavailable due to challenges with data storage and retrieval.

Levee Ownership

Ownership information was obtained from the New Jersey Association of County Tax Boards website at: http://www.njactb.org/ . Most levees had an ownership record. A few levees had no ownership record and apparent ownership was categorized by type. There are a variety of types of levee owners in the four county study area (Table 4). Trends in ownership seem to indicate that ownership in some areas is changing from private to either government, non-profit or corporate ownership.

Table 4 - Levee Ownership Types

	Private (Individuals)	Private (Corporations)	Government (County or Township)	Government (US FWS)	Government (NJDEP)	Non-Profit
Number of Levees	47	7	4	1	6	3
Percent of Levees	69.1	10.3	5.9	1.5	8.8	4.4

Levee Location by County

Table 5 shows levees are located predominately in Salem and Cumberland Counties. Though fewer in number, the levees in Cape May and Gloucester Counties protect areas with large numbers of structures, roadways and people from flooding.

Table 5 - Levee Location by County

County	Cape May	Cumberland	Gloucester	Salem
Number of Levees	6	28	3	31
Percent of Levees	8.8	41.2	4.4	45.6

Levees were found in 22 municipalities throughout the four county study area (Table 6). Elsinboro, Pennsville and Lower Alloways Creek Townships in Salem County and in Greenwich, Fairfield and Lawrence Townships in Cumberland County have the greatest number.

Levee Location by Municipality

Table 6 - Levee Location by Municipality

Municipality	Number of Levees
Carneys Point Township	1
Commercial Township	3
Dennis Township	1
Downe Township	1
Elsinboro Township	4
Fairfield Township	5
Greenwich Township (Cumberland Co.)	4
Greenwich Township (Gloucester Co.)	1
Hopewell Township	1
Lawrence Township	11
Logan Township	1
Lower Township	2
Lower Alloways Creek Township	12
Mannington Township	2
Maurice River Township	2
Middle Township	3
Millville City	1
Pennsville Township	8
Quinton Township	2
Salem City	2
West Deptford Township	1

Levee Length

Based on the LiDAR analysis, the levees are of various lengths ranging 340 feet to 22,656 feet. Total length of levees inventoried was 93,216 feet or nearly 18 miles of levee. Table 7 shows the levee number, name and length and county in which it is located. Levee names are based on ownership, road or some other geographic feature. Missing levee numbers are the result of the field inventory process in which those features originally identified as “levees” were found to be dams, not a levee, breached or inaccessible (See Table 2).

Table 7 - Levee Length

Levee Number	Levee Name	Length (Feet)	County
5	Miles Creek	8830.	Salem
6	Whooping John Creek	3363.	Salem
9	Middle Neck	3810.	Salem
11	Town Bank	1251.	Salem
12	Fenwick Creek	672.	Salem
13	Locust Island	8934.	Salem
14	Silver Lake	9617.	Salem
16	Supawna Meadow	6249.	Salem
17	Lighthouse	624.	Salem
18	Sunset Road	1584.	Salem
19	County Route 540	3732.	Salem
20	Beaver Dam	607.	Salem
22	Supawna Meadows Private	5376.	Salem
23	tv towers	1488.	Salem
24	tv towers south	599.	Salem
25	Harrisonville	906.	Salem
27	Fort Elfsborg	706	Salem
29	Mason Point East	3128.	Salem
30	Lower Alloways Creek	4282.	Salem
Levee Number	Levee Name	Length (Feet)	County
31	Private Landowner	5421.	Salem
34	Beasley Neck Road 2	2046.	Salem
35	Beasley Neck Road 3	1290.	Salem
36	Quinton	803.	Salem
37	Moores Bank	1680.	Salem
38	Private Landowner	1639.	Salem
39	Grosscup	340.	Salem
40	Hancocks Bridge Poplar	4785.	Salem
41	County Hwy 623	4151.	Salem
43	Long Bridge Outlier	2610.	Salem
44	Long Bridge Road	2240.	Salem
46	Buckhorn Road	1146.	Salem
47	Pine Mount King	665.	Cumberland
48	Pine Mount Bacons Neck Rd	2002.	Cumberland
50	Market Street	855.	Cumberland
51	Mill Creek (Union Bank)	4552.	Cumberland

58	Pease Road	899.	Cumberland
60	Sea Breeze Road	7014.	Cumberland

Table 7 Levee Length (Continued)

Levee Number	Levee Name	Length (Feet)	County
61	Private Landowner	8049.	Cumberland
62	Back Neck 1	1443.	Cumberland
63	Back Neck 2	4047.	Cumberland
64	Rock Creek	1565.	Cumberland
67	Private Landowner North	5379.	Cumberland
68	Private Landowner South	1979.	Cumberland
68A	Private Landowner Southeast	961.	Cumberland
69	Sayres Neck North	4044.	Cumberland
70	Sayres Neck South	12772.	Cumberland
71	Sayres Neck Southeast	2169.	Cumberland
73	Jones Island Road	5605.	Cumberland
74	Bay Point Road	6273.	Cumberland
75	Blizzard Neck Gut	9996.	Cumberland
75A	Bay Point Road South	2936.	Cumberland
76	Nancy Gut	2430.	Cumberland
81	Port Norris	21458.	Cumberland

Levee Number	Levee Name	Length	County
82	Heislerville	14984.	Cumberland
83	Private Landowner	5914.	Cumberland
85	Port Norris North	488.	Cumberland
86	Berrytown	6797.	Cumberland
88	Maple Street	2809.	Cumberland
91	Stipson Island/Private Landowner	7908.	Cape May
95	Fishing Creek	1320.	Cape May
96	Shaws Meadow	598.	Cape May
97	Cox Hall Creek	363.	Cape May
98	Sunray Beach	1310.	Cape May
101	Private Landowner	19601.	Cape May
103	Birch Creek	674.	Gloucester
104	Repaupo Creek	22656.	Gloucester
106	Red Bank	475.	Gloucester
107	Thompson	5537	Cumberland

Levee Low Elevation

Using LiDAR analysis (for more details on LiDAR, see “Light Detection & Ranging (LiDAR analysis” on page 65), estimates of the low elevations of top or profile of selected levees were determined. These selected levees are protecting more populated areas. The low elevation was determined as the critical elevation at which water would pass over the top of a levee in the event of a high tide with northeaster or other storm conditions. Figures 7 through 15 show the levee identification number, name with LiDAR-produced profile and an overview map for the selected levees from the inventory.

The x-y graphs produced by digitizing a mensuration line can provide a useful profile of the elevations at the top of the structures. However, the Digital Surface Model (DSM) also contains the vegetation heights, and it was not possible to capture only the structure elevation during the mensuration process. Therefore, unusually high spikes in the elevation profile should be assumed to be vegetation heights. Low elevation spikes may indicate the lowest elevation along a structure, but may also indicate where the mensuration line “fell off” the side of a structure in the model. In summary, the mensuration data should be considered useful overall, while individual points along the line may be misleading due to the above referenced issues.

Figure 7- Levee Profile and Overview – Levee #11 Town Bank (Protects Salem City)

(South Jersey LiDAR = Elevations(Y axis) in meters, Mensuration line (X axis)(Feet) = west to east)

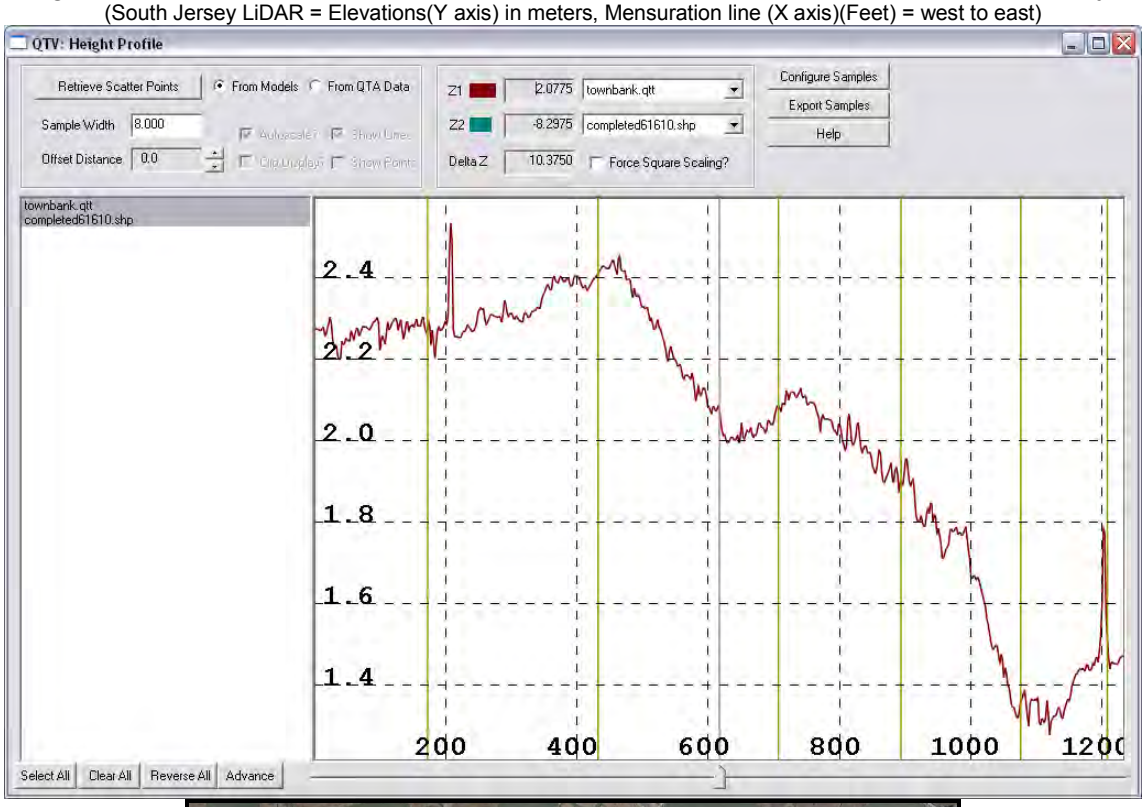
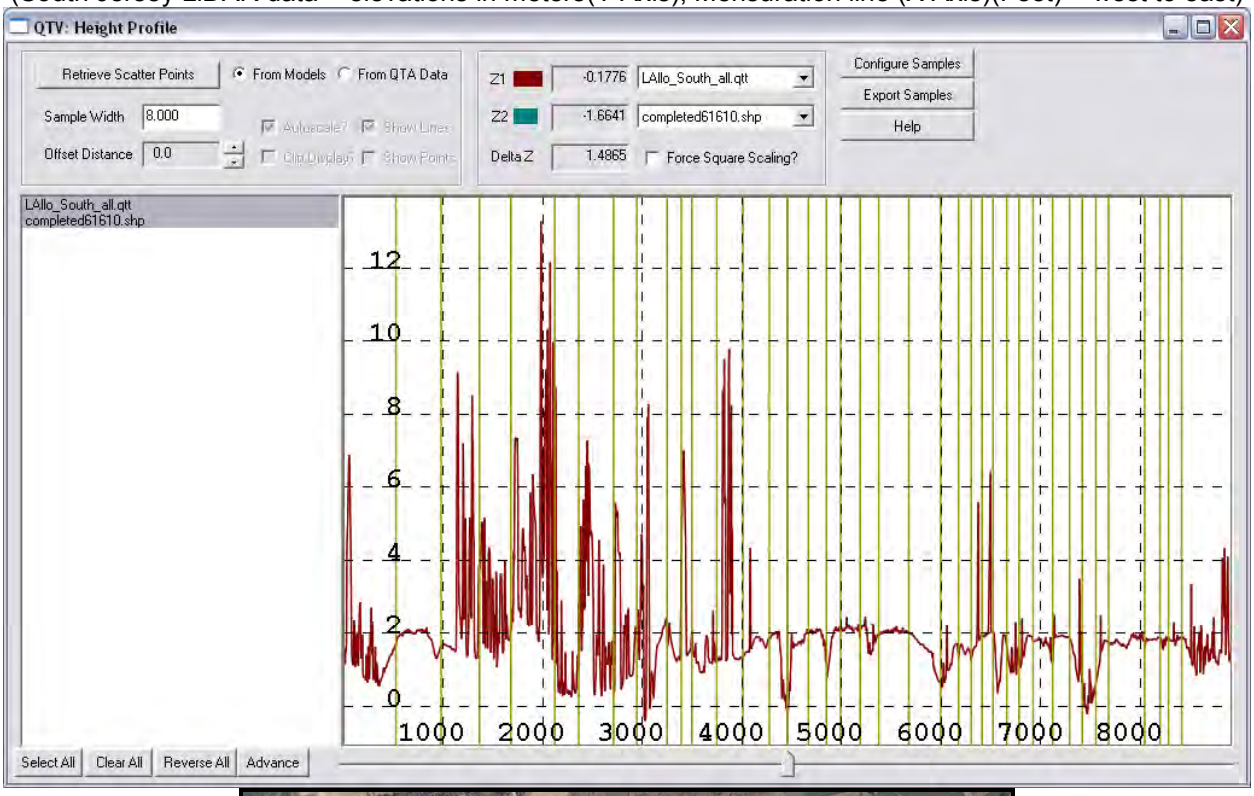


Figure 8- Levee Profile and Overview – Levee #13 Locust Island (Protects Hancocks Bridge)

(South Jersey LiDAR data = elevations in meters(Y Axis), Mensuration line (X Axis)(Feet) = west to east)



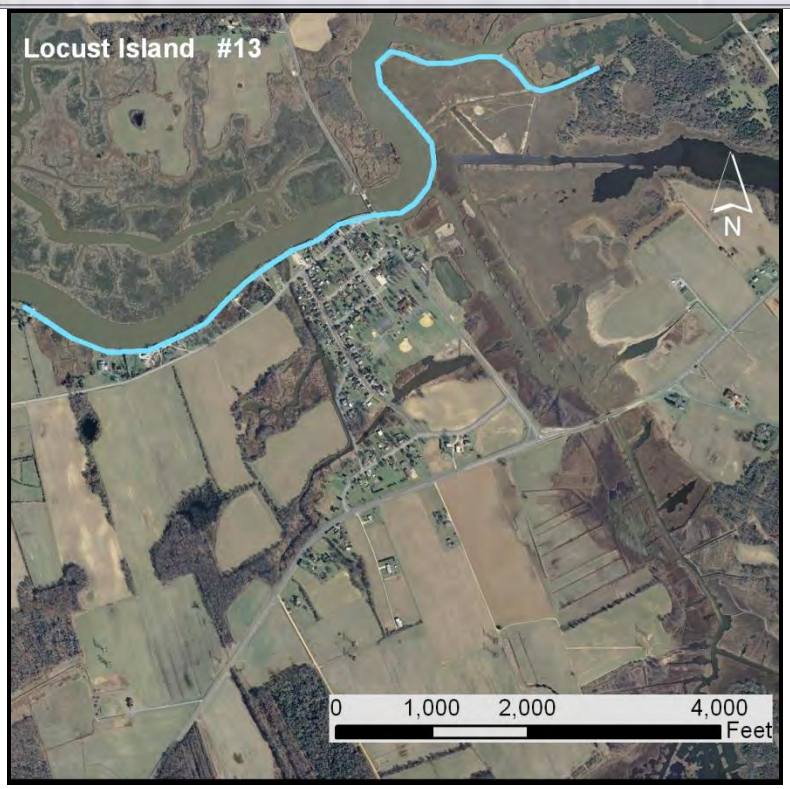
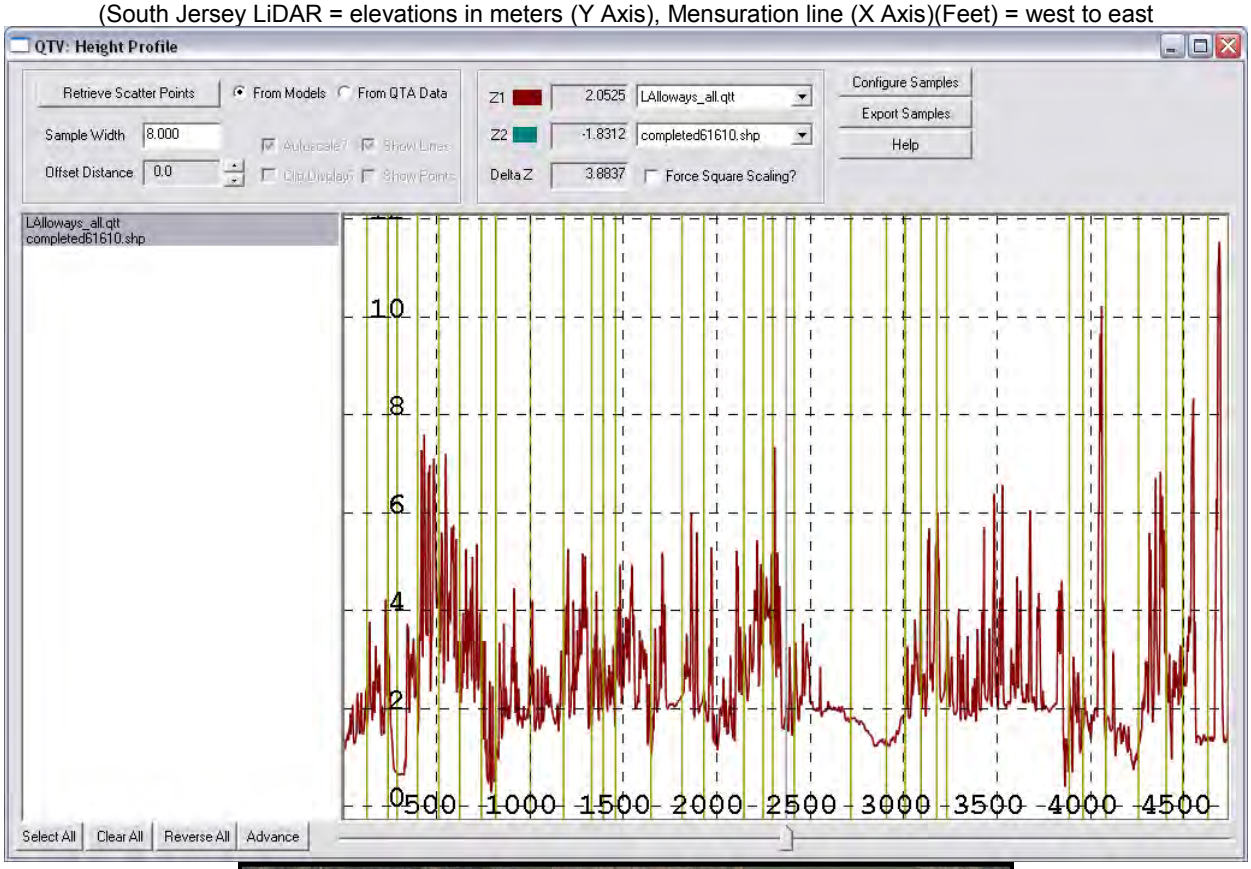


Figure 9- Levee Profile and Overview – Levee #40 Hancocks Bridge Poplar)

(South Jersey LiDAR = elevations in meters (Y Axis), Mensuration line (X Axis)(Feet) = west to east



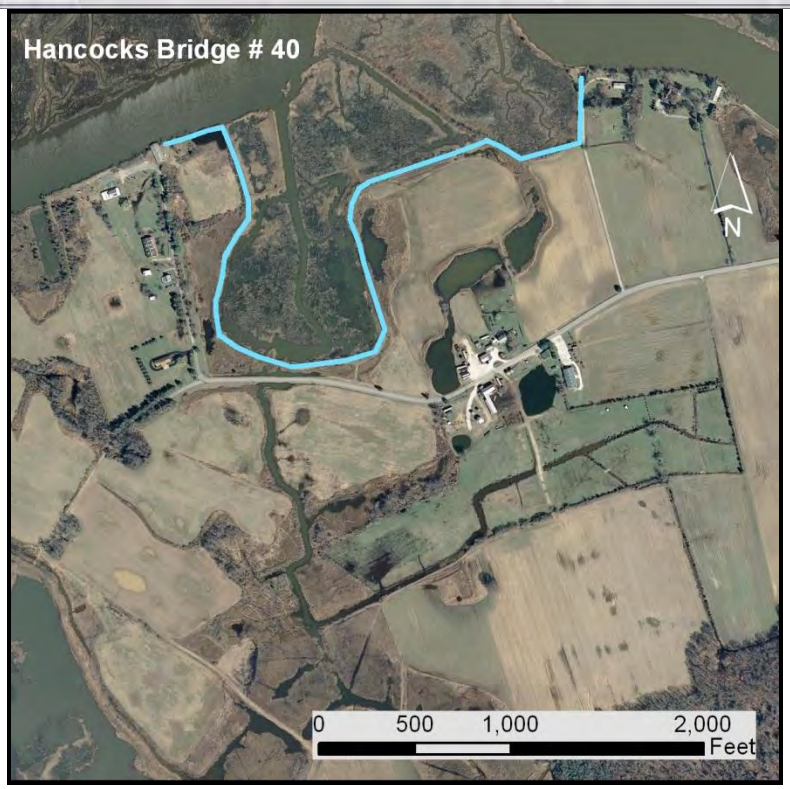


Figure 10- Levee Profile and Overview – Levee #81 Port Norris (East Section)

(South Jersey LiDAR = elevations in meters(Y Axis), Mensuration line (X Axis)(Feet) = south to north)

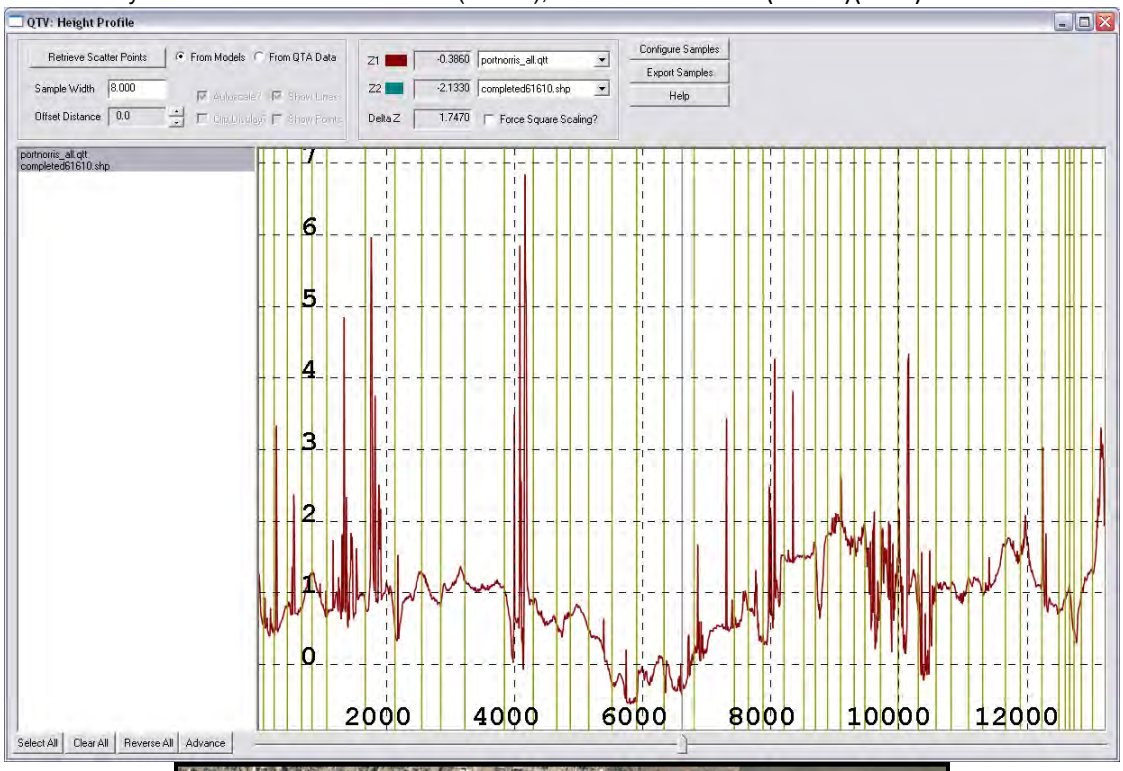


Figure 11- Levee Profile and Overview – Levee #81 Port Norris (West Section)

(South Jersey LiDAR = elevations in meters (Y Axis), Mensuration line (X Axis)(Feet) = north to south)

The low point at 4500 on the graph corresponds to a gap that is visible on the LiDAR Data, however, it was not observed during field verification

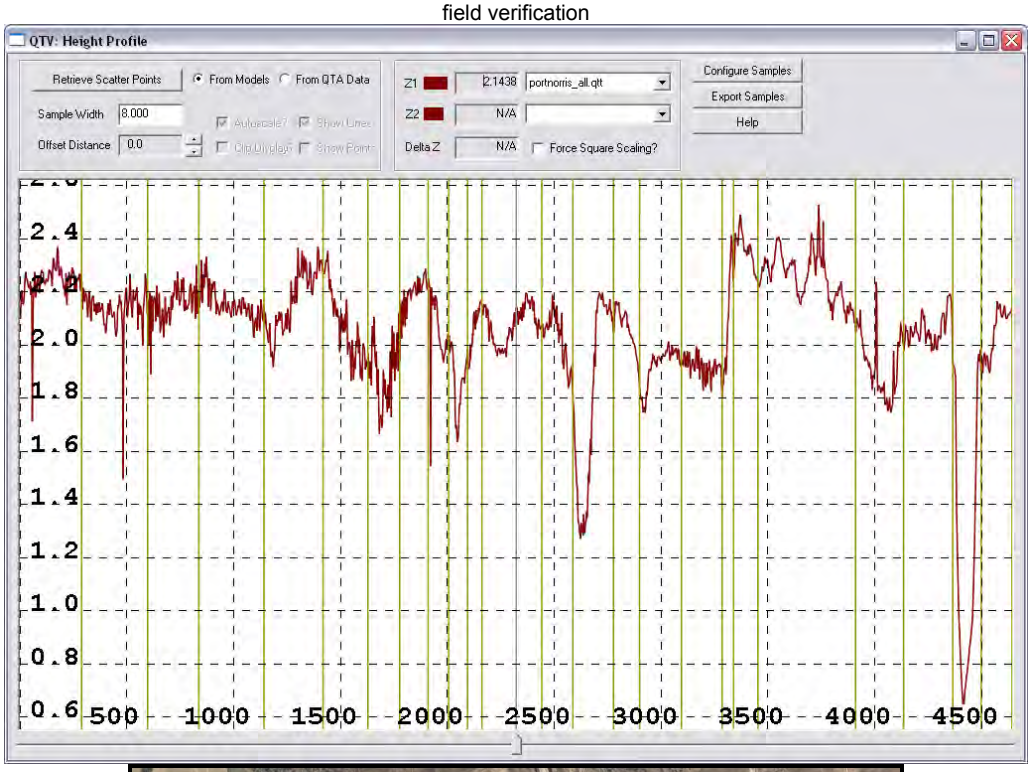


Figure 12- Levee Profile and Overview – Levee #85 Port Norris North

(South Jersey LiDAR = elevations in meters (Y Axis), Mensuration line (X Axis)(Feet) = north to south)

There is a lot of tall vegetation proximate to the structure.

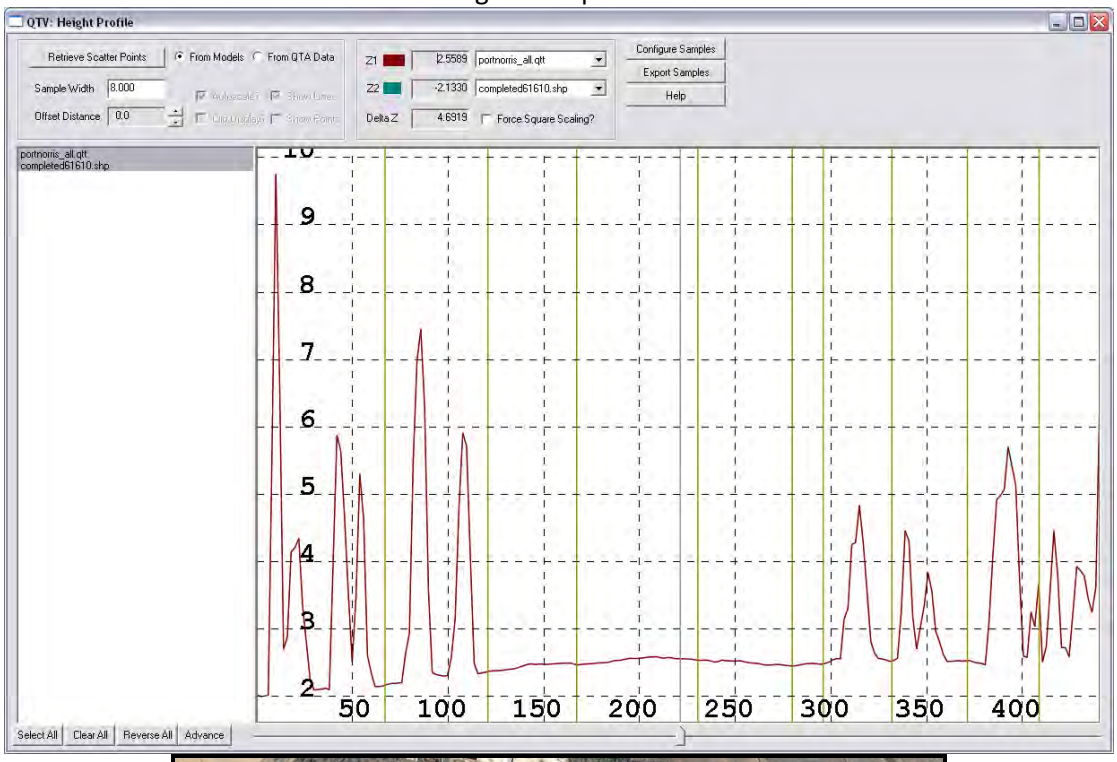


Figure 13- Levee Profile and Overview – Levee #95 Fishing Creek

(South Jersey LiDAR data = elevations in meters(Y Axis), Mensuration line (X Axis) (feet) = north-south)

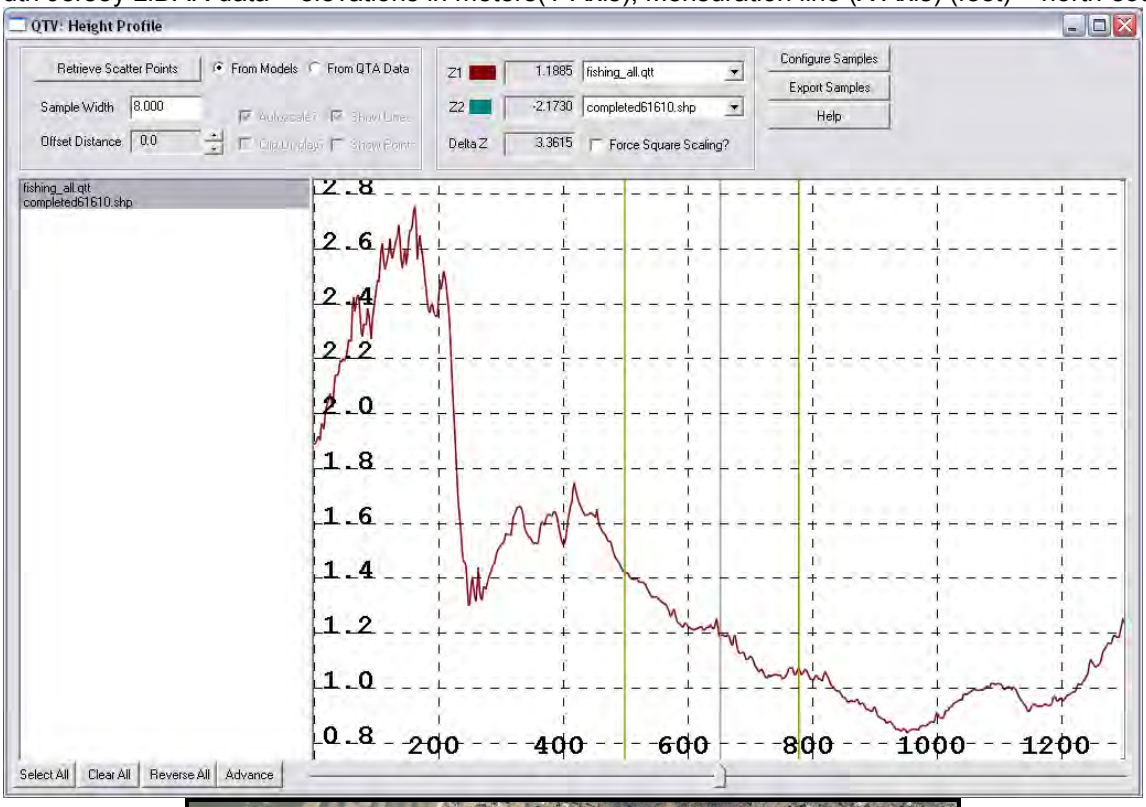


Figure 14- Levee Profile and Overview – Levee #97 Cox Hall Creek

(South Jersey LiDAR data = elevations in meters (Y Axis), Mensuration line(X Axis) Feet = north to south)

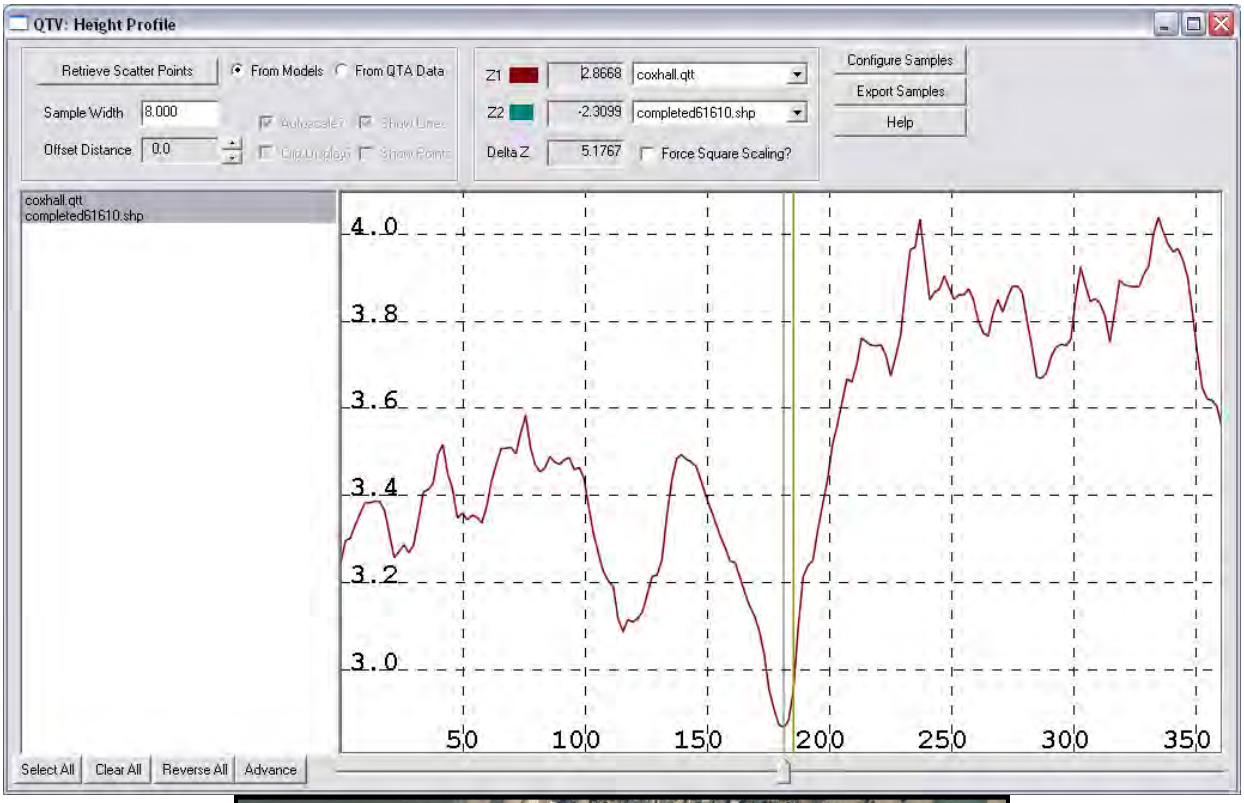
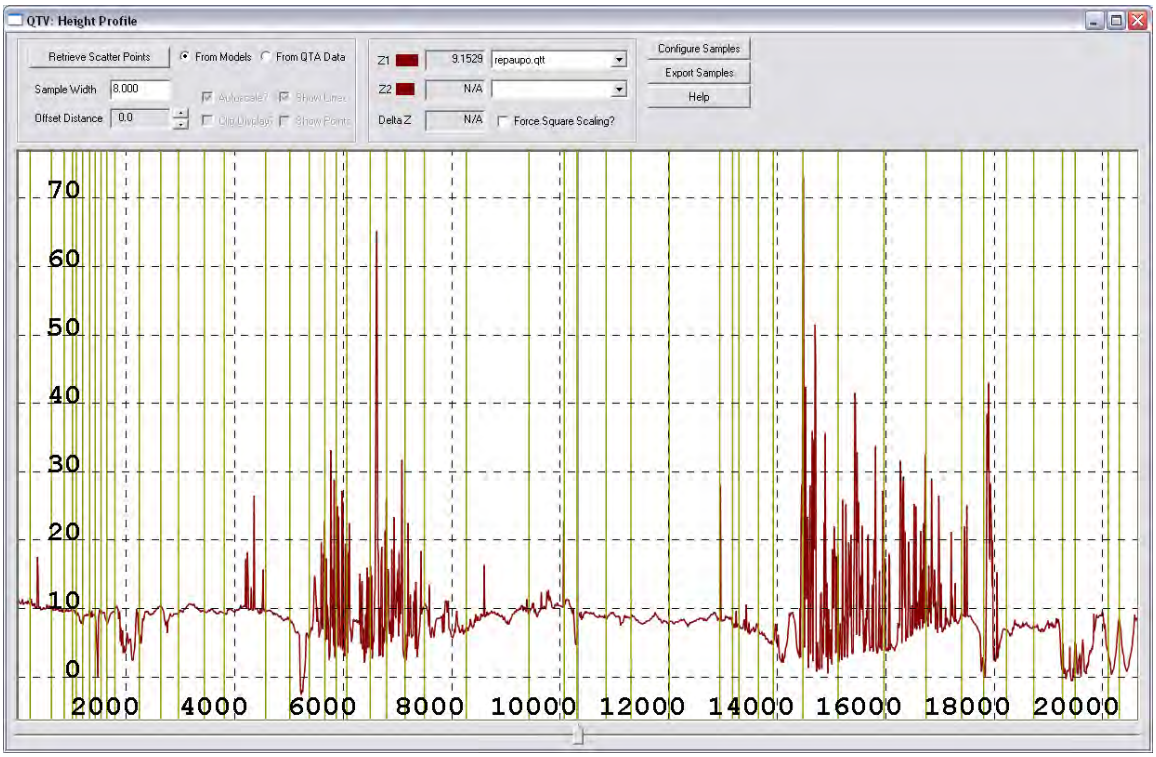


Figure 15- Levee Profile and Overview – Levee #104 Repaupo Creek (Protects Gibbstown)

(Gloucester County LiDAR data = elevations in feet (Y Axis), Mensuration line(X Axis) (Feet)= southwest to northeast)



Levee Vegetation Control

Table 8 shows the number of levees with or without vegetation control. Vegetation control is a critical part of maintenance of these structures. Woody vegetation can compromise the physical integrity of the levee over time by allowing water to follow the root systems through a levee. In addition, woody vegetation during storm events can cause physical failure of the levee by being wind- thrown and upending the tree roots. Nearly half of the levees that were inventoried had little or no vegetation control. Some of those without vegetation control for longer than a year had significant amounts and large-sized woody vegetation.

Table 8 - Levee Vegetation Control

Number of Levees with or without Vegetation Control			
	Vegetation Control	No Vegetation Control	No Record
Number of Levees	30	33	5
Percent of Levees	44.1	48.5	7.4

Levee Percent Sod Cover

Table 9 shows the percent sod cover for the levees. Generally, the greater the percent of sod cover the better protection from soil erosion and degradation of the physical integrity of the levee. Nearly half of the inventoried levees had 90 percent or better sod cover while over a third of the levees had less than 90 percent sod cover.

Table 9 - Levee Percent Sod Cover

Percent Cover	0-25	26-50	51-75	76-90	91-100	No Record
Number of Levees	12	3	4	5	31	13
Percent of Levees	17.5	4.4	5.9	7.4	45.8	19.0

Levee Erosion

Table 10 shows the number and percent of levees which have soil erosion problems. The physical integrity of a levee is affected by the extent and severity of soil erosion. Nearly a quarter of the inventoried levees have some type of erosion.

Table 10 - Levee Erosion

	Levee Erosion		
	Yes	No	No Record
Number of Levees	16	30	22
Percent of Levees	23.5	44.1	32.4

Levee Slope Stability

Table 11 shows the slope stability for the levees. Slope stability is dependent on the material of which levee is built as well as the protection of the slope toe from wave action and the underlying geologic material upon which the levee has been built. In addition to these factors the vegetation control and percent sod cover are important. Approximately 60 percent of the levees were stable.

Table 11 - Levee Slope Stability

	Stable	Moderately Unstable	Unstable	No Record
Number of Levees	40	12	1	15
Percent of Levees	58.8	17.6	1.5	22.1

Levee Settlement

Table 12 shows the number of levees that were determined to have some degree of settlement. Settlement could indicate that the soil and geologic material underlying the levee may be organic in nature which would cause settling over time as decomposition occurs. This type of physical process could cause the ultimate failure of a levee if the measures are not taken to reverse or stabilize it.

Table 12 - Levee Settlement

	None	Some	Considerable	No Record
Number of Levees	28	18	6	16
Percent of Levees	41.2	26.5	8.8	23.5

Levee Depression

Table 13 shows the depressions and rutting of the levees. Depressions could be resulting from activities on the levee such as all-terrain vehicles or other vehicles which are used repeatedly. The resulting depression formation could result in ultimate levee failure due to the lack of uniformity in the levee profile. The use of all-terrain vehicles was found to be a problem on several levees.

Table 13 - Levee Depression

	None	Some	Considerable	No Record
Number of Levees	30	19	1	18
Percent of Levees	44.1	27.9	1.5	26.5

Levee Cracking

Table 14 shows the amount of cracking in the levee which could indicate that it is unstable and in need of reinforcement. Lack of remediation of this problem could result in levee failure.

Table 14 - Levee Cracking

	None	Some	Considerable	No Record
Number of Levees	34	17	0	17
Percent of Levees	50.0	25.0	0.0	25.0

Levee Burrowing Animal Presence

Table 15 shows the degree to which burrowing animal evidence was found during the field inventory. Burrowing animals can cause water to flow through a structure and generally weaken the structure integrity.

Table 15 – Levee Burrowing Animal Presence

	None	Some	Considerable	No Record
Number of Levees	29	17	3	19
Percent of Levees	42.7	25.0	4.4	27.9

Levee Rock Riprap Protection

Table 16 shows the presence of rock riprap protection currently in place along a portion of a levee. Rock riprap protection is used to reduce the impact of wave action and storm activity to a levee. This type of protection can reduce the potential for weakening of the toe of the slope of the levee structure.

Table 16 – Levee Rock Riprap Protection

	Yes	No	No Record
Number of Levees	21	30	17
Percent of Levees	30.9	44.1	25.0

Levee Encroachment

Table 17 shows the number and percent of levees inventoried that had encroachments of buildings or other permanent structures which threaten the integrity of the levee structure and make it difficult to properly operate and maintain the levee.

Table 17 – Encroachment on Levees

	None	Some	Considerable	No Record
Number of Levees	41	8	2	17
Percent of Levees	60.3	11.8	2.9	25.0

Levee Pump Stations

Pump stations for the removal of internal drainage during high tide and/or storm events are located at five (5) levees. These locations (with number of stations at each) are Pennsville (2), Salem City at Town Bank (1), Fishing Creek (3), Cox Hall (2), and Repaupo (3). All of these locations are protecting urban locations which include residential, commercial and industrial areas.

A number of photos were taken of each of the levees with a select photo for each levee included in this report. A Personal Data Assistant (PDA) with Global Positioning System (GPS) capability was used to determine the latitude and longitude of the levee endpoints as well as key locations such as those associated with data groupings identified in Table 3.

Light Detection and Ranging (LiDAR) Analysis

The second component of the South Jersey Levee Inventory was the development of Light Detection and Ranging (LiDAR) information to analyze the length, height and elevation of the levees as well as development of estimated information for the data groups shown in Table 9. **LIDAR** (**Li**ght **D**etection **A**nd **R**anging) is an optical remote sensing technology that measures properties of scattered light to find range and/or other information of a distant target. The prevalent method to determine distance to an object or surface is to use laser pulses. Like the similar radar technology, which uses radio waves, the range to an object is determined by measuring the time delay between transmission of a pulse and detection of the reflected signal

Summary of GIS Methods and Data Products

LiDAR data for the analysis came from two separate datasets. Metadata for these datasets is included on the hard drive of deliverables.

1. Gloucester County LiDAR project 2007
2. South New Jersey LiDAR project 2008 (Cape May, Cumberland, Salem –below CAFRA)

.LAS files for “All Returns” were used to create Digital Surface Models (DSM) for areas proximate to the levees and other structures in the study areas. Gloucester County LiDAR data already had elevation values in feet in the original product. The South Jersey LiDAR had elevation in meters. These values were converted to feet for the output raster grid products and all of the maps.

The (horizontal) nominal point spacing for the South Jersey LiDAR was 1 meter, while the nominal point spacing for the Gloucester data was 1.25 meters. This distance is equal to 4.1 feet. Thus, it was reasonable to assume that the output data could be created at a cell size of 4 feet, without overly “pushing” the statistical soundness of the model -- and also taking into account the purpose and scale of the study.

The horizontal coordinate system for all data was New Jersey Stateplane, NAD83. The vertical datum was NAVD88.

For each “landscape”, raw .LAS data tiles were imported into Quick Terrain Modeler as .QTT models. These models were then exported as geotiffs with floating point elevation values. In ArcCatalog, the “Calculate statistics” function was run on the geotiffs in order to flag any “no data” areas and prepare the data for further conversion. Geotiffs were then converted to Arc GRID format (South Jersey data were also converted to foot elevation values by applying the 3.2808 conversion for meters to feet with the Raster Calculator).

The Gloucester LiDAR contract called for 0.19 meters vertical accuracy at 95 percent confidence level. The South Jersey LiDAR contract called for 0.15 meters for vertical

accuracy at 95 percent confidence level. With LiDAR data and derived products, it is important to consider that 95 percent of data elevations are within spec, and 5 percent of the points may be off by a greater distance. With this in mind, we created raster grids for mapping that had values **rounded down to the nearest foot**.

On the DVD of deliverables, raster grids that are named with a "_rd" suffix, such as "portnorris_rd" have values that have been rounded down to the nearest foot. These grids were used for creating informative color maps, which are included as .pdf files on the hard drive. The color maps show 2-foot intervals for each color, with blue color tones assigned to all elevations below 8 feet. People often associate blue colors on maps with water, so the intention is to show a picture of possible flood areas at the low elevations.
The DSM format allows for more than just ground elevations to be observed, and produces more of a "3d" effect when draped over the orthophotography. Yards and streets can show blue "inundation", while treetops and roofs will show colors of higher elevations.

On the DVD of deliverables, raster grids that are named with a "_ft" suffix contain the elevation values in feet, but in **floating point decimal.** These grids can be used for further analytical work in the future, but users are cautioned that most computers do not properly handle floating point decimals, so it is unclear if using the data in this format will really produce significantly more accurate analyses. See link: http://forums.esri.com/Thread.asp?c=93&f=988&t=285805.
For some users, the decimal format may also seem to imply that the data are more accurate than +/- 5.9 inches with the South Jersey LiDAR data (or +/- 7.48 inches in the Gloucester data).

The x-y graphs produced by digitizing a mensuration line can provide a useful profile of the elevations at the top of the structures. However, the DSM also contains the vegetation heights and it was not possible to capture only the structure elevation during the mensuration process. Therefore, unusually high spikes in the elevation profile should be assumed to be vegetation heights. Low elevation spikes may indicate the lowest elevation along a structure, but may also indicate where the mensuration line "fell off" the side of a structure in the model. In summary, the mensuration data should be considered useful overall, while individual points along the line may be misleading due to the above referenced issues.

The DVD contains .pdf versions of all of the elevation maps. Each map is named for a structure within the landscape. The maps are in a folder named "Elevation Maps." Overview maps are in a folder named for them.
The data are in Arc GRID format, and are within folders named for the structures (e.g., Repaupo, Fishing Creek). Grids that are named with a "_rd" suffix, such as "portnorris_rd" have values that have been rounded down to the nearest foot.
Grids that are named with a "_ft" suffix contain the elevation values in feet, but in floating point decimal. Users are cautioned that the LiDAR elevation data accuracy is no better than =/- 15 cm (~ 6 inches), so the extra decimal places are <u>not significant</u>.

Verification of LiDAR Elevation Data

Early in the study a comparison was made between the elevation data obtained from LiDAR against field data obtained from known USGS benchmarks and elevation data obtained from a survey grade GPS total station system. The site selected for the comparison was the levee at Repaupo Creek where NRCS had access to historic data, including structure elevations from project work completed in the 1960's. Benchmark elevations were at that time in the National Geodetic Vertical Datum of 1929 (NGVD) datum system. These elevations were field verified using standard total station equipment and were converted to the North American Vertical Datum of 1988 (NAVD 88) datum using the location specific conversion factor obtained from National Oceanic and Atmospheric Administration (NOAA). The points were then surveyed using a survey grade GPS total station system and compared to the LiDAR obtained elevations. As the data Table 18 indicates, there was a good degree of correlation between the elevations obtained through the various survey methods and the LiDAR data, certainly within the stated level of accuracy of the information (+/- 6 inches).

Figure 13 shows elevation of the surface including trees, shrubs and buildings at the Mill Creek Levee (Levee # 51). Elevations that are 8 feet or less are denoted by shades of blue. The areas shown in blue shades are approximately equivalent to the elevation of the top of most levees in South Jersey. Areas at this elevation or less would likely be inundated in the event of levee failure. Major flooding from hurricane or other storm events would exceed the levee heights in most areas of South Jersey.

Figure 14 shows the FEMA Flood Map for the area of inundation in Greenwich Township (Cumberland County) behind Levee 51 or Mill Creek Levee.

The FEMA Flood Insurance Study for Greenwich Township shows that the 100 year flood elevation is at 8.8 feet msl. (1929 Datum). The LiDAR representation of this area is consistent with this. A recent NRCS survey of Levee #51, which is in need of a water control structure replacement, shows the elevation of the levee ranges from 9.0 to 9.5 (1929 Datum). FEMA Flood Insurance requirements for a levee require that the levee have a minimum of three (3) feet of freeboard above the 100 year flood elevation (FEMA, 2005). So while the levee has been constructed approximately to the 100 year flood elevation, it does not qualify under FEMA criteria as a flood control structure due to insufficient freeboard. This is similar to other levees in South Jersey where, at best, reliable protection is provided against tidal inundation and low level flood events only.

Table 18 – Repaupo Levee Data Comparison

Location	NGVD 1929 Datum	NAVD 1988 Conversion	GPS NAVD 1988	LIDAR NAVD 1988
White Sluice Tidegate Deck	13.02	11.95	11.47	11.8
Top of Curb, White Sluice	14.00	12.93	12.42	--
Top of levee (near observation deck)	10.96	9.89	9.76	10.1
Top of levee (bollard line)	10.42	9.35	9.16	9.6

Conversion from NGVD 1929 to NAVD 1988: -1.07 (NOAA web site)
All elevations in feet

Figure 16- Mill Creek (Union Bank) Levee (Levee 51), Greenwich Twp., Cumberland County-
An Example of LiDAR-Derived Elevations

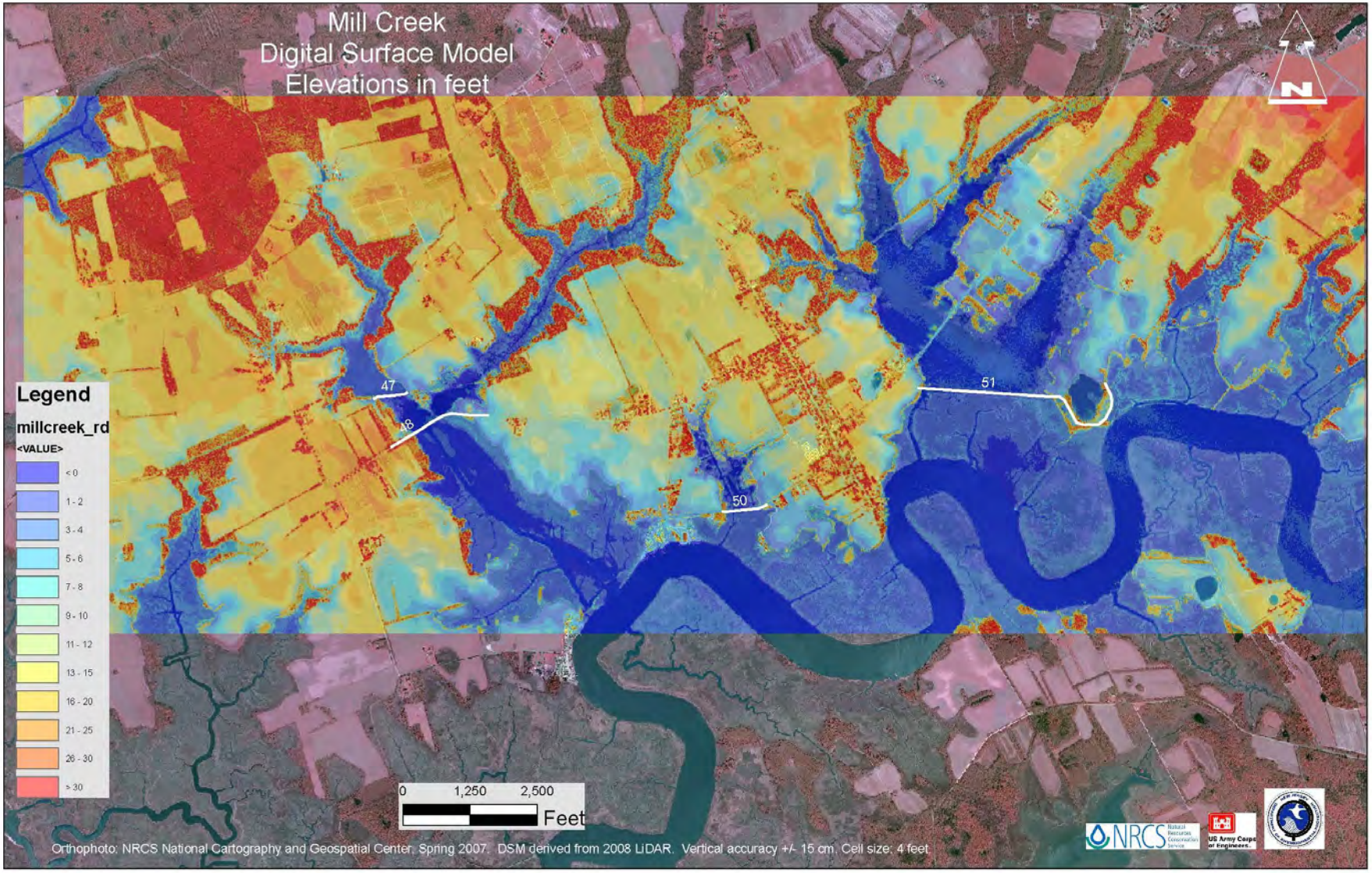
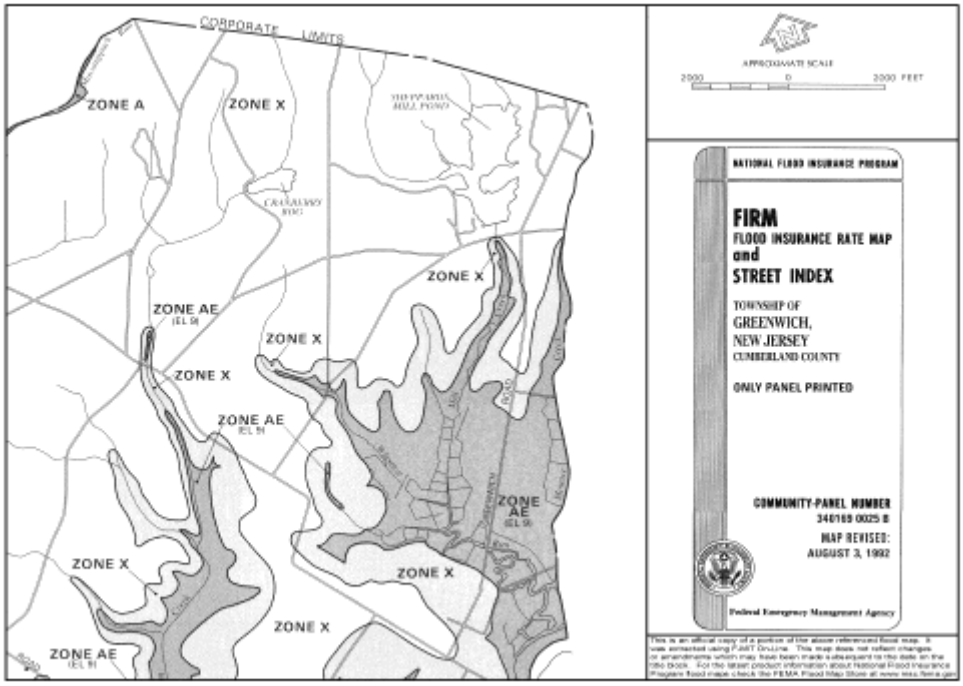


Figure 17- Mill Creek (Union Bank) Levee (Levee 51), Greenwich Twp., Cumberland County- FEMA Flood Map



Structure Counts and Land Use/Cover Impacts Due to Inundation

LiDAR was used to estimate the number of structures (homes, businesses, etc.) that would be impacted by a failure of the existing levee system. The existing levees were assumed to be at an elevation of 8 feet msl. Data in Table 19 is based on the failure of an existing levee and is not intended to represent a specific flood or category hurricane event.

Development of dynamic inundation models was not within the scope of this project, given limitations of hardware and GIS staff. These acreages are estimates of the land cover/land use proximate to the inventoried levees shown on each map. The estimates are bounded by the geographic area of the digital surface models developed for each landscape. It was not possible to develop LiDAR-derived surface models for the entire four county region. Table 20 shows the estimated acres of various land cover/land use types in the event of a failure of a levee or levees in the specified vicinity.

Table 19 - Light Detection and Ranging (LiDAR) Analysis for Selected Flood Inundation Areas

Data Group	Descriptor
Area Protected	Acres
Agricultural Land Protected	Acres
Homes/Businesses/Structures Protected	Number
Population of Area Protected	Number
Roads, Railroads and Utilities Protected	Feet

Table 20 - Number of Homes/Businesses/Structures Protected for Selected Levees

Municipality Vicinity	Structures
Hancocks Bridge, Salem County	141
Fishing Creek, Cape May County	2,052
Port Norris, Cumberland County	212
Gibbstown, Gloucester County	344
Salem City, Salem County	*
Pennsville Township, Salem County	*

*Available LiDAR Coverage for these areas was insufficient to provide an estimate, but several hundred structures (homes and businesses) are suspected to be protected by levees in each of these municipalities. LiDAR coverage for these areas is expected to become available in 2011.

Table 21 – Estimated Protected Land Use/Cover for Selected Levees

Municipality Vicinity	Estimated Protected Land (Elevations 8 feet msl or lower) by Land Use/Cover (Acres)				
	Urban	Agricultural	Forest	Wetland	TOTAL
Hancocks Bridge, Salem County	176	1089	65	2234	3564
Fishing Creek, Cape May County	376	19	12	954	1361
Port Norris, Cumberland County	284	72	66	2177	2599
Gibbstown, Gloucester County	980	405	161	2224	3770
Town Bank Portion of Salem City, Salem County	526*	978*	56*	1558*	3118*
Pennsville Township, Salem County	*	*	*	*	*

*Available LiDAR Coverage for these areas was insufficient to provide an estimate or LiDAR coverage only was for a portion of the municipality vicinity. LiDAR coverage for these areas is expected to become available in 2011.

Levee Photos

Levee 5 – Miles Creek, Pennsville Township, NJ

Levee 9 – Middle Neck/Sinnickson Landing Levee, Elsinboro Twp, NJ

Levee 11 – Town Bank Levee, Salem City, NJ

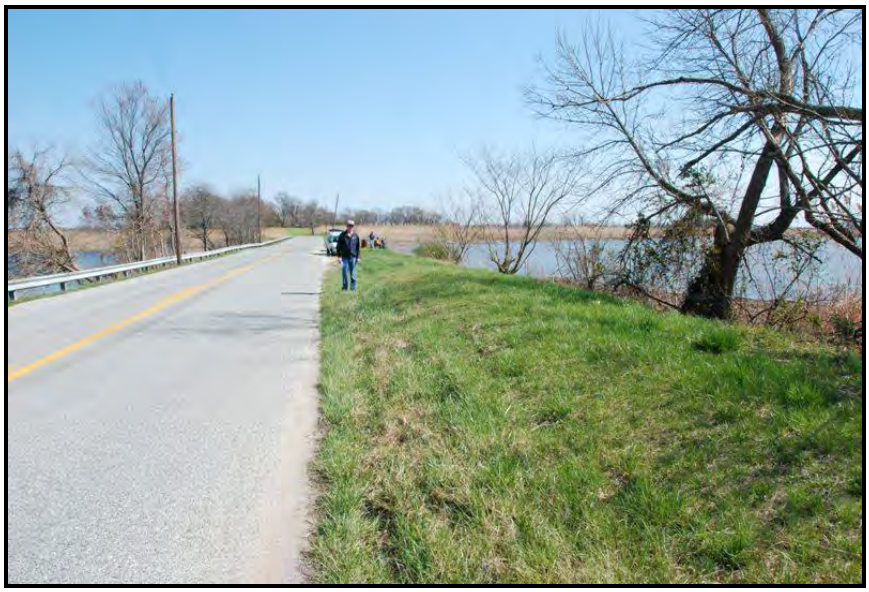
Levee 12 – Fenwick Creek Levee, Salem City, NJ

Levee 13 – Locust Island Levee, Hancocks Bridge, Lower Alloways Creek Twp, NJ

Levee 14 – Silver Lake Levee, Canton, Lower Alloways Creek Twp, NJ

Levee 16 – Supawna Meadow, Pennsville Township, NJ

Levee 17 – Lighthouse, Pennsville Township, NJ



Levee 18 – Sunset Road, Mannington Township, NJ

Levee 19 – County Route 540, Mannington Township, NJ

Levee 20– Beaver, Pennsville Township, Salem Co., NJ

Levee 22 – Supawna Meadow Private, Pennsville Township, NJ

Levee 23 – TV Towers, Pennsville Township, NJ

Levee 24 – TV Towers South, Pennsville Township, NJ

Levee 25 – Harrisonville, Pennsville Township, NJ

Levee 27 – Fort Elsborg Vicinity, Elsinboro Township, NJ

Levee 29 – Mason Point East/Abbots Farm Road, Elsinboro Township, NJ

Levee 30 – Alloways Creek, Lower Alloways Creek Township, NJ

Levee 31 – Private Landowner, Lower Alloways Creek Township, NJ

Levee 34 – Beasley Neck Road 2, Lower Alloways Creek Township, Salem Co., NJ

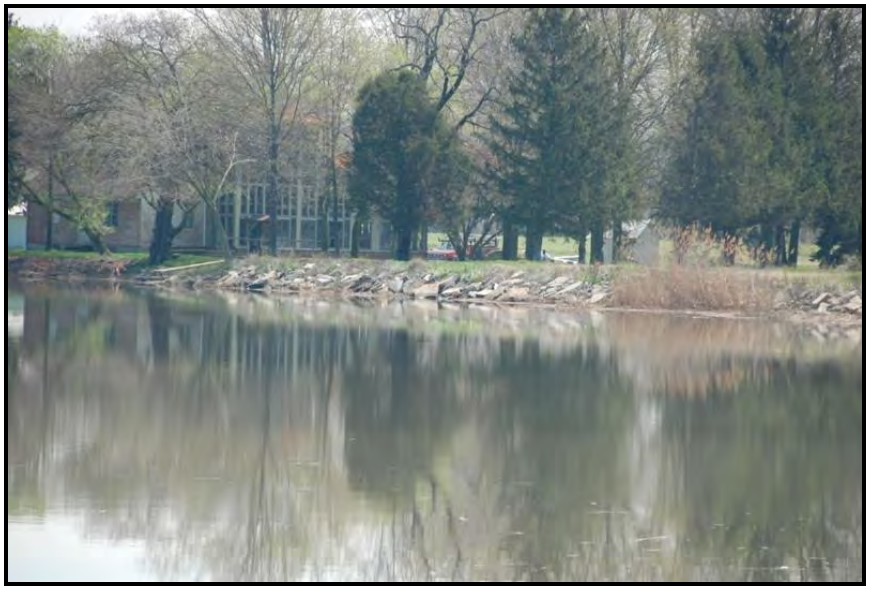
Levee 35 – Beasley Neck Road#3, Quinton Township, NJ

Levee 37 – Moores Bank, Lower Alloways Creek Township, NJ

Levee 38 –Private Landowner, Lower Alloways Creek Township, NJ

Levee 39 – Grosscup, Lower Alloways Creek Township, NJ

Levee 40 – Hancocks Bridge Poplar, Lower Alloways Creek Township, NJ



Levee 41 – County Road 623, Lower Alloways Creek Township, NJ

Levee 43 – Long Bridge Outlier, Lower Alloways Creek Township, NJ

Levee 44 – Long Bridge Road, Lower Alloways Creek Township, NJ

Levee 46 – Buckhorn Road, Lower Alloways Creek Township, NJ

Levee 47 – Pine Mount Private Landowner, Greenwich Township, Cumberland Co., NJ

Levee 48 – Pine Mount Bacons Neck, Greenwich Township, Cumberland Co., NJ

Levee 50 – Market Street, Greenwich Township, Cumberland Co., NJ

Levee 51 – Mill Creek (Union Bank), Greenwich Township, Cumberland Co., NJ

Levee 58 – Pease Road, Hopewell Township, Cumberland Co., NJ

Levee 62 – Back Neck 1, Fairfield Township, Cumberland Co., NJ

Levee 63– Back Neck 2, Fairfield Township, Cumberland Co., NJ

Levee 67– Private Landowner North, Lawrence Township, Cumberland Co., NJ

Levee 68– Private Landowner South, Lawrence Township, Cumberland Co., NJ

Levee 69– Sayres Neck North, Lawrence Township, Cumberland Co., NJ

Levee 70– Sayres Neck South, Lawrence Township, Cumberland Co., NJ

Levee 71 – Sayres Neck South, Lawrence Township, Cumberland Co., NJ

Levee 73 – Jones Island Road, Lawrence Township, Cumberland Co., NJ

Levee 81 – Port Norris, Commercial Township, Cumberland Co., NJ

Levee 82 – Heislerville, Maurice River Township, Cumberland Co., NJ

Levee 83 – Private Landowner, Millville City, Cumberland Co., NJ

Levee 85 – Port Norris North, Commercial Township, Cumberland Co., NJ

Levee 86 – Berrytown, Commercial Township, Cumberland Co., NJ

Levee 88 – Maple Street, Downe Township, Cumberland Co., NJ

Levee 91 – Private Landowner, Dennis Township, Cape May Co., NJ

Levee 95– Fishing Creek, Middle Township, Cape May Co., NJ

Levee 96– Villas/Shaw Meadow, Lower Township, Cape May Co., NJ

Levee 97– Cox Hall Creek, Lower Township, Cape May Co., NJ

Levee 98– Sunray Beach, Middle Township, Cape May Co., NJ

Levee 103– Birch Creek, Logan Township, Gloucester Co., NJ

Levee 104– Repaupo Creek, Greenwich and Logan Townships, Gloucester Co., NJ

Levee 106– Red Bank, West Deptford Township, Gloucester Co., NJ

Levee 107– Private Landowner, Maurice River Township, Cumberland Co., NJ

Considerations for Potential Future Action

Some difficulties exist for the continued maintenance and rehabilitation of many South Jersey levees that are increasingly putting lives and property at risk. These include "orphaned" levees, lack of local sponsorship, archaic legal entities for sponsorship, fragmented ownership, lack of funding for ongoing operation and maintenance, permitting costs and time frames, and lack of policy coordination and communication among Federal, State, County and Local governments. A further explanation of these problems can be found on page 124-125.

Recommendations include the following:

1 . Seek a legal successor to Meadow Companies where they are no longer effective.

2. Develop local and county capacity for providing shared equipment for vegetation control on existing levees.

3. Develop an overarching entity which acts as a clearinghouse through which coordination, communication and cooperation could take place for potential projects funded by Federal, State and County agencies and other partners which have funding for levee rehabilitation and maintenance.

4. Provide on-going technical and cost share assistance for existing levee operation and maintenance to private landowners, meadow bank companies, county and local units of government.

5. Provide training and information to county and local emergency management coordinators for the purpose of effective and efficient evacuation of people from vulnerable areas behind existing levees.

6. Provide information, on an on-going basis, to the general public on eligibility or ineligibility of existing levees for PL-84-99 US Corps of Engineers emergency assistance and the status of certification of existing levees as providing protection under the Federal Emergency Management Agency (FEMA) National Flood Insurance Program.

7. Upgrade and rehabilitate levees to meet the necessary Federal Emergency Management Agency (FEMA) accreditation requirements for the National Flood Insurance Program (NFIP) and the US Army Corps of Engineers PL-84-99 emergency assistance requirements in the event of levee failure.

Table 25 – Recommendations for Levee Problems

Recommended Action	Who	When
Seek a Legal Successor to Meadow Companies where they are no longer effective.	State of New Jersey	2-3 years
Develop local and/or county capacity for providing shared equipment for vegetation control on existing levees.	Delaware Estuary Levee Organization (DELO) Cape May County Cumberland County Gloucester County Salem County	3-5 years
Develop an overarching entity which acts as a clearinghouse through which coordination, communication and cooperation could take place for potential projects funded by Federal, State and County agencies and other partners which have funding for levee rehabilitation and maintenance.	State of New Jersey	On-going
Provide on-going technical and cost share assistance for existing levee operation and maintenance to private landowners, meadow bank companies, county and local units of government.	New Jersey	3-5 years

Recommended Action	Who	When
Provide training and information to county and local emergency management coordinators for the purpose of effective and efficient evacuation of people from vulnerable areas behind existing levees.	Counties and local government DELO	Immediately
Provide information, on an on-going basis, to the general public on eligibility or ineligibility of existing levees for PL-99 US Corps of Engineers emergency assistance and the status of certification of existing levees as providing protection under the Federal Emergency Management Agency (FEMA) National Flood Insurance Program.	US Army Corps of Engineers Federal Emergency Management Agency DELO	On-going
Upgrade and rehabilitate levees to meet the necessary Federal Emergency Management Agency (FEMA) accreditation requirements for the National Flood Insurance Program (NFIP) and the US Army Corps of Engineers PL-99 emergency assistance requirements in the event of levee failure.	Counties and local government US Army Corps of Engineers Federal Emergency Management Agency	On-going

Appendix

Appendix A - Background

A levee is defined as an earthen embankment constructed to protect low lying areas from tidal, riverine or other flooding. These structures often will have water control structures built to allow internal drainage water to exit during low tide but prevent the movement of tidal or other flooding from moving into the low lying area. Definitions of other terms used in this report can be found in the Glossary.

There are many facets to the story of levees in and along the Delaware Bay and lower Delaware River in South Jersey. While this Inventory is a direct outgrowth of the public concern that occurred following the levee failures in New Orleans during Hurricane Katrina September 2005, its origins are from much earlier in time. In fact, this inventory is the result of many years of discussion regarding the vulnerability of low-lying areas, currently protected by aging levees, in South Jersey to flooding from daily tidal, Northeasters and storm surge flooding.

There are at least twenty two municipalities in the four counties (Figure 1) that have areas protected by dikes and levees. Many of these levees were constructed by "meadow bank companies" which are state-chartered organizations of agricultural landowners originally formed for the purpose of establishing and maintaining "meadow banks" or levees to protect low-lying areas from flooding so that agricultural crops could be grown. In many cases these levees were constructed 200 or more years ago. Unfortunately some of these structures, which originally protected relatively low value agricultural land, are now protecting high value land which includes many homes, businesses, power generating facilities, Super Fund sites and public transportation corridors. In addition, these levees provide for a freshwater supply for agricultural irrigation, protection of public and private well water supplies, mosquito control and wildlife habitat. A full discussion of meadow bank companies and other levee-related topics can be found in the next section.

Levees have been constructed in South Jersey, and other parts of New Jersey, since the late 18th century. Earlier settlers constructed the levees to increase the amount of agricultural acreage, from previously tidal areas, for the purpose of grazing animals and/or harvesting of salt hay. Levees have been built by single landowners or groups of cooperating parties including farmers, municipalities, counties and industries, as well. Often, meadow bank companies, some of whose origins date prior to the nation's formation, were and still are the institutional vehicle that groups of landowners used to build and maintain the "banks" or levees. The meadow bank companies acted and, in some cases still act, as a legal and economic institution to assess the benefiting landowners with costs on the basis of the number of benefited acres.

As non-agricultural development has taken place behind and inland of these structures, higher value property and greater numbers of people have been and are becoming

dependent, oftentimes unknowingly, upon the original levee system. The demise of meadow bank companies as non-agricultural development has occurred has further exacerbated the increasing threat to property and lives. The history of major levee breaching shows that it has been nearly 50 years (March 1962) since the last widespread failures occurred and, as a result, there appears to be a complacency that has settled in among those knowingly or unknowingly protected as well as key decision makers.

Meadow Bank Companies: Origin and Early History

Human use of tidal marshes of the Delaware Estuary has taken place within a period of relative sea level rise (Titus, 1988). Orson, et al. (1992) used sediment dating and pollen analysis to analyze the history of a tidal marsh near National Park, New Jersey. Land clearing and farming of the fertile floodplain and marshy fringe occurred in the 1600-1700s. In the next century farmers needed to build dikes to keep out storm and spring tides as sea level rose about one foot per 100 years (Titus, 1988). Farming meadowlands behind dikes became a widespread practice throughout the estuary in the 1700 and 1800s and is documented in records of Meadow bank companies (Seebold, 1992). During the 1990s, Public Service Electric and Gas Company, through its Estuary Enhancement Program, removed a number of pre-existing levee systems in South Jersey to permit re-establishment of the tidal condition for fishery nurseries. The salt marsh restoration effort through this program focused on undiked natural tidal marshes, diked lands breached by severe storms over 100 years ago, and diked lands breached incrementally as recently as 20-50 years ago (Philipp, 2005).

Origin and Early History

As early as 1685, prominent New Jersey landowner Thomas Budd, proposed diking and draining portions of the salt marshes in Commercial Township. His purpose was to provide for cattle pasture and for farming of salt hay. Between 1697 and 1783, the legislature passed about 74 statutes to require salt marsh owners to build bridges and dikes needed to farm salt hay (Dybas, 2003). During the past 200+ years numerous “meadow companies” have been formed along the Delaware Estuary to erect levees, tidegates and other waterworks to prevent tidal inundation. Today’s meadow companies were formed under New Jersey State legislation passed on November 29, 1788 (L.1788, Chapter 254). Specific reference to the Act’s implementation is provided under New Jersey Statutes supplemented on several occasions, most recently in 1991. One example of the Meadow Companies, chartered by King George, is the Repaupo Meadow Company in Greenwich and Logan Townships in Gloucester County, New Jersey (NRCS, 1996a). Originally these structures provided flood protection and drainage for predominately agricultural land, however, as development has occurred, many of these areas now have high value agricultural land, residential and commercial development, power generating facilities, Super Fund sites and transportation corridors (NRCS, 1996b). As a result, today’s meadow companies now have a major responsibility for the protection of public safety in the areas in which they operate.

A Case Study: Repaupo Meadow Company

The meadow companies, in some cases, have failed to continue to provide the necessary flood protection and other benefits. They have been described as "phantoms" evidenced only by the deteriorating levees and tide gates that were spawned by the "existing" but powerless, penniless associations of marsh owners (DiMuzio, 2006). Forty years passed after a recommendation that the Repaupo Meadow Company tidegate and levee be restored and improved. Only temporary repairs were made and only in response to "flood events" (DiMuzio, 2006). An October 9, 2001 letter from then NJDEP Commissioner Shinn explained that the Repaupo Meadow Company was legally responsible for the levee and tide gates. NJDEP had no authority or jurisdiction to direct repairs to the structures (DiMuzio, 2006). Previously, in the 1960s and 1970s the Repaupo Meadow Company made numerous, futile attempts to obtain federal assistance because it had no funds to satisfy the local cost-sharing requirements.

The meadow bank companies in some areas have become non-functional due to death of members, changes in land use and ownership, lack of awareness by those protected by these structures, and the cost of operation and maintenance of structures. During this same timeframe, non-agricultural development has been taking place in areas protected by these structures sometimes in spite of the 1975 New Jersey adopted special hazard floodplain regulations. The existing levee structures have been described as "orphaned" structures (DiMuzio, 2006, 2007) because municipalities and counties have been unwilling or unable to take legal responsibility for their continued operation, maintenance and, where necessary, rehabilitation, in part due to the continued existence of the legally authorized meadow bank companies. In at least one case, fragmented operation and maintenance responsibilities (resulting from a non-functional but legally extant meadow bank company) have resulted in a loss of registration of the structure to receive federal assistance in the event of damage due to a major flood (Corps, 2003). The result of these trends is that increasingly there are deficiencies in the timely repair and upkeep of levees and their associated structures including pump stations, tidegate and other water control structures. Some local and county governments are reluctant to take on the role of the entity to be responsible for operation and maintenance of these structures due to concerns about cost, permitting and liability.

A 1996 survey of meadow bank companies found that three of the four companies responding did not have adequate funding for routine operation and maintenance. The survey found that the number of assessed landowners ranged from seven to more than 35 per meadow bank company. All four meadow bank companies did not have adequate funding for major repair and replacement costs. All four meadow companies had been in existence since at least 1788 (November 29, 1788 (L.1788 Chapter 254) which is the year the New Jersey State legislation was passed authorizing new as well as recognizing pre-existing meadow bank companies.

Levee Purposes

Management of levees in South Jersey today is being done for a variety of purposes. A number of levees are being managed for mosquito control by the Salem County Mosquito Commission. Other levees are managed by industrial park companies to reduce the incidence of flooding due to daily tidal inundation as well as major flood events. Still other levees are in place to protect cropland where high value crops, such as tomatoes, asparagus, and others, for human consumption are grown as well as protect surface water supply sources to irrigate a significant acreage of agricultural crops. One such farm, having 1400 acres of such cropland, is protected by miles of levees. In addition to protecting irrigation water supplies, levees may be protecting both municipal (City of Salem) and private water supply wells from salt water intrusion.

Levees are used for management of fish and wildlife areas, such as the Heislerville Wildlife Management Area, to provide a diverse freshwater and saltwater habitat for various species. Levees protect some of the most historical properties in South Jersey including the 1722 Abel Nicholson House (named a National Historic Landmark in March 2000) in Elsinboro Township, Salem County. Additionally, many levees are managed for their intrinsic public benefits to reduce daily tidal inundation and to reduce flooding from major storm events. The Pennsville levee system along the Delaware River not only is managed for these purposes but also provides public recreational opportunities via walking trails, beach and boat ramp.

History of Levee Failures

There is little or no published information on levee failures in South Jersey, however, there have been incidents of levee failures here. Interviews with long-time government officials and others indicate that, while these incidents have been rare in recent years they have occurred in the past. The most recent significant event was the Good Friday event which occurred on March 9, 1962. A November 25, 1950 storm resulted in a recorded 8.5 foot high tide on the Delaware River at the mouth of the Cohansey River in Cumberland County (NCDC, 2009). Many of the levees built or re-built since that event use the high water mark of that event for their top of levee elevation.

The history of levee failures is written on the landscape of South Jersey with a number of failed levee remnants being replaced by a newer generation of levees farther inland. Figures 25 and 26 show the Mill Creek (Union Meadow Bank Company) levee at Greenwich Township, Cumberland County in 1930 and its newer location in 2002. The pre-1962 levee remnant which followed the Cohansey River bank has been replaced by 1964-built, straighter levee built under the USDA SCS Watershed Protection and Flood Prevention Program. A summary of its history is as follows:

> *The dike protecting the Mill Creek tidal marsh was constructed by the Union Bank Meadow Company, organized in the early 1800's. This meadow Company presently has seven members, with control of about 300 acres.*
>
> *The Mill Creek dike was constructed along the bank of the Cohansey River, from material taken out of the river. It was thus subject to erosive effects of*

of wave action and river current, and maintenance was costly. Periodically, high tides, often associated with hurricanes, caused damage to the dike. Storms that damaged or overtopped the dike occurred in August 1933, October 1933, November 1953, August 1955, and May 1960 (USDA SCS, 1962).

Figure 25 – Mill Creek Dike at Greenwich on Cohansey River,Cumberland County – 1930
(Photo Courtesy of NJDEP I-map)

Figure 26 – Mill Creek Dike at Greenwich on Cohansey River,Cumberland County – 2002
(Photo Courtesy of NJDEP I-Map)

Figures 27 and 28 show the Port Norris and Heislerville levees along the Maurice River in 1930 and 2002. Note the change in the Heislerville levee over that time frame.

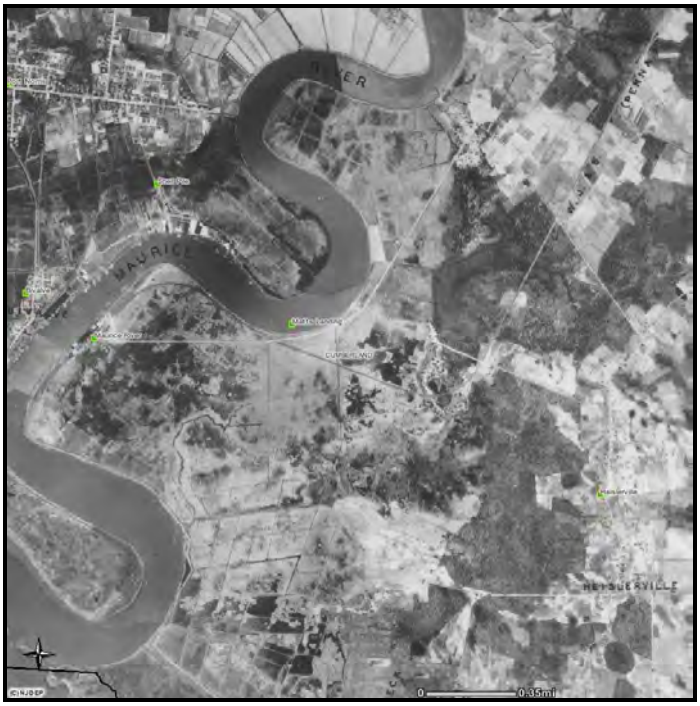


Figure 27 – Port Norris and Heislerville Levees,Cumberland County – 1930
(Photo Courtesy of NJDEP I-map)

Figure 28 – Port Norrris and Heislerville Levees on Maurice River, Cumberland County – 2002
(Photo Courtesy of NJDEP I-Map)

Figures 29, 30, 31 and 32 show the Locust Island and Silver Lake dikes. Information on its levee history is as follows:

> *The Silver Lake dike has been breached in recent years as follows:*
> *August 22, 1933, 3 breaches of approximately 60 feet, repair cost, $1256.00*
> *November 25, 1950, 810 Ft of dike washed out, repair cost $12,157.16*
> *August 14, 1955, 90 Ft beach, repair cost $16, 221.30*
> *January 11, 1956, 50 Ft breach, no repairs to date (January 1957). This was part of the work repaired after the August 14, 1955 storm.*
>
> *The Locust Island dike was overtopped in September 1940 by excessive Runoff in the Lower Alloways Creek. This runoff was caused by a severe Tropical storm which started on September 1, 1940, with over ten inches of rainfall in twelve hours. The water flooded the entire Silver Lake-Locust Island area. The annual repair costs run between $300 and $500 and are in addition to the annual maintenance costs (USDA SCS, 1957).*

Figure 29 – Locust Island Levee at Hancocks Bridge, Lower Alloways Creek, Salem County – 1930
(Photo Courtesy of NJDEP I-Map)

Figure 30 – Locust Island Levee at Hancocks Bridge, Lower Alloways Creek – 2002
(Photo Courtesy of NJDEP I-map)

Figure 31 – Silver Lake Levee, Lower Alloways Creek Township, Cumberland Co. – 1930
(Photo Courtesy of NJDEP I-Map)

Figure 32 – Silver Lake Levee, Lower Alloways Creek Township, Cumberland Co. – 2002
(Photo Courtesy of NJDEP I-Map)

Figures 33 shows the Town Bank dikes/levees. Information on its levee history is as follows:

> *Town Bank was built over 100 years ago, when the Town Bank Meadow Company was organized. Flooding occurs annually, the most severe storms coming between July and November, often associated with hurricanes. Severe floods occurred in August 1933, September 1940, September 1944, September and November 1950, August 1954, and August 1955….The Town Bank dike was breached and destroyed during a hurricane storm on August 22, 1933. The County of Salem rebuilt the dike to adequate height and cross section. Nine 24-inch tide gates were installed and a road was built on top of the dike. There has been no damage to the dike since it was rebuilt in 1933. (USDA SCS, 1959).*

Figure 33 – Town Bank Levee – Salem City, Salem County – 2002
(Photo Courtesy of NJDEP I-Map)

Figure 34 – Middle Neck Levee – Elsinboro Township, Salem County – 2002
(Photo Courtesy of NJDEP I-Map)

Figure 34 shows the Middle Neck dike/levee. Information on its levee history is as follows:

> *The Middle Neck Meadow Company was organized under authority of State Law in 1810. It is one of many such groups organized in coastal areas of New Jersey about this time. The system of dike and tidegates functions for many years. Maintenance of the system was accomplished by the Middle Neck Meadow Company through assessment of its members.*
>
> *The storm of August 1933 severely breached the dike and clogged drainage channels with sediment and debris. Occurring in the height of the depression era, the Middle Neck Meadow Company could not finance the needed repairs. Salem County repaired the damage, and has since maintained the dike as a county road. The channels have never been adequately repaired and have undergone additional clogging with vegetation since 1933 (USDA SCS, 1964).*

Another measure of the number of levee failures is the requests that USDA NRCS has received from local sponsors (municipalities, counties, meadow bank companies). Table 22 shows failed structures that the USDA NRCS has provided Emergency Watershed Program funding and technical assistance over a period of time.

Table 22 – USDA Natural Resource Conservation Service Emergency Watershed Program Funding for Levee Repair

Name of Structure	Type Job	Municipality	County	Date
Moores Beach Dike Repair	Dike Repair	Maurice River Twp.	Cumberland	January 1981
Mason Point Dike Repair	Dike Repair	Elsinboro Twp.	Salem	April 1981
Miles Creek Dike Repair	Dike Repair	Pennsville Twp.	Salem	June 1981
Greenwich (Pine Mount) Dike Repair	Dike Repair	Greenwich Twp.	Cumberland	June 1986
Greenwich (Pine Mount) Dike Repair	Dike Repair	Greenwich Twp.	Cumberland	December 1991

Source: USDA NRCS Emergency Watershed Program records.

Appendix B - Critical Times and Increasing Vulnerability to Lives and Property

One of the most vulnerable times for levees to fail can occur when a number of conditions occur at the same time. These conditions are most likely to occur in the fall. These conditions include high tide, northeaster storm, and a full moon at perigee (nearest to the Earth). Long time residents who live near levees refer to this condition as the "moon tide."

Sea Level Rise

The Grant F. Walton Center for Remote Sensing & Spatial Analysis at Rutgers University, in partnership with the American Littoral Society has examined the potential effects of sea level rise on coastal habitats. Lathrop and Love (2007), using digital elevation model (DEM) data with a 1.0 meter and 10 meter resolution, vertically and horizontally, analyzed the impact of sea level rise on New Jersey's coastal development and ecosystems. While the precise rate of sea level rise is uncertain, current models indicate that climate change will cause the rate to increase. Based on the trend of sea level rise from 1961 through 2003, sea level would rise by almost 6-inches by the end of this century in the absence of any effects of climate change. Taking climate change into account, sea level is projected to rise between 7 and 21 inches by 2100 (http://www.state.nj.us/dep/cmp/czm_hazards.html) . This increase would result in the threat of more sustained extreme storm surges, increased coastal erosion, escalating inundation of coastal wetlands and saline intrusion (Cooper, et al., 2005). The ramifications of these changes, whatever their magnitude, will threaten the stability, reliability and "protection" afforded by existing levees in South Jersey.

Increasing Development in "Protected" Areas

Since the original building of levees for protection and improvement of land for agricultural use, significant non-agricultural development has and continues to take place in areas thought to be "protected" by these structures. One example of this has occurred in Greenwich and Logan Townships in Gloucester County, New Jersey. Figure 18 and 19 show the Gibbstown, Gloucester County, New Jersey vicinity (in lower right quadrant) on 1930 and 1995-1997 aerial photos. Note the increased development which has occurred. Figure 20 shows that the increased development relative to floodprone (darker) areas.

Figure 18 - Gibbstown (Greenwich Township) Gloucester County – 1930

Figure 19- Gibbstown (Greenwich Township) Gloucester County – 1995-1997

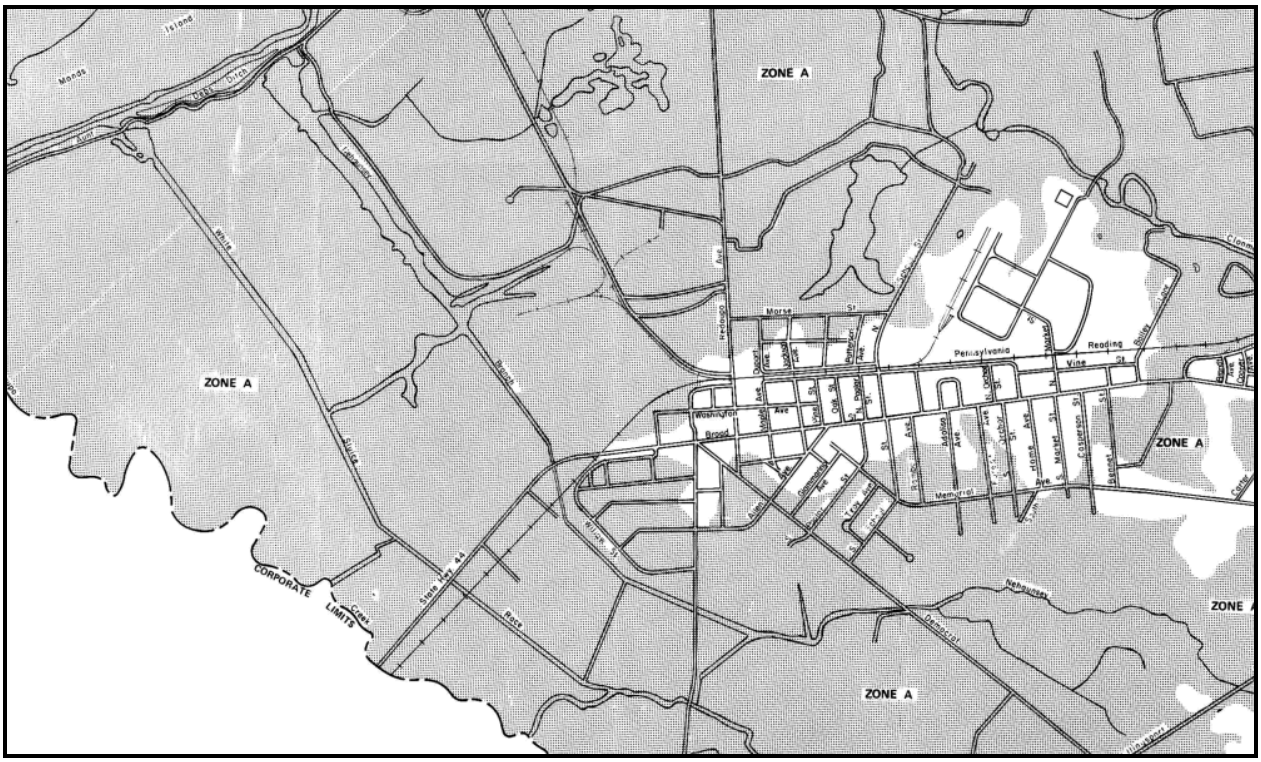


Figure 20 - Historic Flood Zone Map for Gibbstown (Greenwich Township), Gloucester County
(Image Courtesy of FEMA)

Figure 21 and 22 show the Pennsville, Salem County, New Jersey vicinity on 1930 and 1995-1997 aerial photos. Note the increase development which has occurred. Figure 23 shows the increased development relative to the flood zone (darker) areas.

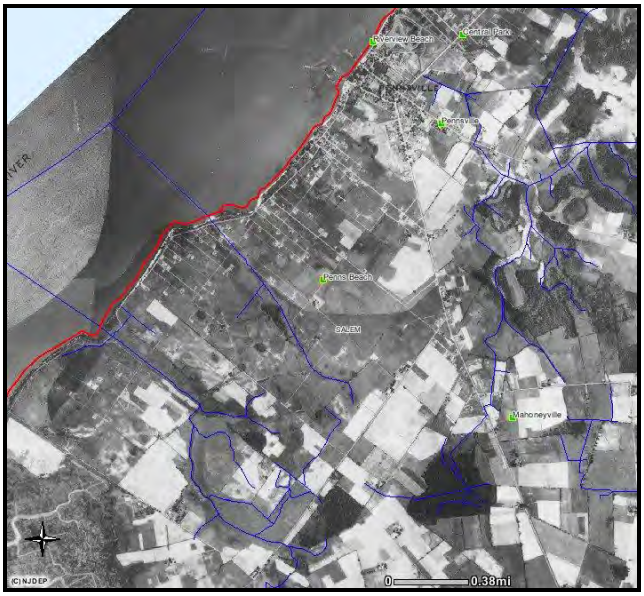


Figure 21 - Pennsville, Salem County – 1930

Figure 22- Pennsville, Salem County – 1995-1997

Figure 23 - FEMA Flood Map for Pennsville Township, Salem County
(Image Courtesy of FEMA)

Appendix C - Levee Problems

South Jersey levees and their continued maintenance and rehabilitation are plagued by the following problems:

Lack of Local Sponsorship

As has been previously mentioned, many of the levees here do not have a legal entity capable and/or willing of taxation and acquiring land rights for the proper operation and maintenance of these structures.

Archaic Legal Entities

Meadow Companies were associations of marsh owners which formed in the late 1700 and early 1800 timeframe to construct and maintain levees and their associated water control structures. While some of these entities still are functional, many of these "phantom" associations still exist but are powerless and penniless (DiMuzio, 2006). Evidence of their existence is in the deteriorating levees and tide gates throughout South Jersey. Where these entities exist there is a reluctance by municipalities and counties to take on the role of responsibility for the maintenance of these structures. The regional, state and federal implications of the failure of these structures would have incalculable adverse economic and public health consequences similar to what took place in New Orleans following the Hurricane Katrina event in September 2005 (DiMuzio, 2006).

Fragmented Ownership

Unless a local entity has taken on the role to acquire land rights, many of these levees have numerous owners.

Lack of Funding for Ongoing Operation and Maintenance

Many municipalities in this four county area do not have the funding to carry out the necessary rehabilitation work required and, in some cases, the annual maintenance needed.

Permitting Costs and Time Frames

Repeatedly we heard from individuals, groups of landowners and others that permitting fees were too onerous and time schedules to complete needed work too long.

Lack of Policy Coordination and Communication Among Federal, State, County and Local Governments

There is no overarching entity or organization which acts as a clearinghouse through which coordination, communication and cooperation could take place for potential projects funded by Federal, State and County agencies and other partners which have received funding.

Appendix D – Levees as Historical Landmarks

The State Historic Preservation Office has identified a number of early levees and diked farms as eligible for the State and National Historic Registers. The area along the Delaware Bay has some of the best preserved early farms in New Jersey, which often included diked fields as well as upland fields (Saunders, 2009). One example of early agriculture which relied on levees is the 150 acre farm owned by the Howell family in Fairfield Township, Cumberland County. This farm, now in its tenth generation of family ownership, is approximately four feet above sea level and produces salt hay, soybeans, alfalfa and beef cattle (http;//www.co.cumberland.nj.us). The Abel Nicholson House (1722), a patterned brick or Flemish-bond pattern house (http://www.nps.gov/history) is located in Elsinboro Township, Salem County and its surrounding acreage was formerly protected by the Mason Point Meadow Company levee. Levees were once common along the Maurice River in Cumberland County. Figure 24 shows the Burcham Farm in Millville City where the levees are still maintained.

Figure 24 - Burcham Farm along Maurice River, Millville City, NJ
(Photo Courtesy of Sebold, 1992)

Appendix E – Operation, Maintenance and Permit Costs

The operation, maintenance and permit costs of South Jersey dikes and levees are of particular note. Outreach was made to Soil Conservation Districts, Mosquito Commissions, County Engineers and Planner to obtain this information.

One example of the cost of several permits is as follows:

Army Corps - Nationwide Permit - $100.00 (permit #3 maintenance)

NJDEP - Waterfront Development - Based on construction costs:
0 - $50,000 $3500 + 1.2 % of construction cost
$50,000 - $100,000 $4,100 + 2.4% " "

Coastal Wetlands - $600.00

(USDA NRCS Vineland Service Center, 2009)

Table 23 – Operation and Maintenance Costs for Dikes/Levees

Municipality	Levee	Type of Work (Mowing, Filling in, Tidegate Replacement, Tidegate Structure Replacement, etc.	Labor Cost	Material Cost
Greenwich	Mill Creek Dike	Tidegate Structure Replacement for two tide gates Levee Repair and Stabilization	>$500,000.	
Fairfield	Agricultural Levee	2 Tidegate structure replacements; dike fill; ditch maintenance; seeding/stabilization	#1 $17,435.00 #2 $11,118.50	$3,245.00 $3,734.24
Greenwich	Agricultural Levee	Dike Rehab and Water Control Structure; Seeding	$29,945.40	$17,785.60

Source: USDA NRCS Vineland Service Center

Appendix F - Current Federal and State Assistance Related to Dikes/Levees

Over the course of the years, both the Corps and NRCS have, for those levee structures and their associated parts on which they have provided the original technical and financial assistance, overseen their operation and maintenance. ***The operation and maintenance for these structures, however, is a local responsibility.***

Federal Emergency Management Agency

National Flood Insurance Program

The Federal Emergency Management Agency (FEMA) is currently modernizing its flood maps throughout the nation. FEMA will be reviewing data associated with levees. It is the levee owner's or community's responsibility to provide data and documentation to demonstrate that a levee meets the requirements of the National Flood Insurance Program (NFIP). To be recognized as providing protection from the 1-percent-annual chance flood on Flood Insurance Rate Maps (FIRMs), levee systems must meet and continue to meet the minimum design, operation, and maintenance standards of 44 CFR (Code of Federal Regulations) Section 65.10 of the NFIP regulations (FEMA, 2007). FEMA will remap the levee-impacted areas landward of these levee systems as high-risk areas, called Special Flood Hazard Areas (SFHAs). Flood insurance is required in SFHAs for any mortgage that is federally backed, regulated, or insured (FEMA, 2008). The FEMA fact sheet (FEMA, 2007) provides this note about levee risk and flood insurance:

It is important to note that levees are designed to provide a specific level of protection. They can be overtopped or fail in larger flood events.

Levees also decay over time. They require regular maintenance and periodic upgrades to retain their level of protection. When levees do fail, they fail catastrophically. The damage may be more significant than if the levee was not there at all.

For all these reasons, FEMA strongly urges people to understand their flood risk, know their evacuation procedures, and protect their property by purchasing flood insurance.

FEMA maps levees in flood plains in of three categories as follows:

Levee Accredited on FIRM
Provisionally Accredited Levee (PAL)
Levee Not Accredited or De-accredited on FIRM

FEMA does not certify levees rather it accredits or de-accredits levees based on other agency/professional certification. The purpose of an accreditation of a levee is to

determine whether the property protected by the levee is required to have flood insurance protection. Those levees which are not accredited protect property which must have flood insurance coverage in order to continue to have federally-backed mortgages and loans. ***There are no accredited levees in the Inventory area of Cape May, Cumberland, Gloucester or Salem Counties*** *(Springett, 2009).*

Hazard Mitigation Assistance Program

On October 30, 2000, the President signed into law the Disaster Mitigation Act of 2000 (DMA 2000).The federal government recently mandated that all states and local governments must have DMA 2000 consistent hazard mitigation plans approved by FEMA by November 1, 2004 to maintain eligibility for certain types of federal disaster assistance funding, such as pre-disaster and post-disaster funding. In February 2002, the Federal Emergency Management Agency (FEMA) published Interim Final Rule 44 CFR Part 201 which modified the original act.

A multi-jurisdictional Hazard Mitigation Plan was developed for Camden, Cumberland, Gloucester and Salem Counties over the 2008-2009 period. This Plan shows that the local County Hazard Mitigation Work Group (HMWG) identified flooding and specifically levee failure as among the top six natural and technological/manmade hazards (out of 21 hazards initially identified and profiled by the HMWG which required more detailed countywide risk assessments.

Corps of Engineers

The Corps of Engineers PL 84-99 Program provides emergency assistance for levees which are damaged or destroyed as a result of flooding, etc. The requirements for receipt of federal funding for this purpose include a sponsor that is a public entity with financial authority, that there has been adequate maintenance of the structures and fixtures, and that this public entity is willing to be the responsible party for operation and maintenance of the structure.

In 1999, the Army Corps of Engineers provided emergency funding to repair the Repaupo Creek tidegate.

Most recently $2.5 million was provided by the State of New Jersey (through a 2003 voter-approved Bond Act) to the Gloucester County Improvement Authority for the replacement of the Repaupo Creek tidegate system at Greenwich and Logan Townships along the Delaware River. The 4.5 mile levee at this location was breached during the “Good Friday” flood of 1962 and has been subsequently breached on several more recent occasions. Following the 1962 event there was much discussion regarding the need to rebuild the levee to the standards then acceptable. Currently the levee is identified as protecting the 400+ homes and businesses to approximately a 14 year flood event (Corps, 1967). A 1996 analysis by the NRCS identified several alternatives for better flood protection of the potentially flood damaged area (NRCS, 1996).

The Gibbstown Levee (along the Delaware River in Gloucester County from the Repaupo Creek watershed through the Clonmell Creek watershed) has been Active in the PL 84-99 program in the past, but is currently “Inactive” due to not having a public non-federal sponsor for the entire length of the levee system. Four different entities maintain the levee -- Logan Twp, Greenwich Twp, DuPont, and Hercules -- but no public sponsor has assumed the responsibility for overseeing maintenance of the entire system since the state-sanctioned Repaupo Meadow Company became defunct. The Corps of Engineers has been encouraging the county, the state, or the two townships to take on this role but none has done so to date (Rogers, 2009).

There are no levee systems in the four county region that meet the necessary criteria for emergency assistance under PL 84-99(Rogers, 2009).

Natural Resources Conservation Service

The Natural Resources Conservation Service, formerly known as the Soil Conservation Service, through its PL 83-566 Watershed Protection and Flood Prevention Program, has provided technical and financial assistance to a number of project sponsors in the South Jersey Levee Inventory area. These are listed in Table 24. At least six projects were constructed during the 1960s which benefitted over 6,200 acres in three counties (Cumberland, Gloucester and Salem Counties) including at least three urban areas.

Rehabilitation Amendments to PL83-566 were passed in 2000 to address aging infrastructure, constructed under this Program. ***There is no funding for levees included in the Rehabilitation Amendments*** as there is for dams and related structures. NRCS has done work on PL83-566 dikes as a remedial repair to address a design or construction deficiency (Lamm, 2009) or through Emergency Watershed Program funding, which has been repeatedly used over time to address storm-related damages to the PL83-566 structures, however, these are not funding sources for rehabilitation of dikes. For example, in 1993, as a result of a storm event which caused the failure of the existing levee, NRCS provided emergency funding to repair the levee at Pine Mount. Since that time the levee has again failed.

Table 24 - USDA Natural Resources Conservation Service-Assisted Levee/Dike Projects under the PL83-566 Watershed Protection and Flood Prevention Program

Project	Municipality	County	Improvement	Year Completed
Town Bank	Salem City	Salem	Pump Plant	1961
Silver Lake-Locust Island	Lower Alloways Creek	Salem	Levee and Tidegate Structures	1962
Pine Mount-Mill Creek	Greenwich	Cumberland	Levee and Tidegate Structure	1964
Repaupo Creek – White Sluice	Greenwich	Gloucester	Tidegate Structure	1964
Middle Neck	Elsinboro	Salem	Tidegate Structure	1965
Tributaries of the Maurice River Cove	Commercial	Cumberland	Levees and Tidegate Structures	1965

Source: USDA NRCS Watershed Plans

New Jersey Department of Agriculture - Agricultural Development Committee

New Jersey agricultural property owners are eligible for cost sharing for agricultural practices which include water control structures and levees if their property is in an 8-year farmland preservation program or the farm has been permanently preserved for agriculture. Cost sharing is available for as follows:

> Sediment detention or retention structures, such as erosion control dams (excluding water storage type dams), desilting reservoirs, sediment basins, dikes, sluice gates, or similar structures. (Tim Fekete, 2009)

This opportunity is not available to agricultural landowners who are not in a designated agricultural development area (ADA) which is based on such a designation by local government.

Appendix G - Other Organizational Activities Related to Levees and Dikes

New Jersey Flood Mitigation Task Force

The New Jersey Flood Mitigation Task Force in its May 2006 Report on Delaware River Flood Mitigation made the following recommendation regarding levees:

The State, in coordination with federal entities, should ensure that existing flood control structures are properly maintained. Further, in addition to its current dam inventory and regulation program, the State should initiate and maintain a comprehensive inventory and regulation system for all levee systems, regardless of ownership, that have potential impacts on public safety. In addition, as part of the USACE Delaware River Basin Comprehensive Feasibility Study, consideration should be given for new structures only when economically justified and environmentally appropriate.

Maintenance of smaller flood control facilities including dams, levees, and other water control structures is the responsibility of either state, county, local governments, or private individuals. Water supply and hydropower reservoirs, and many small privately owned dams, although not designed for flood control, carry similar operating and maintenance needs. The Basin States each fund dam inspection programs which are critical to the protection of downstream citizens. Protection of funding for these programs is a necessity, in addition to securing funding for maintenance. There is a need for repair or removal of those structures not meeting current safety standards. Federal funding for the USACE flood control reservoirs must be protected, along with that of the Federal Energy Regulatory Commission, which has regulatory oversight of the large hydropower dams.

The State should make available incentive-based funding for county and municipal operation and maintenance activities on existing flood protection infrastructure including

dams, channels, levees, tidegates, and pump plants. The State should provide funding to county and municipal governments for the funding of the local share of Federal flood mitigation grants and projects. This would apply to federal funding from all federal agencies including USACE, FEMA and the NRCS.

Small local flood control projects that may be beneficial for prevention of stream tributary flooding should be investigated. Backwater flooding along the stream tributaries could be controlled and prevented through the use of structural measures along the existing levee system including flap gates, tide gates, and pumping stations.

Public Service Electric and Gas Company Estuary Enhancement Program

In 1994, Public Service Electric and Gas Company began an unprecedented effort to help restore a portion of the Delaware Estuary. The Estuary Enhancement Program (EEP) was implemented under terms of a 1994 permit issued by NJDEP. The application for renewal of the permit for the Salem Generating Station was determined to be protective of the balanced indigenous populations of the estuary. As a result of the EEP, over 20,000 acres (approximately 32 square miles) of coastal salt marsh and adjacent uplands in Delaware and New Jersey were restored and preserved. Many former salt hay farm dikes were removed and natural tidal flows were restored (PSEG, 2004).

Delaware Estuary Levee Organization (DELO)

The Delaware Estuary Levee Organization was formed in November 2005. The group, while not officially incorporated, is sponsored by the South Jersey Resource Conservation and Development Council, Inc. It is currently made up of representatives of local, county, state and federal organizations from Cape May, Cumberland, Gloucester and Salem Counties. The group identified the need for an inventory to identify the location and extent of levees in the four counties. The organization's minutes are at the following website: http://www.sjrcd.org/delo/

Glossary

ARC – refers to **ArcMap** is the main component of Esri's ArcGIS suite of geospatial processing programs, and it is used primarily to view, edit, create, and analyze geospatial data. ArcMap allows the user to explore data within a data set, symbolize features accordingly, and create maps.

ARC GRID - Arc Grid coverage format is a proprietary format that is primarily used in ArcInfo.

CAFRA – Coastal Area Facilities Review Act. CAFRA applies to projects near coastal waters in the southern part of the State. The CAFRA area begins where the Cheesequake Creek enters Raritan Bay in Old Bridge, Middlesex County. It extends south along the coast around Cape May, and then north along the Delaware Bay ending at the Kilcohook National Wildlife Refuge in Salem County. The inland limit of the CAFRA area follows an irregular line drawn along public roads, railroad tracks, and other features. The CAFRA area varies in width from a few thousand feet to 24 miles, measured straight inland from the shoreline.

CDF - A confined disposal facility, or CDF, is a structure planned and designed to receive sediments dredged from a navigation channel and safely contain the contaminants, preventing their reentry into the waterway or lake.

DELO – Delaware Estuary Levee Organization was formed in November 2005. The group, while not officially incorporated, is sponsored by the South Jersey Resource Conservation and Development Council, Inc. It is currently made up of representatives of local, county, state and federal organizations from Cape May, Cumberland, Gloucester and Salem Counties.

Dike, bank, meadow bank and levee are considered to be interchangeable terms. These terms refer to the earthen berm used to protect low lying areas from daily tidal inundation and storm tides and surges.

DSM or DEM - A digital elevation model (DEM) is a digital representation of ground surface topography or terrain.

DVD - also known as Digital Video Disc or Digital Versatile Disc, is an optical disc storage media format.

EEP – Public Service Electric and Gas Company Estuary Enhancement Program

FEMA – Federal Emergency Management Agency

FIRM – Flood Insurance Rate Map

GIS – Geographic Information System which captures, stores, analyzes, manages, and presents data that are linked to location.

GPS – Global Positioning System

Levee - A levee is defined as an earthen embankment constructed to protect low lying areas from tidal, riverine or other flooding

LiDAR - **Li**ght **D**etection **A**nd **R**anging is an optical remote sensing technology that measures properties of scattered light to find range and/or other information of a distant target. The prevalent method to determine distance to an object or surface is to use laser pulses. Like the similar radar technology, which uses radio waves, the range to an object is determined by measuring the time delay between transmission of a pulse and detection of the reflected signal.

Meadow and marsh are terms used to describe the low lying areas protected by dikes, banks, meadow banks or levees.

Meadow Bank Company or Meadow Company refers to an organization created by N.J. Law under provisions of N.J.A.C. Section 15.5 et.seq. “Drainage and Flowage of Lands” (Irelan, 1994). According to this law, the dike and water control structures are built and maintained by the landowners who benefit from same.

NAD 83 - Because Earth deviates significantly from a perfect ellipsoid, the ellipsoid that best approximates its shape varies region by region across the world. Clarke 1866, and North American Datum of 1927 (NAD 27)with it, were surveyed to best suit North America as a whole. The North American Datum of 1983 (NAD 83) is based on a newer defined spheroid (GRS 80); it is an Earth-centered (or "geocentric") datum having no initial point or initial direction.

NAVD 88 - The North American Vertical Datum of 1988 (NAVD 88) is the vertical control datum of orthometric height established for vertical control surveying in the United States of America based upon the General Adjustment of the North American Datum of 1988.

NFIP – National Flood Insurance Program

NGVD 1929 - The Sea Level Datum of 1929 was the vertical control datum established for vertical control surveying in the United States of America by the General Adjustment of 1929. The datum was used to measure elevation (altitude) above, and depression (depth) below, mean sea level (MSL).

NJDEP – New Jersey Department of Environmental Protection

NOAA – National Oceanic and Atmospheric Administration

NRCS – United States Department of Agriculture, Natural Resources Conservation Service

Orphaned structures are those structures that are no longer routinely maintained by either meadow bank companies, landowners, local and county governments are termed "orphaned." These structures are increasingly putting lives and property at risk.

PDA – Personal Data Assistant A personal digital assistant (PDA), also known as a palmtop computer is a mobile device that functions as a personal information manager.

PL83-566 – Natural Resources Conservation Service Watershed Protection and Flood Prevention Program

PL84-99 – Public Law 84-99 which authorizes the US Army Corps of Engineers to undertake activities including disaster preparedness, Advance Measures, emergency operations, rehabilitation of flood control works threatened or destroyed by flood, protection or repair of federally authorized shore protective works threatened or damaged by coastal storm, and provisions of emergency water due to drought or contaminated source.

PSEG – Public Service Electric and Gas Company which operates the Delaware Estuary Enhancement Program

RC&D – Resource Conservation and Development (RC&D) is a unique program that is led by local volunteer councils that help people care for and protect their natural resources in a way that improves the local economy, environment and living standards. RC&D is a way for people to work together to plan and carry out activities that will make their areas a better place to live. The South Jersey RC&D Council is one example.

SCS – Soil Conservation Service, name used prior to 1994 for the current Natural Resources Conservation Service (NRCS)

USFWS – U.S. Fish and Wildlife Service

USGS – U.S. Geological Survey

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