WK DICKSON
community infrastructure consultants

Town of Oak Island, NC
Ocean Drive Drainage Study

August 2021

Town of Oak Island

Ocean Drive Drainage Study

Drainage and Infiltration System Feasibility Project

Final Submittal
August 2021

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Table of Contents

List of Tables

List of Figures

List of Appendices

Section 1. Executive Summary

This study's purpose is to evaluate the feasibility of diverting flood waters from four critical flooding areas on E. Beach Drive and Ocean Drive between 74th Street and Womble Street to potential infiltration areas (Sites 1-6), to the existing storm drainage system on the North side (sound side) of E. Oak Island Drive (SR-1190) and Womble Street (Site 7), or to the existing Satellite Water Reclamation Facility (SWRF) at 5209 E. Yacht Drive (Site 8).

The Town of Oak Island has four flooding areas that cause routine road flooding even during moderate rainfall events. These are shown in Figure 1A and Figure 1B. This study includes evaluation of pumping stormwater from the road during storm events, into a series of infiltration chambers embedded within the existing Secondary Dune system (Sites 1-4) or within the existing Town's Right-of-Way on E. Pelican Drive (Sites 5-6). The infiltration systems utilize the in-situ soil as infiltration media. Alternatives evaluated are to pump the stormwater to the existing storm drainage system at the intersection of E. Oak Island Drive (SR-1190) and Womble Street (Site 7) or to pump the stormwater to the existing Satellite Water Reclamation Facility (SWRF) (Site 8).

To address the above stated issues, this study presents the following:

- Evaluation of the feasibility of using the Town's Public Beach accesses to determine if the ponded flood waters can be infiltrated into the Secondary Dune system (Sites 1-4).
- Evaluation of the feasibility of diverting flood waters to the existing Town Right-of-Way on E. Pelican Drive to determine if the existing Right-of-Way can be converted into an infiltration gallery to infiltrate the ponded flood waters (Sites 5-6).
- Evaluation of the feasibility of diverting flood waters from the 801 Building on Ocean Drive to an existing NCDOT storm drainage system on the North side (sound side) of E. Oak Island Drive at Womble Street (Site 7).
- Evaluation of the feasibility of diverting flood waters to the existing Satellite Water Reclamation Facility (SWRF) (Site 8).
- A geotechnical analysis to determine the Seasonally High Water Table (SHWT) and hydraulic conductivity of in-situ soils.
- Evaluation of available site area to ensure proper ground elevation and vertical separation to SHWT and horizontal separation between the infiltration system and surrounding structures, including residential walkways and residential buildings.
- Estimate of the volume of water ponding within the roads.
- Evaluation of the size of the pumps to be comparable to the stormwater infiltration rate based upon the surface area of the proposed infiltration system.

- Evaluation of reducing flooding level (draw down) in less than twelve hours.

This study's findings include the following:

- Sites 1-4 are located within the VE Floodzone, where adding fill material is not allowed. Therefore, given the high SHWT and restrictions on adding fill material, the infiltration systems for Sites 1-4 are required to be located in the Secondary Dune system where elevations are several feet higher than surrounding lower dune elevations where associated soil borings were performed.
- Sites 1-4 have very limited site area available at the required higher elevations associated with the Secondary Dune system.
- Sites 1-4 are located in the Ocean Hazard Area of Environmental Concern (AEC); therefore, a Coastal Area Management Area (CAMA) minor permit is required, and a CRC variance for ocean setback requirements is anticipated. If the project disturbed area exceeds 1.0 acre of disturbance, a CAMA major permit would be required. A CAMA major permit would increase the overall project timeline.
- Sites 5-6 have slightly lower SHWT elevations and are not located in the VE Floodzone, however, adequate separation to the SHWT is not provided without adding fill material depth over the Infiltration System within the existing Town's Right-of-Way.
- Sites 1-4 construction costs are significantly below the comparable alternative Sites 5-8 options; however, construction costs do not include easement acquisition.
- Site 8 construction costs are significantly higher than the other combined Site options.
- Sites 1-3 and a small portion of Site 7 are located within private residential property and will require easements from the private landowners.

Based on this feasibility analysis, it is concluded that Sites 1-6 are feasible, Site 7 is not likely to be feasible based on currently available information, and Site 8 is feasible; however, the higher construction cost may make this Site option cost prohibitive. A survey provided by a NC Professional Land Surveyor and verification of geotechnical values used would provide improved information allowing for a more accurate evaluation of the feasibility of these systems. Also, several items should be considered during the design process, including private property easement acquisition as well as sources of funding available, and required permits.

Diverting flood waters to infiltration systems will provide flood reduction on E. Beach Drive and Ocean Drive and allow for safer vehicular travel within twelve hours of a moderate rainfall event for all the Sites except Site 8.

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Figure 1A
Vicinity Map
Ocean Drive Drainage Study

The Town of Oak Island North Carolina

0 250 500 Feet
1 inch = 500 feet

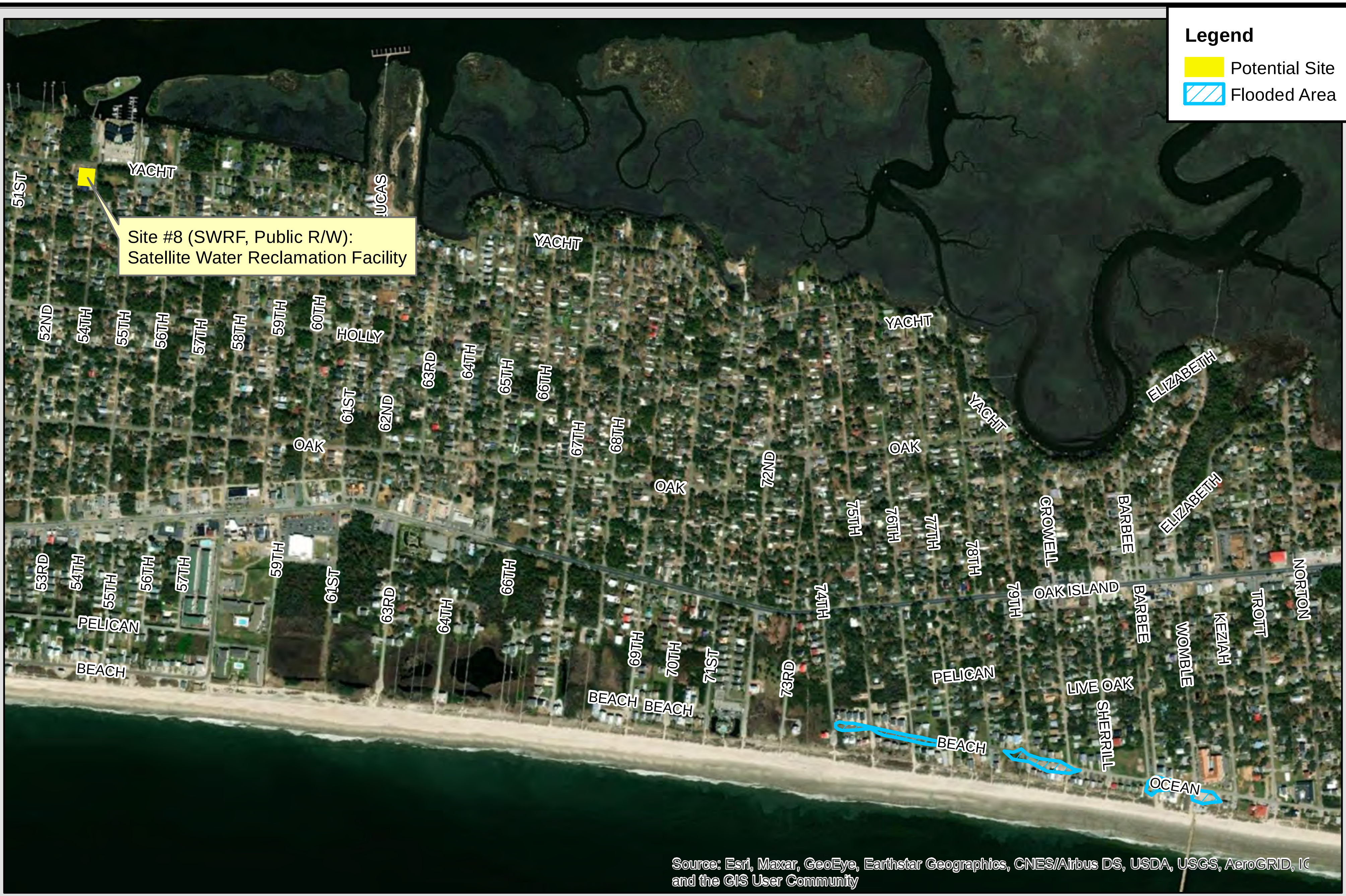

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Figure 1B
Vicinity Map
Ocean Drive Drainage Study

The Town of Oak Island North Carolina

0 500 1,000 Feet
1 inch = 1,000 feet

Section 2: Project Feasibility

Analyzed Site Locations and Feasibility Parameters

Eight different sites/options were considered for this analysis based upon the chronic and sometimes hazardous stormwater flooding from four areas on E. Beach Drive and Ocean Drive between 74th Street and Womble Street. Flooding along E. Beach Drive and Ocean Drive, which reaches depths of approximately 6-inches, prevents residents from safely accessing their driveways for several days after storm events greater than 0.5 inches of rainfall. The analyzed sites were identified and selected based upon locations where stormwater infiltration systems with pumping systems (Sites 1-6) and where pumping systems only (Sites 7-8) could be installed near areas where ponding stormwater occurs during moderate rainfall events. Refer to Appendix F for photos of the Sites and examples of ponding stormwater taken during the field site visits on January 14-15, 2021 and March 9, 2021. Please note, the photos do not reflect typical examples of extreme stormwater ponding, but only reflect the site conditions at the time of the site visit. The analyzed sites include:

- Site 1: 74th Street at E. Beach Drive (Vacant Lot Adjacent 115 SE 74th St)
- Site 2: 76th Street at E. Beach Drive (7507 E. Beach Drive)
- Site 3: 79th Street at Ocean Drive (7807 E. Beach Drive)
- Site 4: Barbee Blvd at Ocean Drive (Public R/W)
- Site 5: E. Pelican Drive R/W in-between 77th and 78th Street
- Site 6: E. Pelican Drive R/W in-between 78th and 79th Street
- Site 7: Existing storm drainage system at E. Oak Island Drive (SR-1190) and Womble Street
- Site 8: Existing Satellite Water Reclamation Facility (SWRF) at 5209 E. Yacht Drive

Sites 1-4 are located in the existing Secondary Dune system in-between the primary dune system and the oceanfront of private residences, and are generally confined by residential walkways, houses, public beach access paths, and or public parking areas that allow pedestrian traffic between the beachfront and a private residence or public parking area. Sites 1-3 are located on private property, and Site 4 is located on public property. Because the infiltration systems are installed within the dune system, they are commonly referred to as Dune Infiltration Systems (DIS). The DIS are a relatively new installation practice, and a recent North Carolina State University Extension publication is included as Appendix E and was used as a resource to aid in this feasibility study. Additionally, Sites 1-4 with DIS can be used for educational and research purposes. Researchers at North Carolina State University or local universities such as UNC-Wilmington can utilize the infiltration system for research purposes to better understand the effectiveness of DIS.

The proximity of the infiltration system to a public beach access provides educational opportunities for visitors and residents to learn about the benefits of infiltration systems and stormwater improvements. Sites 5-6 are located on public property within the Town Right-of-Way on E. Pelican Drive between 77th Street and 79th Street. The E. Pelican Drive is wooded and grassed with no road infrastructure present. Site 7 is located almost exclusively within public Right-of-Way along Ocean Drive near Womble Street and continuing to the intersection of E. Oak Island Drive (SR-1190) and Womble Street; however, a small portion of the proposed storm drain infrastructure is on private property. Site 8 is located exclusively within public Right-of-Way along Ocean Drive and E. Beach Drive between 74th Street and Womble Street and continuing to the north along 76th Street until reaching E. Oak Drive, and then continuing to the west along E. Oak Drive until reaching 54th Street, and then continuing to the north on 54th Street until reaching the SWRF at 5209 E. Yacht Drive.

The eight sites analyzed provide at least one infiltration option (Sites 1-4) within the Secondary Dune system for each of the four flooding areas. In addition, two separate infiltration options are provided for three of the flooding areas (Sites 5-6) and Site 8 combines all four of the flooding areas with discharge to the existing SWRF. The options are as follows:

- The 74th-75th flooding area has three options considered (Site 1, Site 5, Site 8).
- The 75th-77th flooding area has three options considered (Site 2, Site 5, and Site 8).
- The 79th-Crowell flooding area has three options considered (Site 3, Site 6, and Site 8).
- The Barbee-Womble flooding area including #801 Building has three options considered (Site 4, Site 7, and Site 8).

The Infiltration feasibility analysis (Sites 1-6) investigated the following five parameters to evaluate the suitability of each site, including:

- Distance to Seasonal High Water Table (SHWT);
- In-Situ Soil Saturated Hydraulic Conductivity;
- Available Site Area;
- Draw Down Time; and
- Estimated Construction Costs.

These five parameters evaluate the site constraints to accept and infiltrate the runoff that will be pumped from the flooded sections of E. Beach Drive and Ocean Drive into the proposed Infiltration Systems.

Utilizing the existing storm drain systems (Site 7) and the SWRF to collect and pump stormwater to existing infiltration basins (Site 8) were investigated for the following three parameters to evaluate the suitability, including:

- Capacity of Existing Storm Drain System (Site 7 only);
- Storage Volume of SWRF and Infiltration Basins (Site 8 only);
- Draw Down Time; and
- Estimated Construction Costs.

The following provides a short summary of how each parameter impacts the feasibility of the proposed system.

Existing Storm Drain System

Sites 1-2 existing storm drain system consists of driveway culverts, roadside ditches, and storm drain pipe that is intended to convey the storm drainage to the low lying area/wetland area immediately to the west of 74th street; however, the low lying areas do not provide positive drainage, and this results in the storm water accumulating, and eventually backing up into the streets and driveways. Sites 1-3 have inadequate culverts to drain the areas.

The Site 7 existing storm drain system consists of a closed storm drain system along E. Oak Island Drive (SR-1190) to Womble Street, and eventually discharging into a natural area that provides positive drainage to the Sound. A planning level capacity analysis of this existing storm drain system from the intersection of E. Oak Island Drive (SR-1190) and Womble Street to the existing storm drain pipe outlet was performed for Site 7 and the results indicate that the existing storm drain system, especially the main trunk of the storm drain system along Womble Street to the pipe outlet, are significantly undersized and under capacity. Therefore, adding additional discharge to the system is not practical. The pumped storm drainage discharge would occur at the same time the existing storm drain system was receiving and discharging its drainage flow, and this would adversely impact the existing system capacity. A detailed survey of the existing storm drainage system to ensure that the existing storm drain system's configuration is approximately as shown per the GIS information would help validate drainage areas and associated storm drain discharges.

Existing Satellite Water Reclamation Facility (SWRF)

The existing Satellite Water Reclamation Facility (SWRF) was built in the late 2000's and is approximately 15 years old. The SWRF is a 400,000 gallon per day reclaimed water generation treatment system that can discharge reclaimed water to a 2.71 acre spray utilization area, a 0.53 acre high-rate infiltration basin, and a 0.39 acre high-rate infiltration basin. Both infiltration basins are located at the Oak Island Golf Club. A groundwater lowering system with nine wells, each with a 30 gallon per minute (gpm) pump, lowers the groundwater level to allow the infiltration basins to function as designed with the reclaimed water infiltrating through the bottom of the infiltration basins. The SWRF treatment components consist of: an influent pump station with dual 300 gallon per minute (gpm) submersible pumps; a fine screen; two 10,500 gallon anoxic tanks; two 42,000 gallon aeration tanks; two 5,420 gallon membrane tanks; one 131,000 gallon effluent storage tank; an effluent pump station with dual 300 gpm effluent pumps; one 75,000 gallon elevated storage and distribution tank; 4-inch sludge discharge force main; and 8-inch reclaimed water force main. In recent years, primarily because of operational issues and higher treatment costs associated with the membrane system at the SWRF, the Town has been sending sewage to the Brunswick County Sewer Treatment Plant and not using the SWRF; however, the SWRF is still in use for overflow events.

A planning level storage capacity analysis of the existing SWRF was performed for Site 8 and the results indicate that the existing SWRF could be converted to store and discharge ponded stormwater from the four ponding areas. The SWRF has a combined storage capacity of 321,900 gallons and the two infiltration basins combined provide an additional 283,300 gallons of storge. This results in a total storage volume of 605,200 gallons. Additional storge may be available within the two infiltration basins, and this has been estimated to be an additional storage depth of 8-inches above the normal pool elevation in the basins for a combined additional storage volume of 201,000 gallons. If the additional 8-inch storage depth is available in the infiltration basins, then the total storage volume would increase to 806,200 gallons. The total ponding volume from the four ponding areas is estimated to be 597,100 gallons. Therefore, the existing SWRF has adequate capacity to store and discharge the routinely ponded stormwater.

The existing SWRF has two 300 gpm pumps for both the influent and effluent pump stations. If both pumps are utilized, maintaining the existing pump stations and assuming a pumping rate of 550 gpm of the SWRF for the proposed stormwater pump station at E. Beach Drive and 76th Street requires a proposed 10-inch PVC force main to the SWRF with a drawdown time of approximately 18.1 hours for the four flooding areas. If a drawdown time of 12 hours is desired, significant changes would need to be made to the SWRF and the existing force main. In addition, the existing infiltration basins storage capacity and infiltration capabilities would require further analysis.

The conversion of the SWRF from treating raw sewage to store and discharge stormwater could be accomplished with minimal changes to the SWRF. The existing tanks would be maintained for storage volume. Some unnecessary equipment to include membranes, blowers, chemical feed pumps, and associated piping should be removed. The facility would need to be cleaned to include removal of solids and chemical spraying of tanks. The existing sewage sludge could be removed from the facility by utilizing the existing sludge discharge force main.

Distance to Seasonal High Water Table (SHWT)

ECS performed a soil analysis on January 12th, 13th, and 21st, 2021 at potential sites to evaluate the relative SHWT elevation. This soil analysis is included within Appendix A of this report, where the SHWT findings are reported on Pages 1-2. For this feasibility study, due to the shallow depths to the SHWT elevation, it is the most significant physical constraint. In addition, it is worth noting that the soil borings I-7 to I-11 were performed near the toe of the slope of the primary dune system i.e. near the lowest elevation in the dune system.

The Seasonal High Water Table (SHWT) indicates the shallowest depth to free water that stands in an unlined borehole or where the soil moisture tension is zero for a significant period, long enough to produce anaerobic conditions. The resulting anaerobic conditions promotes biogeochemical processes such as the reduction, translocation, and accumulation of iron and manganese forming redoximorphic markers, such as reduction/oxidation indicators and organic matter accumulation.

The separation or distance to the SHWT from the bottom of any infiltration device is imperative to successful infiltration, as this separation will promote groundwater flow from the infiltration device to existing groundwater. North Carolina Department of Environmental Quality (NCDEQ) requires the lowest point of the infiltration system to be a minimum of two feet above the SHWT. However, the separation may be reduced to no less than one foot if a hydrogeologic evaluation demonstrates that the water table will subside to its pre-storm elevation within five days or less. Due to shallow depths to the SHWT and based upon the geotechnical engineer's experience with similar types of projects where one foot separation has proven to be acceptable, 1.0-foot separation was utilized in this analysis to evaluate the feasibility of each proposed Infiltration System.

In-Situ Soil Saturated Hydraulic Conductivity

The In-Situ Soil Saturated Hydraulic Conductivity describes the physical ability of groundwater to be transmitted through the in-situ soil. Generally, this parameter describes the resistance the soil imparts on the groundwater flow and is a function of the soil water characteristic, or soil water retention curve. The soil water characteristic is mainly influenced by the soil's particle size distribution, which relates to the static tension potential of this soil to hold water. As indicated in the soil analysis report and shown in Table 1, all proposed infiltration system locations (Sites 1-4) within the existing dune system (Boring I-7 to I-11) have very high recorded Saturated Hydraulic Conductivity results, where the values ranged between 26.0 to 28.5 inches/hr. The measured results are consistent with the common soil type for sand dunes along the Southeastern North Carolina Coast. The proposed infiltration system locations (Sites 5-6) within the existing Town Right-of-Way on E. Pelican Drive (Boring I-3 to I-6) have high recorded Saturated Hydraulic Conductivity results, where the values ranged between 7.98 to 16.02 inches/hr. The high value results for the Saturated Hydraulic Conductivity provide a greater infiltration capacity of the proposed infiltration system for each Site 1-6 and promote the feasibility of these systems. In addition, it is worth pointing out that within the existing Town Right-of-Way on E. Pelican Drive (Boring I-1 to I-2), although the recorded Saturated Hydraulic Conductivity results were in an acceptable range of 2.20 inches/hr.; these results in conjunction with high SHWT make this portion of E. Pelican Drive R/W more difficult to provide an infiltration solution.

Table 1: SHWT and Hydraulic Conductivity

	Site 1 [1]	**Site 2**	**Site 3**	**Site 4**	**Site 5** [2]	**Site 6**	**Site 7**	**Site 8**
SHWT (ft) [3]	2.0	2.0	2.0	2.5	2.5	3.5	N/A	N/A
Hydraulic Conductivity (K, in/hr)	26.0	26.0	28.3	27.8	12.0	14.6	N/A	N/A

[1]Site 1 information is estimated using the lowest values from boring I-7 to I-11.
[2]Site 5 information is estimated using boring I-3 to I-4.
[3]Site 2-4 SHWT elevations were measured at the elevation low point within the dune system and not within the Secondary Dune elevation.

<u>Available Site Area</u>

In addition to depth to SHWT and the Saturated Hydraulic Conductivity, the available infiltration area at the required elevation contributes significantly to the overall infiltration system capacity. The larger the infiltration system surface area footprint, the higher the overall infiltration capacity.

Sites 1-4 are located within the VE Floodzone and adding fill material within this zone is not allowed. Therefore, given the high SHWT and restrictions on adding fill material, the infiltration systems for Sites 1-4 are required to be located in the Secondary Dune system where elevations are approximately a couple feet higher than surrounding lower dune elevations where associated soil borings were performed. This elevation increase will provide the necessary depth to install the infiltration system while meeting vertical separation requirements to the SHWT. Sites 1-4 have very limited site area available at the required higher elevations associated with the Secondary Dune system. In addition, the Infiltration Systems are located within all or mostly private residential property and will require easements from the private landowners.

Sites 5-6 have slightly lower SHWT elevations and are not located in the VE Floodzone, however, adequate separation to the SHWT is not provided without adding fill material depth over the Infiltration System within the existing Town Right-of-Way. Site 5 will require approximately two feet of fill and Site 6 will require approximately one feet of fill to be provided. Sites 5-6 have more usable space available within the Town Right-of-Way than currently shown and increasing the surface area would increase the storage volume.

The infiltration systems were located taking into consideration at least 3 horizontal feet from residential walkways and parking lots, and 10 feet from houses. The infiltration system design uses 1-foot separation between each chamber row and along the outside perimeter of the infiltration system. Calculations are provided in Appendix D and Figures 2-7 illustrate the proposed infiltration system layout for each Site 1-6 based upon the provided site area and the equivalent infiltration capacity.

It is noted that available site area was estimated based upon information provided by Brunswick County GIS data, including topographic contours, parcel limits and existing structural footprints as well as using Google Earth for both aerial images and topographic information in conjunction with field exploration. Given the approximate nature of the Secondary Dune system area available at the required elevations and how these areas are very limited, it is recommended that a more detailed site survey especially for these site areas, but also for all site areas, be performed by a NC licensed Professional Land Surveyor before any design plans are generated. The detailed survey with addition geotechnical soil borings would provide improved information allowing for a more accurate evaluation of the feasibility of these systems. This detailed survey might reveal that less or additional site area is available as the dune topography and existing structural footprints become better defined.

Draw Down Time

Another physical component for the overall feasibility study is evaluating the anticipated time it will take to pump down and infiltrate the ponded volume. Three parameters that influence the critical flooding areas include ponded volume, infiltration capacity of the infiltration system, and maximum pumping flowrate.

Ponded volume was estimated as the total runoff volume contained in a critical flooding area based upon GIS contours, Town photographs, and field exploration. Based upon these sources of information, all the critical flooding areas are contained within a natural low spot, or "bowl", that prevents the ponded water from leaving as surface runoff. This estimate volume represents the reasonable amount of volume that the infiltration system would need to infiltrate, as it is assumed that any excess volume would spill over the "bowl" lip. It is noted that the ponded volume is just an estimate based upon provided source information and should be reevaluated once a detailed survey is obtained for each critical area.

The infiltration capacity of the infiltration system is a function of available surface area and saturated hydraulic conductivity. The details of the mathematical relationship between these parameters are further explored in the calculations in Appendix D. However, it is noted that the infiltration capacity of the infiltration system, infiltration flowrate, is the constraining parameter for calculating the draw down time to pump the street free of standing water. For the purposes of this feasibility study, the draw down time for Sites 1-6 was calculated by dividing the estimated water ponded volume by the infiltration capacity of the infiltration system, assuming the pump flowrate matches this infiltration flowrate. Site 7, the pump flowrate of 500 gallons per minute (gpm) was deemed an appropriate value and was used in the analysis. Site 8, the pump flowrate of 550 gallons per minute (gpm) was used to match the existing pumping capacity within the SWRF. This takes into account some assumed losses, and this results in a drawdown time of 18.1 hours. The existing pumping capacity of 550 gpm would need to be confirmed during the design stage. The drawdown time for Site 8 could be reduced to approximately 12 hours; however, significant modifications to the SWRF and existing force main would be required.

Refer to Table 2 and Figure 2-9B for Sites 1-8 concept infiltration system, storm drain pump station, and closed storm drain system information.

Table 2: Site 1-8 Information

	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Site 7	Site 8
Infiltration Surface Area Provided (sf)	900	1,540	1,768	700	4,020	3,600	N/A	N/A
Number of Chambers	21	36	42	18	102	90	N/A	N/A
Hydraulic Conductivity (K, in/hr)	26.0	26.0	28.3	27.8	12.0	14.6	N/A	N/A
Infiltration Capacity (cfs)	0.54	0.93	1.16	0.45	1.12	1.22	N/A	N/A
Calculated Ponded Volume (cf)	6,875	28,125	31,313	13,500	35,000	31,313	13,500	79,813
Drawdown Time (hours)	3.6	8.5	7.6	8.4	8.8	7.2	3.4	18.1
System Located on Private Property	Yes	Yes	Yes	No	No	No	Yes	No

Estimated Construction Cost

A planning level construction cost estimate for each site 1-8 is provided in Appendix C. The total estimated construction cost for each site is provided below in Table 3. Site 5 combines two of the flooding areas, Site 8 combines all four of the flooding areas, and the other Sites provide a solution for one flooding area. Therefore, to provide more accurate cost comparison evaluation the Sites have been grouped together to provide a total combined cost of addressing all four flooding areas. Sites 1-4, Sites 5-7, and Site 8 combined construction cost are provided below in Table 4. It is noted that easement acquisition, professional surveying, professional engineering design, geotechnical evaluation, construction administration and observation, and overall project administration costs are not included within this construction cost estimate.

Table 3: Construction Cost

	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Site 7	Site 8
Estimated Construction Cost[1]	$237,200	$319,400	$364,400	$332,600	$669,500	$532,900	$461,300	$2,740,100

[1]The Estimated Construction Costs does not include easement acquisition estimates or professional services expenditures.

Table 4: Combined Site Construction Cost

	Site 1-4	Site 5-7	Site 8
Estimated Construction Cost[1]	$1,253,600	$1,663,700	$2,740,100

[1]The Estimated Construction Costs does not include easement acquisition estimates or professional services expenditures.

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Ocean Drive Drainage Study

Figure 2 - Proposed Project Aerial Map
Site #1 - 112 SE 74th St.

The Town of Oak Island North Carolina

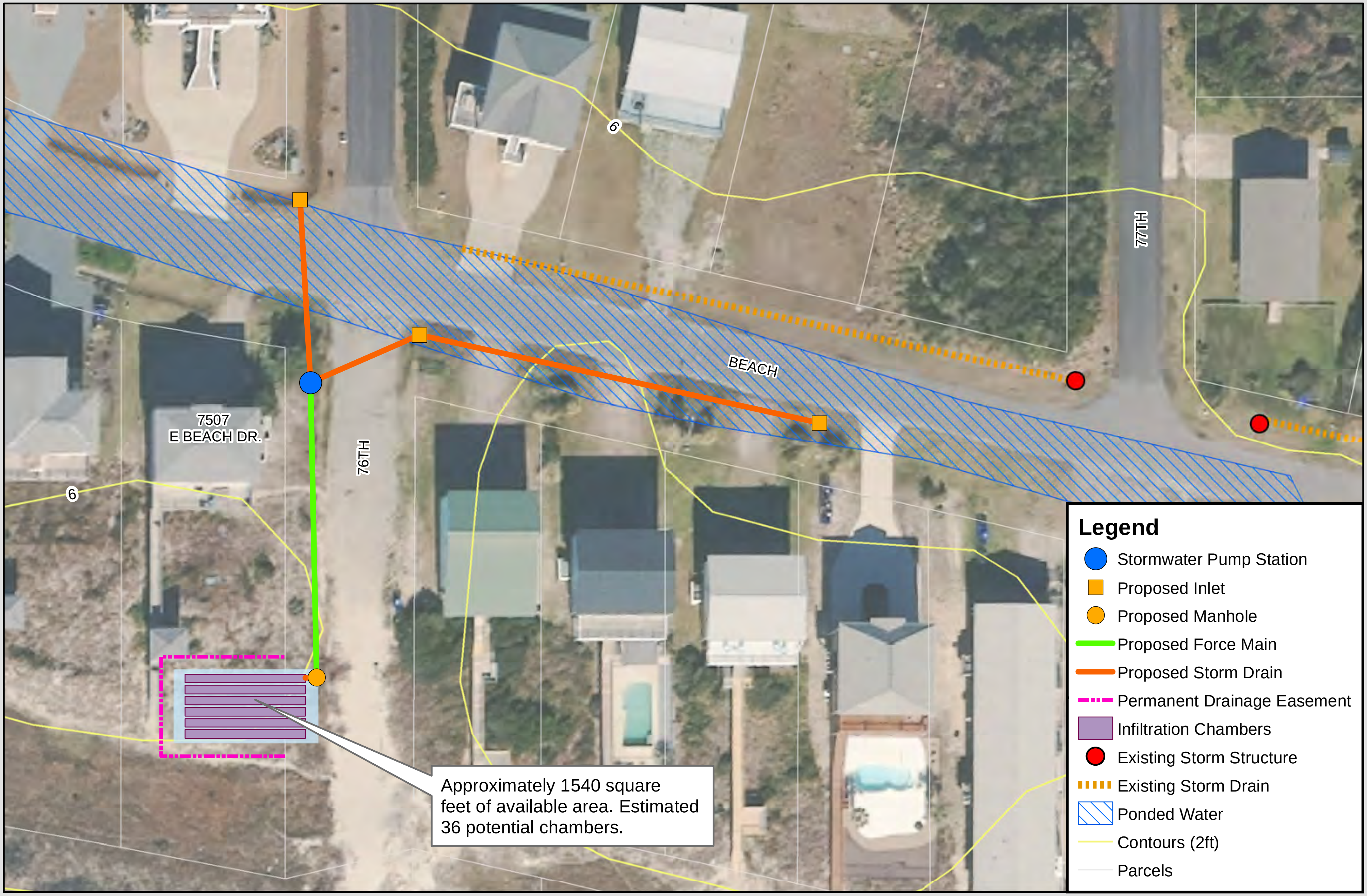

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Figure 3 - Proposed Project Aerial Map
Site #2 - 7507 E Beach Dr.

The Town of Oak Island North Carolina

0 25 50
Feet
1 inch = 50 feet

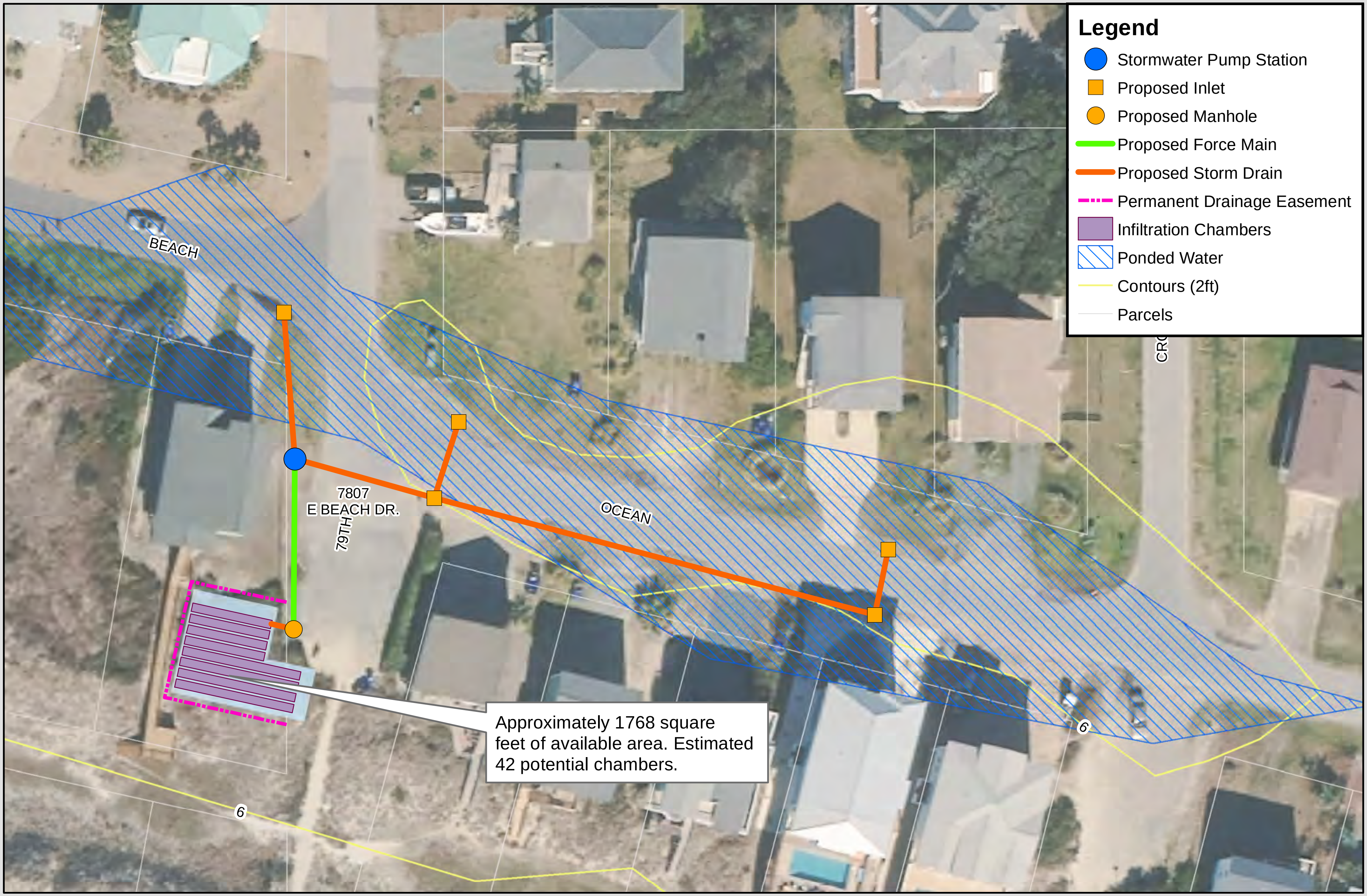

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Figure 4 - Proposed Project Aerial Map
Site #3 - 7807 E Beach Dr.

The Town of Oak Island
North Carolina

0 25 50 Feet
1 inch = 50 feet

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Ocean Drive Drainage Study

Figure 5 - Proposed Project Aerial Map
Site #4 - Ocean Dr. at Barbee Blvd.

The Town of Oak Island North Carolina

0 25 50
Feet
1 inch = 50 feet

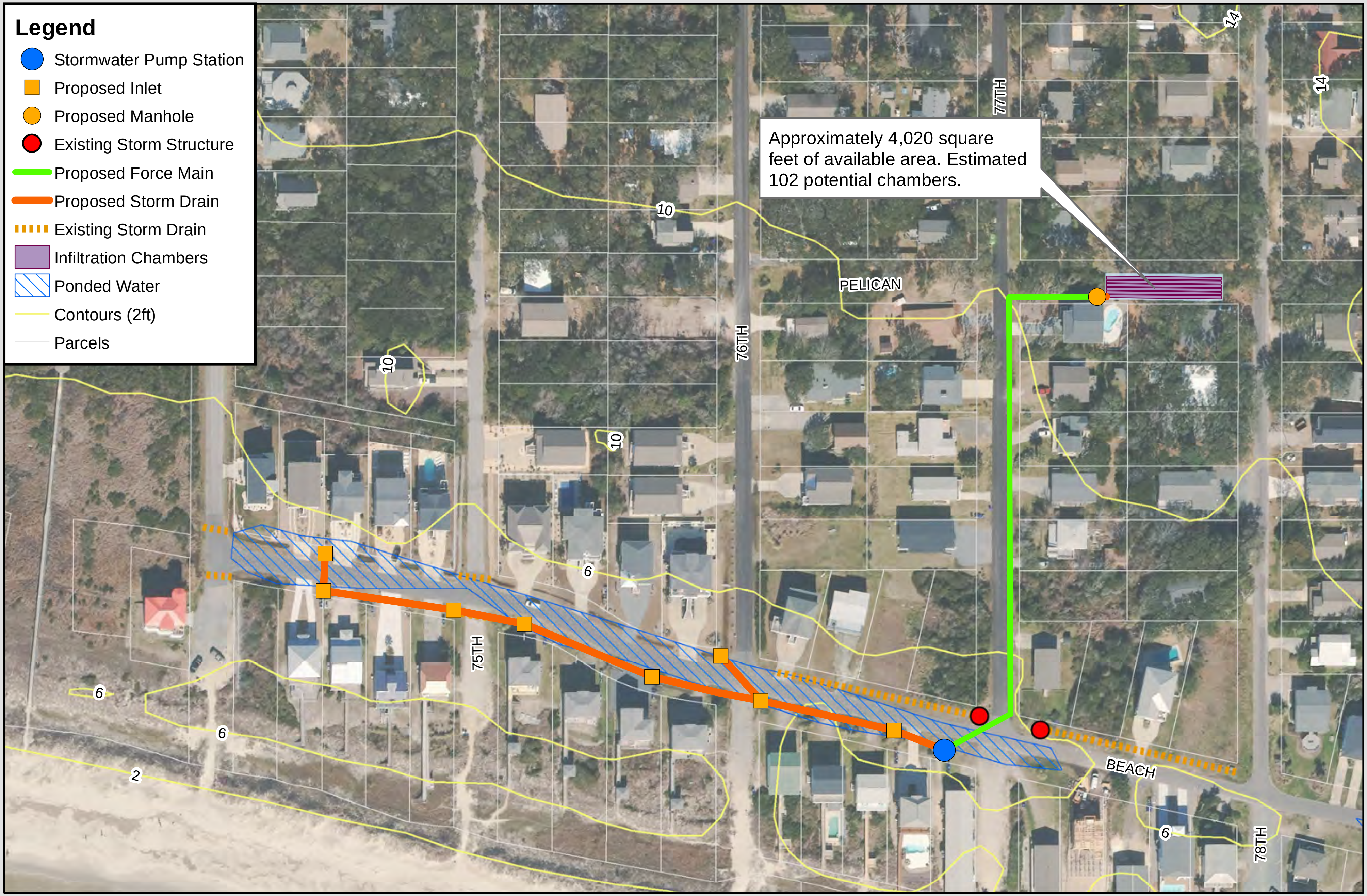

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Figure 6 - Proposed Project Aerial Map
Site #5 - Pelican Infiltration West

The Town of Oak Island North Carolina

0 75 150 Feet
1 inch = 150 feet

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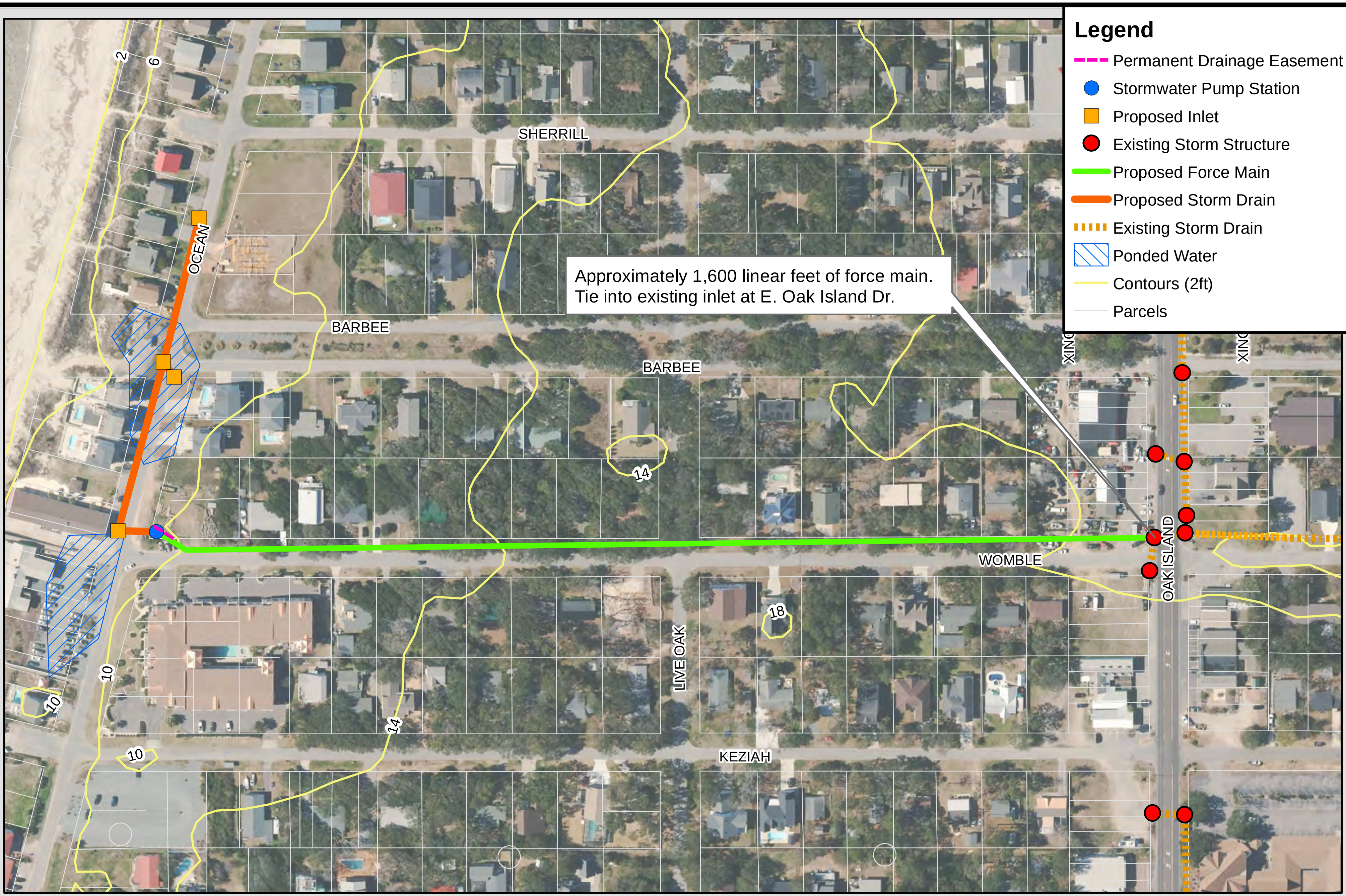
Ocean Drive Drainage Study

Figure 7 - Proposed Project Aerial Map
Site #6 - Pelican Infiltration East

The Town of Oak Island North Carolina

0 50 100 Feet
1 inch = 100 feet



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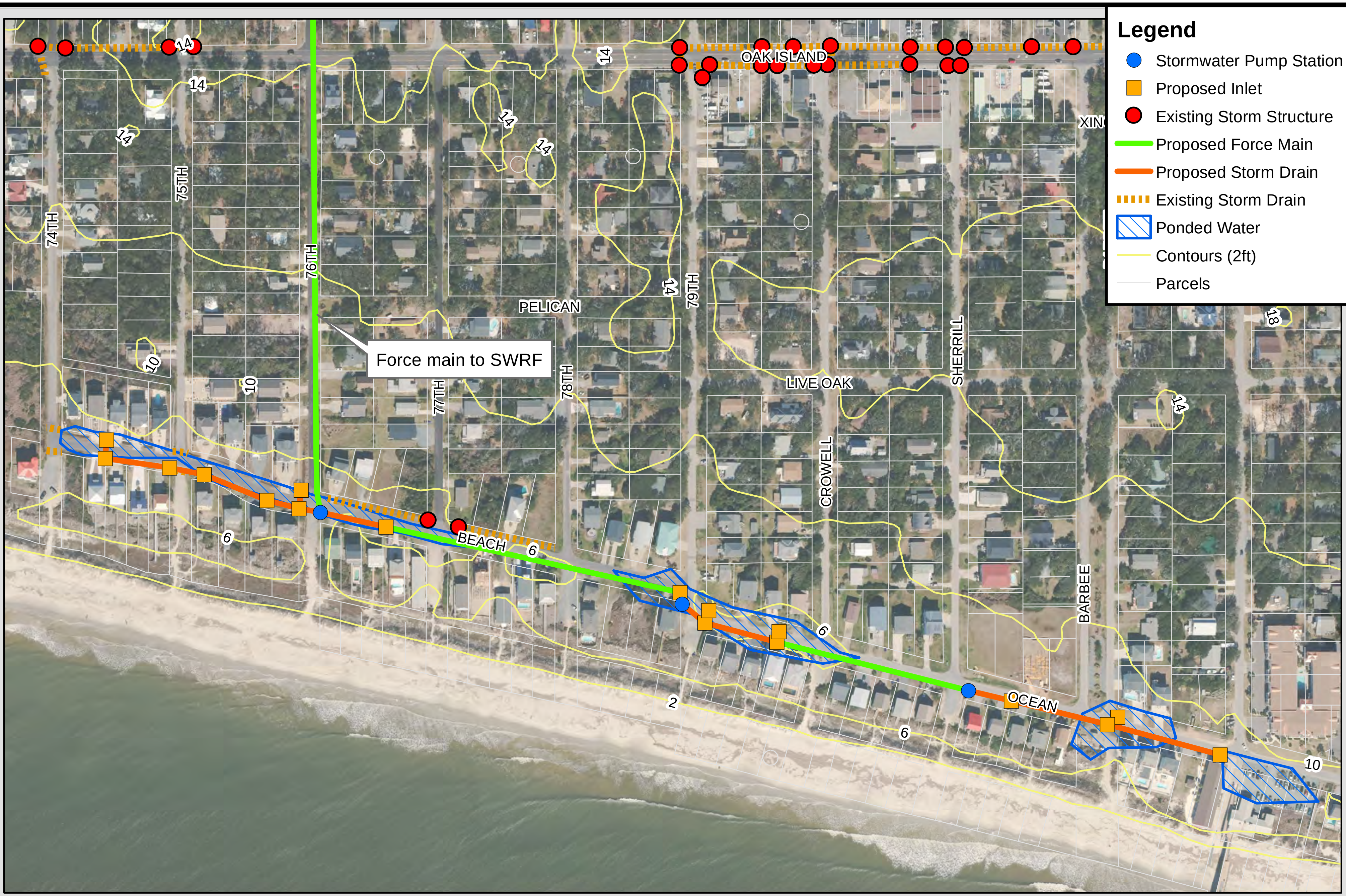
Ocean Drive Drainage Study

Figure 8 - Proposed Project Aerial Map
Site #7 - Existing DOT Tie-In

The Town of Oak Island North Carolina

0 100 200 Feet
1 inch = 200 feet



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Ocean Drive Drainage Study

Figure 9A - Proposed Project Aerial Map
Site #8 - Satellite Water Reclamation Facility (SWRF)

The Town of Oak Island, North Carolina

0 150 300 Feet
1 inch = 300 feet

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Ocean Drive Drainage Study

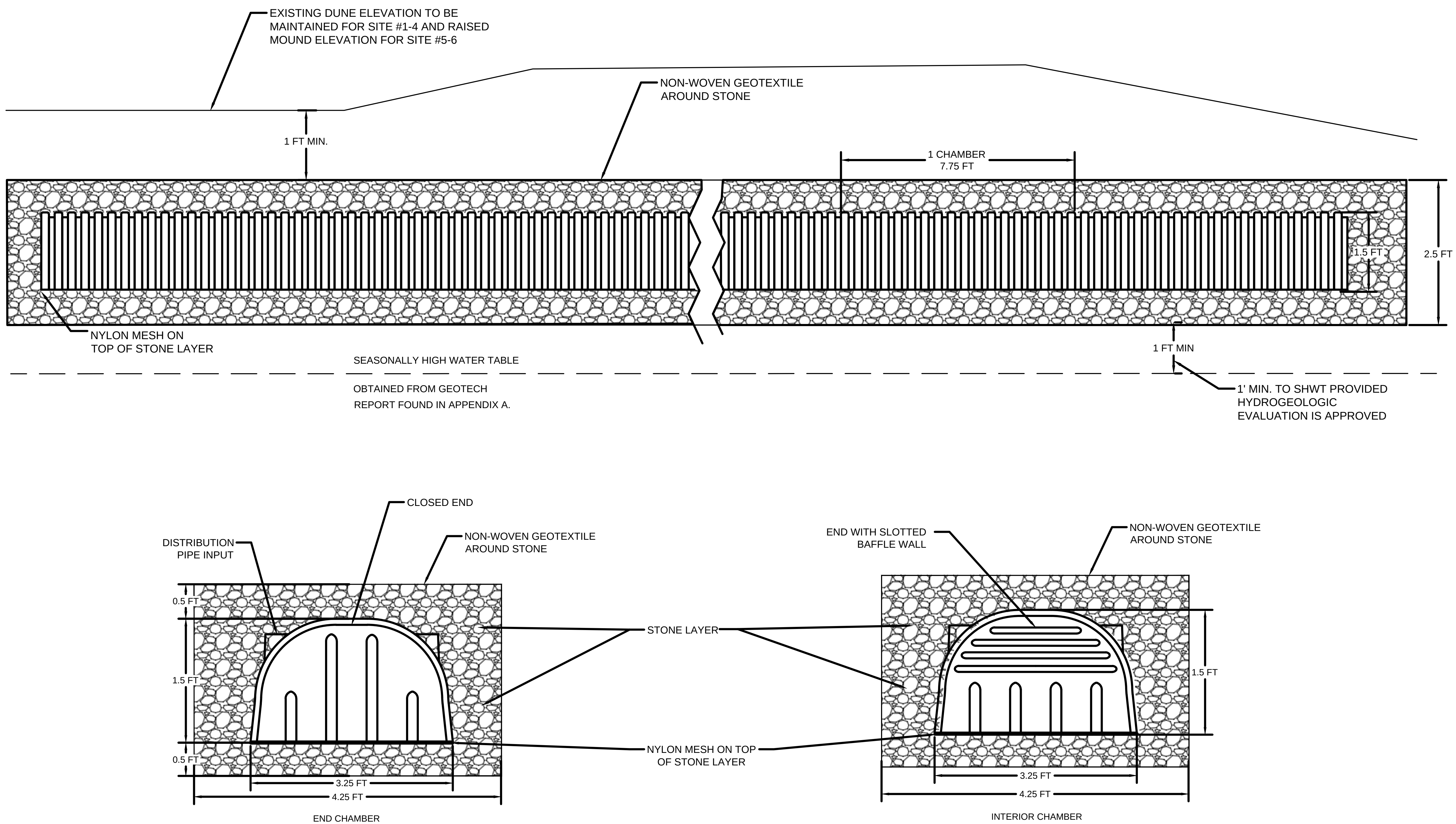
Figure 9B - Proposed Project Aerial Map
Site #8 - Satellite Water Reclamation Facility (SWRF)

The Town of Oak Island North Carolina

0 500 1,000 Feet
1 inch = 1,000 feet

Approximate Infiltration System Profile

The Infiltration System Profile Figure include a side view of the system including the existing or proposed ground surface, infiltration chambers, nylon mesh lining, stone layer, and Seasonally High Water Table (SHWT). In addition, end of chamber profiles is included, featuring a terminal and interior chamber, to demonstrate potential pipe inputs and system placement. See Figure 10 for profile of the proposed systems.



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The Town of Oak Island North Carolina

FIGURE 10
TYPICAL INFILTRATION SYSTEM PROFILE
OCEAN DRIVE DRAINAGE STUDY

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720 CORPORATE CENTER DRIVE
RALEIGH, NC 27607
(919) 782-0495
NC LICENSE NO. F-0374
Office Locations:
North Carolina
South Carolina
Georgia

Section 3. Permits, Easements and Grant/Funding Approach

Required Permits

Since the proposed Infiltration System is located with the secondary dune system for Sites 1-4, which is in the Ocean Hazard Area of Environmental Concern (AEC), a Coastal Area Management Act (CAMA) minor development permit and a CRC variance is anticipated for ocean setback requirements, and these must be granted by the NC Division of Environmental and Natural Resources Coastal Resources Commission (CRC). These must be obtained before the project can begin, and it will authorize the temporary disturbance to the dune system.

If the Project Limits of Disturbance exceeds 1.0 acre of disturbance, a NC Department of Environmental Quality (NCDEQ) Division of Energy, Mineral & Land Resources (DEMLR) Erosion & Sediment Control Permit will be required. If an Erosion and Sediment Control Permit is required, a CAMA Major Permit will be required, which would increase the overall project timeline.

The conversion of the existing Satellite Water Reclamation Facility (SWRF) from treating raw sewage to store and discharge stormwater for Site 8 is not anticipated to require a permit; however, coordination with NCDWQ will be required.

Required Easements

Sites 1-3 and a very small portion of Site 7 are proposed to be on private property and therefore will require easements. Sites 4-6 and Site 8 are located within public property. Two easement types are recommended for consideration, the Temporary Construction Easement (TCE) and a Permanent Drainage Easement (PDE). A TCE is considered a temporary access easement allowing only contractors, Town officials and project representatives access to the site for the purposes of constructing the proposed project. The TCE should encompass the entire project's Limit of Disturbance (LOD) but will be nullified once the project is constructed. A PDE is a permanent easement established on private property to allow Town officials access to the Infiltration System and or Storm Drain System for inspection and maintenance. This permanent easement also prevents the property owner from removing or building over the installed Infiltration System and any associated pipe networks or system components. For maintenance access, it is recommended that a PDE be established to the public Right-of-Way.

Both TCEs and PDEs will impose a property restriction burden on the impacted property owner. Subsequently, most entities offer mitigatory compensation for this restriction, which should be considered during the project budget estimation. However, it is recommended that the Town pursue the willingness of private property owners to donate easements for this project, specifically since this project will directly benefit private property owner access to their residential structures.

For Sites 7-8 since E. Oak Island Drive (SR-1190) is a NCDOT maintained road, an NCDOT Encroachment agreement will be required if any infrastructure, such as a proposed force main, is placed within the NCDOT Right-of-Way.

Finally, the proposed PDE easements shown in this feasibility study are just estimates based upon the GIS information provided. It is recommended that no easement negotiations should occur until each site design is more solidified and easement lines are established on an easement exhibit prepared by a NC licensed Professional Land Surveyor.

Funding Analysis

The funding analysis is included as Appendix B. Four (4) specific funding sources, outside of the Town financed source, have been identified in this analysis, including the FEMA-BRIC program, FEMA-FMA program, the DWI-LASII program and the GoldenLEAF foundation. Specific funding requirements and deadlines are identified within Appendix B. However, the following chart provides a summary of each funding source and the associated funding requirements.

Funding Analysis
Town of Oak Island - Ocean Drive Drainage Study
July 2021

WK DICKSON

Source	BRIC - FEMA	FMA - FEMA	Stormwater - DWI	Open Grants - Golden LEAF
Project Eligibility	* All elements conditionally eligible * Can include pre-award costs	* All elements conditionally eligible * Can include pre-award costs	* All elements conditionally eligible * Cannot cover expenses already paid	* Most elements conditionally eligible * Cannot cover grant/funding adminsitration or land/easment acquisition (but can be part of match)
Application Deadline	1/29/2022 (Estimated)	1/29/2022 (Estimated)	New funding to be awarded in three rounds 4/29/2022 9/30/2022 4/28/2023	Rolling Application Period
Award Date	Estimated 6/2022	Estimated 6/2022	Estimated 7/2022 2/2023 7/2023	3-6 months from full application
Match Requirements	25% match from non-federal sources	25% match from non-federal sources	Match requirements unknown at this time	No specific match requirements
Maximum Grant Award	$50 million	$30 million	$15 million (*construction*) $500,000 (*planning*)	$500,000
Period of Performance	36 months	48 months	24 months to construction contract execution	Based on approved project schedule
Partners	Needed for competitive application	Needed for competitive application	None	Needed for competitive application
Post-Project Requirements	Needed for competitive application	Needed for competitive application	None	Reports on economic factors (job creation/retention, etc.)
Other Requirements	* NEPA/Historic Preservation Compliance * FEMA-approved Hazard Mitigation Plan	* NEPA/Historic Preservation Compliance * FEMA-approved Hazard Mitigation Plan * Located in a state with at least 1 federally-declared disaster within last 7 years	* ARPA funded new Stormwater State Reserve Fund * Other requirements unknown at this time	* Projects must align with Golden LEAF's priortity focus areas * Economic factors are important

Section 4: Conclusion

This purpose of this study is to explore the feasibility of diverting flood waters from the four critical flooding areas on E. Beach Drive and Ocean Drive between 74th Street and Womble Street to potential infiltration areas (Sites 1-6) and/or to the existing storm drainage system on the North side (sound side) of E. Oak Island Drive (SR-1190) and Womble Street (Site 7) or to the existing Satellite Water Reclamation Facility (SWRF) at 5209 E. Yacht Drive (Site 8) in order to reduce flooding and provide safer vehicular passage along E. Beach Drive and Ocean Drive after moderate rainfall events.

Sites 1-4 offers the potential for future educational opportunities, including, but not limited to, university research and citizen involvement. The proposed Sites 1-4 are located in the Ocean Hazard Area of Environmental Concern (AEC); therefore, a Coastal Area Management Area (CAMA) minor permit will be required by the NC Division of Environmental and Natural Resources Coastal Resources Commission, and a CRC variance is anticipated for ocean setback requirements. A CAMA major permit may be required if the project disturbed area exceeds 1.0 acre of disturbance. A CAMA major permit would increase the overall project timeline.

Infiltration at Sites 1-6 is feasible. Site 7 is not feasible based on currently available information. For Site 8, the conversion of the existing Satellite Water Reclamation Facility (SWRF) from treating raw sewage to store and discharge stormwater could be accomplished with minimal changes to the SWRF; however, the estimated construction cost is significantly higher than the other combined Site options and it has the longest drawdown time. Sites 1-4 construction costs are significantly below the comparable alternative Sites 5-7 options; however, construction costs do not include easement acquisition, and Sites 1-3 as well as Site 7 will require easements on private residential property.

A survey provided by a NC licensed Professional Land Surveyor and verification of geotechnical values used would provide improved information allowing for a more accurate evaluation of the feasibility of these systems. The implementation of these options will provide flood reduction on E. Beach Drive and Ocean Drive and allow for safer vehicular travel within 12 hours of a moderate flooding event, at each evaluated site except Site 8. Refer to Table 6 for summary of some of the key parameters and findings.

During the design stage, several items will need to be evaluated further, including easement acquisition, potential project costs including funding sources if any, and project timeline.

Table 6: Site Feasibility Parameters and Findings

	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Site 7	Site 8
Infiltration Capacity (cfs)	0.54	0.93	1.16	0.45	1.12	1.22	N/A	N/A
Calculated Ponded Volume (cf)	6,875	28,125	31,313	13,500	35,000	31,313	13,500	79,813
Drawdown Time (hours)	3.6	8.5	7.6	8.4	8.8	7.2	3.4	18.1
Estimated Construction Cost[1]	$237,200	$319,400	$364,400	$332,600	$669,500	$532,900	$461,300	$2,740,100
System Located on Private Property	Yes	Yes	Yes	No	No	No	Yes	No

[1]The Estimated Construction Costs does not include easement acquisition estimates or professional services expenditures.

Appendices

Appendix A

Geotechnical Report

January 21, 2021

Mr. Marc Horstman, P.E.
WK Dickson
1213 West Morehead Street
Charlotte, North Carolina 28208

Reference: Report of Seasonal High Water Table Estimation and Infiltration Testing
Oak Island Stormwater Study
Oak Island, Brunswick County, North Carolina
ECS Project No. 49.12975 A

Dear Mr. Horstman:

ECS Southeast, LLP (ECS) recently conducted a seasonal high water table (SHWT) estimation and infiltration testing at requested locations between 76th Street and Crowell Street in Oak Island, Brunswick County, North Carolina. This letter, with attachments, is the report of our testing.

Field Testing

On January 12, 13, and 21, 2021, ECS conducted an exploration of the subsurface soil and groundwater conditions, in accordance with the NCDEQ Stormwater Design Manual section A-2, at eleven requested locations shown on the attached Boring Location Plan (Figure 1). ECS used GPS equipment in order to determine the boring locations. The purpose of this exploration was to obtain subsurface information of the in situ soils for the SCM area(s). ECS explored the subsurface soil and groundwater conditions by advancing one hand auger boring into the existing ground surface at each of the requested boring locations. ECS visually classified the subsurface soils and obtained representative samples of each soil type encountered. ECS also recorded the SHWT and groundwater elevation observed at the time of the hand auger borings. The attached Infiltration Testing Form provides a summary of the subsurface conditions encountered at the hand auger boring locations.

The SHWT and groundwater elevation was estimated at the boring locations below the existing grade elevation. A summary of the findings are as follows:

Location	SHWT	Groundwater
I-1	12 inches	18 inches
I-2	15 inches	20 inches
I-3	20 inches	36 inches
I-4	40 inches	50 inches
I-5	42 inches	50 inches
I-6	48 inches	55 inches
I-7	24 inches	30 inches
I-8	30 inches	36 inches
I-9	24 inches	30 inches

I-10	24 inches	30 inches
I-11	30 inches	36 inches

ECS has conducted eleven infiltration tests utilizing a compact constant head permeameter near the hand auger borings in order to estimate the infiltration rate for the subsurface soils. Infiltration tests are typically conducted at two feet above the SHWT or in the most restrictive soil horizon. Tests in clayey conditions are conducted for durations of up to 30 minutes. If a more precise hydraulic conductivity value is desired for these locations, then ECS recommends collecting samples and performing laboratory permeability testing.

Field Test Results

Below is a summary of the infiltration test results:

Location	Description	Depth	Inches/ hour
I-1	Brown silty SAND	10 inches	2.20
I-2	Brown/orange fine SAND w/ silt	10 inches	2.24
I-3	Brown/orange fine SAND w/ silt	10 inches	7.98
I-4	Brown/orange fine SAND	16 inches	13.48
I-5	Brown/orange fine SAND	18 inches	16.02
I-6	Brown/orange fine SAND	24 inches	14.60
I-7	Tan fine to med. SAND	10 inches	26.00
I-8	Tan fine to med. SAND	10 inches	27.43
I-9	Tan fine to med. SAND	10 inches	28.27
I-10	Tan fine to med. SAND	10 inches	28.50
I-11	Tan fine to med. SAND	10 inches	27.78

Infiltration rates and SHWT may vary within the proposed site due to changes in elevation, soil classification and subsurface conditions. ECS recommends that a licensed surveyor provide the elevations of the boring locations.

Closure

ECS's analysis of the site has been based on our understanding of the site, the project information provided to us, and the data obtained during our exploration. If the project information provided to us is changed, please contact us so that our recommendations can be reviewed and appropriate revisions provided, if necessary. The discovery of any site or subsurface conditions during construction which deviate from the data outlined in this exploration should be reported to us for our review, analysis and revision of our recommendations, if necessary. The assessment of site environmental conditions for the presence of pollutants in the soil and groundwater of the site is beyond the scope of this geotechnical exploration.

ECS appreciates the opportunity to provide our services to you on this project. If you have any questions concerning this report or this project, please contact us.

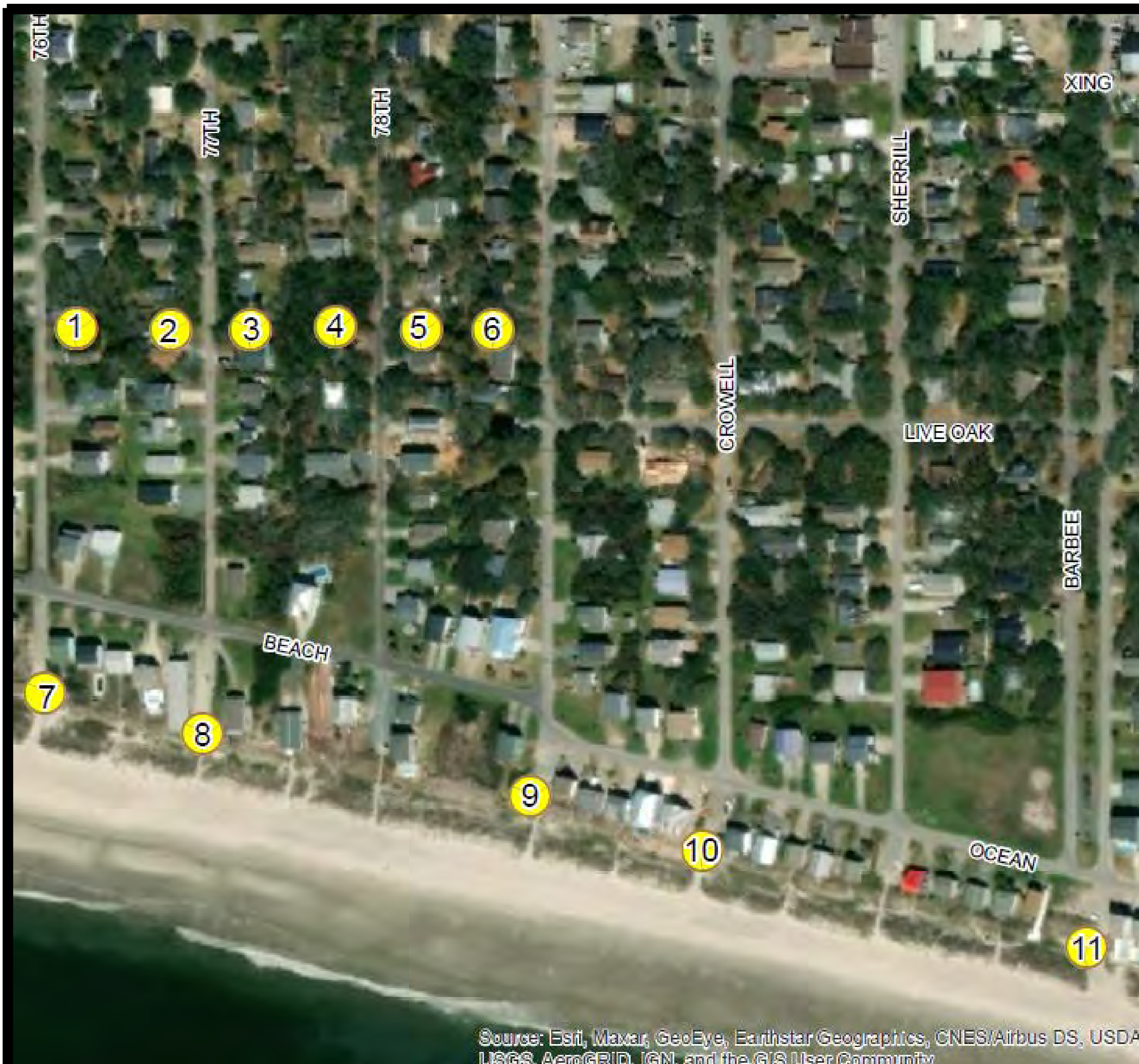
Respectfully,

ECS SOUTHEAST, LLP

K. Brooks Wall
Project Manager
bwall@ecslimited.com
910-686-9114

W. Brandon Fulton, PSC, PWS, LSS
Environmental Department Manager
bfulton@ecslimited.com
704-525-5152

Attachments: Figure 1 - Boring Location Plan
Infiltration Testing Form
GBA Document



1 **APPROXIMATE BORING LOCATIONS**

SCALE SHOWN ABOVE

N W E S

Oak Island Stormwater Study
Oak Island, Brunswick County, North Carolina

ECS Project # 49.12975
January 12 and 13, 2021
KBW

Figure 1– Boring Location Plan

Provided by: WK Dickson

Infiltration Testing Form
Oak Island Stormwater Study
Oak Island, Brunswick County, North Carolina
ECS Project No. 49.12975
January 12 and 13, 2021

Location	Depth	USCS	Soil Description
I-1	0-6”	SM	Brown silty SAND
	6”-24”	SM	Brown/orange fine SAND w/ silt

Seasonal High Water Table was estimated to be at 12 inches below the existing grade elevation.
Groundwater was encountered at 18 inches below the existing grade elevation.
Test was conducted at 10 inches below existing grade elevation
Infiltration Rate: 2.20 inches per hour

Location	Depth	USCS	Soil Description
I-2	0-24”	SM	Brown/orange fine SAND w/ silt

Seasonal High Water Table was estimated to be at 15 inches below the existing grade elevation.
Groundwater was encountered at 20 inches below the existing grade elevation.
Test was conducted at 10 inches below existing grade elevation
Infiltration Rate: 2.24 inches per hour

Location	Depth	USCS	Soil Description
I-3	0-6”	SM	Brown silty SAND
	6”-36”	SM	Brown/orange fine SAND w/ silt

Seasonal High Water Table was estimated to be at 20 inches below the existing grade elevation.
Groundwater was encountered at 36 inches below the existing grade elevation.
Test was conducted at 10 inches below existing grade elevation
Infiltration Rate: 7.98 inches per hour

Infiltration Testing Form
Oak Island Stormwater Study
Oak Island, Brunswick County, North Carolina
ECS Project No. 49.12975
January 12 and 13, 2021

Location	Depth	USCS	Soil Description
I-4	0-50”	SP	Brown/orange fine SAND

Seasonal High Water Table was estimated to be at 40 inches below the existing grade elevation.
Groundwater was encountered at 50 inches below the existing grade elevation.
Test was conducted at 16 inches below existing grade elevation
Infiltration Rate: 13.48 inches per hour

Location	Depth	USCS	Soil Description
I-5	0-50”	SP	Brown/orange fine SAND

Seasonal High Water Table was estimated to be at 42 inches below the existing grade elevation.
Groundwater was encountered at 50 inches below the existing grade elevation.
Test was conducted at 18 inches below existing grade elevation
Infiltration Rate: 16.02 inches per hour

Location	Depth	USCS	Soil Description
I-6	0-60”	SP	Brown/orange fine SAND

Seasonal High Water Table was estimated to be at 48 inches below the existing grade elevation.
Groundwater was encountered at 55 inches below the existing grade elevation.
Test was conducted at 24 inches below existing grade elevation
Infiltration Rate: 14.60 inches per hour

Infiltration Testing Form
Oak Island Stormwater Study
Oak Island, Brunswick County, North Carolina
ECS Project No. 49.12975
January 12 and 13, 2021

Location	Depth	USCS	Soil Description
I-7	0-36”	SP	Tan fine to med SAND

Seasonal High Water Table was estimated to be at 24 inches below the existing grade elevation.
Groundwater was encountered at 30 inches below the existing grade elevation.
Test was conducted at 10 inches below existing grade elevation
Infiltration Rate: 26.00 inches per hour

Location	Depth	USCS	Soil Description
I-8	0-36”	SP	Tan fine to med SAND

Seasonal High Water Table was estimated to be at 30 inches below the existing grade elevation.
Groundwater was encountered at 36 inches below the existing grade elevation.
Test was conducted at 10 inches below existing grade elevation
Infiltration Rate: 27.43 inches per hour

Location	Depth	USCS	Soil Description
I-9	0-24”	SP	Tan fine to med SAND

Seasonal High Water Table was estimated to be at 24 inches below the existing grade elevation.
Groundwater was encountered at 30 inches below the existing grade elevation.
Test was conducted at 10 inches below existing grade elevation
Infiltration Rate: 28.27 inches per hour

Infiltration Testing Form
Oak Island Stormwater Study
Oak Island, Brunswick County, North Carolina
ECS Project No. 49.12975
January 12 and 13, 2021

Location	Depth	USCS	Soil Description
I-10	0-24"	SP	Tan fine to med SAND

Seasonal High Water Table was estimated to be at 24 inches below the existing grade elevation.
Groundwater was encountered at 30 inches below the existing grade elevation.
Test was conducted at 10 inches below existing grade elevation
Infiltration Rate: 28.50 inches per hour

Location	Depth	USCS	Soil Description
I-11	0-36"	SP	Tan fine to med SAND

Seasonal High Water Table was estimated to be at 30 inches below the existing grade elevation.
Groundwater was encountered at 36 inches below the existing grade elevation.
Test was conducted at 10 inches below existing grade elevation
Infiltration Rate: 27.78 inches per hour

Important Information about This

Geotechnical-Engineering Report

Subsurface problems are a principal cause of construction delays, cost overruns, claims, and disputes.

While you cannot eliminate all such risks, you can manage them. The following information is provided to help.

The Geoprofessional Business Association (GBA) has prepared this advisory to help you – assumedly a client representative – interpret and apply this geotechnical-engineering report as effectively as possible. In that way, clients can benefit from a lowered exposure to the subsurface problems that, for decades, have been a principal cause of construction delays, cost overruns, claims, and disputes. If you have questions or want more information about any of the issues discussed below, contact your GBA-member geotechnical engineer. Active involvement in the Geoprofessional Business Association exposes geotechnical engineers to a wide array of risk-confrontation techniques that can be of genuine benefit for everyone involved with a construction project.

Geotechnical-Engineering Services Are Performed for Specific Purposes, Persons, and Projects

Geotechnical engineers structure their services to meet the specific needs of their clients. A geotechnical-engineering study conducted for a given civil engineer will not likely meet the needs of a civil-works constructor or even a different civil engineer. Because each geotechnical-engineering study is unique, each geotechnical-engineering report is unique, prepared *solely* for the client. *Those who rely on a geotechnical-engineering report prepared for a different client can be seriously misled.* No one except authorized client representatives should rely on this geotechnical-engineering report without first conferring with the geotechnical engineer who prepared it. *And no one – not even you – should apply this report for any purpose or project except the one originally contemplated.*

Read this Report in Full

Costly problems have occurred because those relying on a geotechnical-engineering report did not read it *in its entirety*. Do not rely on an executive summary. Do not read selected elements only. *Read this report in full.*

You Need to Inform Your Geotechnical Engineer about Change

Your geotechnical engineer considered unique, project-specific factors when designing the study behind this report and developing the confirmation-dependent recommendations the report conveys. A few typical factors include:

- the client's goals, objectives, budget, schedule, and risk-management preferences;
- the general nature of the structure involved, its size, configuration, and performance criteria;
- the structure's location and orientation on the site; and
- other planned or existing site improvements, such as retaining walls, access roads, parking lots, and underground utilities.

Typical changes that could erode the reliability of this report include those that affect:

- the site's size or shape;
- the function of the proposed structure, as when it's changed from a parking garage to an office building, or from a light-industrial plant to a refrigerated warehouse;
- the elevation, configuration, location, orientation, or weight of the proposed structure;
- the composition of the design team; or
- project ownership.

As a general rule, *always* inform your geotechnical engineer of project changes – even minor ones – and request an assessment of their impact. *The geotechnical engineer who prepared this report cannot accept responsibility or liability for problems that arise because the geotechnical engineer was not informed about developments the engineer otherwise would have considered.*

This Report May Not Be Reliable

Do not rely on this report if your geotechnical engineer prepared it:

- for a different client;
- for a different project;
- for a different site (that may or may not include all or a portion of the original site); or
- before important events occurred at the site or adjacent to it; e.g., man-made events like construction or environmental remediation, or natural events like floods, droughts, earthquakes, or groundwater fluctuations.

Note, too, that it could be unwise to rely on a geotechnical-engineering report whose reliability may have been affected by the passage of time, because of factors like changed subsurface conditions; new or modified codes, standards, or regulations; or new techniques or tools. *If your geotechnical engineer has not indicated an "apply-by" date on the report, ask what it should be*, and, in general, *if you are the least bit uncertain* about the continued reliability of this report, contact your geotechnical engineer before applying it. A minor amount of additional testing or analysis – if any is required at all – could prevent major problems.

Most of the "Findings" Related in This Report Are Professional Opinions

Before construction begins, geotechnical engineers explore a site's subsurface through various sampling and testing procedures. *Geotechnical engineers can observe actual subsurface conditions only at those specific locations where sampling and testing were performed.* The data derived from that sampling and testing were reviewed by your geotechnical engineer, who then applied professional judgment to form opinions about subsurface conditions throughout the site. Actual sitewide-subsurface conditions may differ – maybe significantly – from those indicated in this report. Confront that risk by retaining your geotechnical engineer to serve on the design team from project start to project finish, so the individual can provide informed guidance quickly, whenever needed.

This Report's Recommendations Are Confirmation-Dependent

The recommendations included in this report – including any options or alternatives – are confirmation-dependent. In other words, *they are not final*, because the geotechnical engineer who developed them relied heavily on judgment and opinion to do so. Your geotechnical engineer can finalize the recommendations *only after observing actual subsurface conditions* revealed during construction. If through observation your geotechnical engineer confirms that the conditions assumed to exist actually do exist, the recommendations can be relied upon, assuming no other changes have occurred. *The geotechnical engineer who prepared this report cannot assume responsibility or liability for confirmation-dependent recommendations if you fail to retain that engineer to perform construction observation.*

This Report Could Be Misinterpreted

Other design professionals' misinterpretation of geotechnical-engineering reports has resulted in costly problems. Confront that risk by having your geotechnical engineer serve as a full-time member of the design team, to:

- confer with other design-team members,
- help develop specifications,
- review pertinent elements of other design professionals' plans and specifications, and
- be on hand quickly whenever geotechnical-engineering guidance is needed.

You should also confront the risk of constructors misinterpreting this report. Do so by retaining your geotechnical engineer to participate in prebid and preconstruction conferences and to perform construction observation.

Give Constructors a Complete Report and Guidance

Some owners and design professionals mistakenly believe they can shift unanticipated-subsurface-conditions liability to constructors by limiting the information they provide for bid preparation. To help prevent the costly, contentious problems this practice has caused, include the complete geotechnical-engineering report, along with any attachments or appendices, with your contract documents, *but be certain to note conspicuously that you've included the material for informational purposes only*. To avoid misunderstanding, you may also want to note that "informational purposes" means constructors have no right to rely on the interpretations, opinions, conclusions, or recommendations in the report, but they may rely on the factual data relative to the specific times, locations, and depths/elevations referenced. Be certain that constructors know they may learn about specific project requirements, including options selected from the report, *only* from the design drawings and specifications. Remind constructors that they may perform their own studies if they want to, and *be sure to allow enough time* to permit them to do so. Only then might you be in a position to give constructors the information available to you, while requiring them to at least share some of the financial responsibilities stemming from unanticipated conditions. Conducting prebid and preconstruction conferences can also be valuable in this respect.

Read Responsibility Provisions Closely

Some client representatives, design professionals, and constructors do not realize that geotechnical engineering is far less exact than other engineering disciplines. That lack of understanding has nurtured unrealistic expectations that have resulted in disappointments, delays, cost overruns, claims, and disputes. To confront that risk, geotechnical engineers commonly include explanatory provisions in their reports. Sometimes labeled "limitations," many of these provisions indicate where geotechnical engineers' responsibilities begin and end, to help others recognize their own responsibilities and risks. *Read these provisions closely*. Ask questions. Your geotechnical engineer should respond fully and frankly.

Geoenvironmental Concerns Are Not Covered

The personnel, equipment, and techniques used to perform an environmental study – e.g., a "phase-one" or "phase-two" environmental site assessment – differ significantly from those used to perform a geotechnical-engineering study. For that reason, a geotechnical-engineering report does not usually relate any environmental findings, conclusions, or recommendations; e.g., about the likelihood of encountering underground storage tanks or regulated contaminants. *Unanticipated subsurface environmental problems have led to project failures*. If you have not yet obtained your own environmental information, ask your geotechnical consultant for risk-management guidance. As a general rule, *do not rely on an environmental report prepared for a different client, site, or project, or that is more than six months old.*

Obtain Professional Assistance to Deal with Moisture Infiltration and Mold

While your geotechnical engineer may have addressed groundwater, water infiltration, or similar issues in this report, none of the engineer's services were designed, conducted, or intended to prevent uncontrolled migration of moisture – including water vapor – from the soil through building slabs and walls and into the building interior, where it can cause mold growth and material-performance deficiencies. Accordingly, ***proper implementation of the geotechnical engineer's recommendations will not of itself be sufficient to prevent moisture infiltration.*** Confront the risk of moisture infiltration by including building-envelope or mold specialists on the design team. ***Geotechnical engineers are not building-envelope or mold specialists.***

GEOPROFESSIONAL BUSINESS ASSOCIATION

Telephone: 301/565-2733
e-mail: info@geoprofessional.org www.geoprofessional.org

Appendix B

Funding Analysis

I. Project Overview

The Ocean Drive Drainage and Infiltration System project is on E. Beach Drive and Ocean Drive between 74th Street and Womble Street. The area floods routinely during moderate wet weather events including flooding of an event center at 801 Ocean Drive. The objective of the overall project is to reduce flooding in the area and prevent damage to local businesses.

II. Funding Analysis

Based on the project solutions discussed in this study, four (4) specific sources have been identified as providing the best opportunity for securing the funding needed for the Ocean Drive Drainage and Infiltration System project.

Building Resilient Communities and Infrastructure Program (BRIC) - FEMA

The initial funding source for this project is the FEMA – BRIC Program. This is a new program launched by FEMA to fund pre-disaster mitigation/resilience projects. Below are the details specific to this source and the overall project:

- **Project Elements Eligible** – All elements of this project are conditionally eligible. In addition, BRIC can now fund a project in phases to allow more time for design, environmental assessment and permitting elements to be completed. In addition, pre-award costs related to these elements can also be rolled into the funding request if not phased (*i.e.*, you do not have to wait for award in order to start design-related efforts).

- **Application Deadline** – Application period generally opens on or about September 30 of each year and closes at the end of January. (Note: Specific deadlines will be provided by FEMA for the FY2021 application period in the coming week.) Applications are accepted through the new FEMA GO portal and prospective applicants need to establish an account, which can be done now. Prior to submittal of the application to FEMA, the project must be reviewed and approved by the State Hazard Mitigation Officer (NC Department of Public Safety).

- **Anticipated Award Date** – FEMA normally provides pre-award project selections in late June/early July.

- **Match Requirements** – The federal share for this program is capped at 75%. Leveraging local funding over the 25% garners more points in this program; therefore, it would be advantageous for the Town to contribute additional local funds through both Town resources as well as securing funding from other non-federal partners. For small, impoverished communities (*i.e.*, a community of 3,000 or fewer individuals identified by the applicant that is economically disadvantaged, with residents having an average per capita annual income not exceeding 80 percent of the national per capita income, based on best available data), the federal share is capped at 90% with a local share of 10%.

- **Maximum Award** – **$50 million** (federal share cap) per sub-applicant. All projects must also comply with FEMA's benefit-cost analysis (BCA) ratio of 1 or more to validate its cost-effectiveness. The source(s) of the non-federal share will need to be identified at the time of application.

- **Period of Performance** – BRIC projects are expected to be completed within **36 months** of award date. Depending on final schedule determination, Oak Island could: apply now for the full project; complete a phased project application that would allow for upfront funding of the engineering design costs; or, apply for these funds in 2022 application cycle since pre-award costs for project development are eligible.

- **Partners** – One of the BRIC qualitative scoring criterion (15 out of 100 points) is focused on leveraging partners. This does not have to be funding partners but can be other local civic or environmental groups that support the project. Support from additional local organizations should be discussed to make the application as competitive as possible.

- **Post-Project Requirements** – Although none are specifically required, another one of the BRIC qualitative scoring criterion (15 out of 100 points) is focused on implementation measures. This encompasses both the overall feasibility of completing the project as well as how success can be measured once it is completed. This should also be a consideration when designing the project to garner as many points as possible in the application.

- **Other Requirements for Eligibility** – All projects must meet National Environmental Policy Act (NEPA) and Historic Preservation requirements. In addition, the community applying for funding must have a FEMA-approved Hazard Mitigation Plan at the time of application and award as well as be in a state that has had at least one federally-declared disaster within the last seven (7) years. (*NOTE: All states currently meet this last criterion.*)

- **Initial Project BRIC Scoring**
  - ✓ Technical Criteria (all or no points awarded) – 100 possible (*see attached BRIC Technical Criteria*)
  - ✓ Qualitative Criteria – points awarded on a scale based on evaluation by Review Panel (*see attached BRIC Qualitative Criteria)*

- **Review of Inaugural BRIC Funding**
  - ✓ The funding announcements for the inaugural BRIC funding round were just made in early July 2021. We will be attending FEMA BRIC webinars focused on

application debriefs as well as talking directly with the State Hazard Mitigation Officer to gain additional insight on preparing the most successful application possible and will share that information with the Town in the coming weeks.

- ✓ FEMA has received additional funding for the BRIC program from the American Rescue Plan Act (ARPA) and expects to receive more with the passage of an infrastructure stimulus bill. This is due in large part to the focus on infrastructure resiliency as well as the number of applications FEMA received for this first round of BRIC funding.

Flood Mitigation Assistance Program (FMA) - FEMA

FEMA makes these grant funds available to reduce or eliminate the risk of repetitive flood damage to buildings and structures insured under the National Flood Insurance Program (NFIP). FEMA has a Community Flood Program under FMA, for which this project would most likely be the most competitive. Below are the details specific to this source and the overall project:

- **Project Elements Eligible** – Elements of this project are conditionally eligible, if the building at 801 Ocean Drive is insured under NFIP. If other properties that would benefit from the project have active NFIP policies, those will help secure additional points for the application.

- **Application Deadline** – Application period generally opens on or about September 30 of each year and closes at the end of January. (Note: Specific deadlines will be provided by FEMA for the FY2021 application period in the coming weeks.) Applications are accepted through the new FEMA GO portal and prospective applicants need to establish an account, which can be done now. Prior to submittal of the application to FEMA, the project must be reviewed and approved by the State Hazard Mitigation Officer (NC Department of Public Safety).

- **Anticipated Award Date** – FEMA normally provides pre-award project selections in late June/early July.

- **FMA Community Flood Mitigation Program Initial Scoring:**
  - ✓ Application Requirements:
    - Use the Community Flood Control code/activity type within FEMA's grant application system to be considered.
    - Be designated as a community flood mitigation project in the subapplication title, "Community Flood Mitigation Project."
    - Prove that the proposed project benefits NFIP-insured properties by submitting a benefitting area map and associated geospatial file(s) (*e.g.*, shapefile, KML/KMZ, geodatabase, or other geographic information system [GIS]-enabled document) delineating: 1) Proposed project footprint boundary; 2) Area benefitting from project; and, 3) Active NFIP policies (if data available).
  - ✓ Points are awarded based on a number of factors with community losses, number of NFIP policy holders impacted and number of severe/repetitive loss claims being the categories where the most points can be claimed. (*see attached FMA CFM scoring criteria*)

Match Requirements – The federal share for this program is capped at 75%. The State of North Carolina normally provides the local share of 25% for FEMA grants; however, that is still being finalized. Leveraging local funding over the 25% garners more points in this program; therefore, it would be advantageous for the Town to contribute additional local funds through both Town resources even if the state covers the required 25% as well as securing funding from other non-federal partners.

- **Maximum Award** – **$30 million** (federal share cap) per sub-applicant. All projects must also comply with FEMA's benefit-cost analysis (BCA) ratio of 1 or more to validate its cost-effectiveness. The source(s) of the non-federal share will need to be identified at the time of application.

- **Period of Performance** – FMA CFM projects are expected to be completed within **48 months** of award date. Depending on final schedule determination, Oak Island could: apply now for the full project or submit an application for project scoping (advance assistance) that would allow for upfront funding of the engineering design costs. If the latter is selected, CFM project implementation application that have received funds for project scoping score an additional 20 points.

- **Partners** – One of the FMA CFM scoring criterion (150 points) is focused on leveraging funding partners, specifically private organizations and businesses. Project investment from local organizations/businesses should be discussed to make the application as competitive as possible.

- **Post-Project Requirements** – No specific post-project elements are required.

- **Other Requirements for Eligibility** – All projects must meet National Environmental Policy Act (NEPA) and Historic Preservation requirements. In addition, the community applying for funding must have a FEMA-approved Hazard Mitigation Plan at the time of application and award as well as be located in a state that has had at least one federally-declared disaster within the last seven (7) years. (*NOTE: All states currently meet this last criterion.*) Sub applicants also must be participating in the NFIP, and not be withdrawn, on probation, or suspended for the duration of the project.

Local Assistance for Stormwater Infrastructure Investment Fund (LASII) – NCDEQ-DWI

The State Legislature has proposed the creation of this fund within the State Reserve managed by the Division of Water Infrastructure (DWI). $100 Million is allocated to this new fund from the American Recovery Plan Act (ARPA) funds awarded to the state. This new fund will provide grants for projects that will improve or create infrastructure for controlling stormwater quantity and quality. Below are the details specific to this source and the overall Ocean Drive Drainage and Infiltration System project:

- **Project Elements Eligible** – All elements of this project are conditionally eligible. However, this is a new fund therefore no specifics are available as of the date of this report. Historically costs are eligible to the extent that other funding sources are not reasonably available. This has been interpreted to mean, if the invoice has already been paid, before applying for funding, then other funding was reasonably available.

- **Application Deadline** – It is anticipated these funds will be distributed over 3 funding cycles. DWI takes applications twice a year with due dates in the Spring and Fall.

- **Anticipated Award Date** – The State Water Infrastructure Authority (SWIA) approves projects for funding twice a year, in Summer and Winter. Summer is typically at the July SWIA meeting and Winter can vary between February and March meetings.

- **Match Requirements** – In general, affordability criteria are applied to all projects to determine the amount of grant a project is eligible. However, the proposed legislation that creates this fund does not reference those criteria nor are the criteria based on stormwater utility rates.

- Maximum Award – **$15 million** for projects, **$500,000** for planning.

- **Period of Performance** – DWI puts all projects on a 24-month schedule to award date. There are no limits to time allotted for construction.

- **Partners** – No partners are required.

- **Post-Project Requirements** – No reports are required.

- **Other Requirements for Eligibility** – Because of state law, projects funded through the State Reserve do not require an environmental evaluation.

- **Priority Rating** – DWI is developing a priority rating system for stormwater projects.

Open Grants Program – NC Golden LEAF Foundation

Another funding source and potential local partner for this project may be the Golden LEAF Foundation since it involves assistance for local businesses and the details specific to this source are provided below:

- **Project Elements Eligible** – In general all aspects of this project would be eligible for funding with the exception of grant/funding management and land/easement acquisition.

When combining funding resources, it is generally advantageous to allocate the smaller funding source to a specific budget line item rather than divide across multiple line items. This improves the ease of reporting and demonstrating how/where funds are spent when submitting reimbursement requests.

- **Application Deadline** – Golden LEAF accepts Letters of Inquiry (LOIs) on a **rolling basis** and they are considered by their Board of Directors at each meeting (held at least quarterly). This is a 2-step application process. If the Board accepts the LOI for a project, a full application will be requested.

- **Anticipated Award Date** – Based on when a full application is submitted and the Board meeting schedule (*occur on at least a quarterly basis*) but, generally, funding is awarded within **3-6 months** of full application submittal.

- **Match Requirements** – No specific match requirement; however, source(s) of the additional funds needed to complete the project must be identified at the time of application.

- **Maximum Award** – **$200,000 - $500,000 (*Note: Golden LEAF just announced an increased funding limit for Open Grant awards; however, few projects will secure this level of funding and most awards will still be in the $200,000 range.*)**

- **Period of Performance** – Based on project schedule submitted with the application; however, Golden LEAF expects that their funds will be used as expeditiously as possible.

- **Partners** – Golden LEAF prefers to not be the only funding source participating in a project and also evaluates other local civic or environmental groups that support the project.

- **Post-Project Requirements** – Golden LEAF requires that a project have measurable economic-related outcomes and requires reporting on those outcomes for a period of a least 2 years following project completion.

- **Other Requirements for Eligibility** – Projects must target at least one of Golden LEAF's priority focus areas: Economic Investment and Job Creation, Workforce Preparedness and Education, Agriculture, and Community Vitality – all related to improving economic conditions of a community. Stormwater projects are not normally considered to be high priority infrastructure projects, but Golden LEAF has funded several recently. (*NOTE: In initial discussions with Golden LEAF, they want there to be a very strong tie to economic development and be focused on new infrastructure, not rehabilitation of existing infrastructure.*)

III. Funding Recommendations

Based on the funding analysis for the Ocean Drive Drainage and Infiltration System project, it is recommended to pursue BRIC and LASII funding for the entire project. Timing of the application can be discussed based on the overall project schedule as well as on discussions with the NC State Hazard Mitigation Officer, Jason Pleasant. These discussions will center on the overall competitiveness of the project as well as the state's determination on providing the non-federal share for any approved BRIC funding. We believe the funding discussed are the most advantageous for the Town, however we will continue to monitor new funding sources as they become available like USDA Rural Development and DEQ DWR.

Based on this, the recommended next steps are as follows:

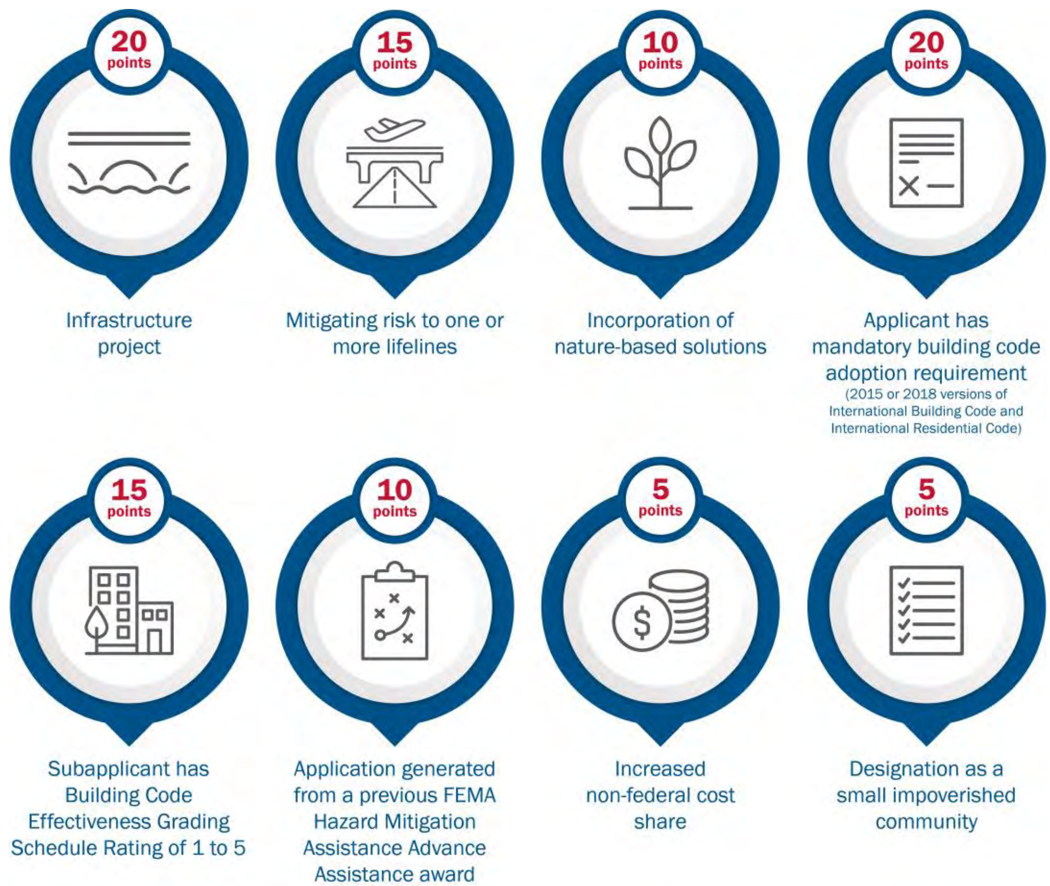
1. Oak Island to register on the FEMA GO portal.
2. Set up meeting with Jason Pleasant (NCDPS) to discuss the project and the state's review/participation.
3. Review/discuss scoring criteria relative to the project elements and develop narrative discussion to ensure the application can secure as many points as possible. (*The BRIC application template is provided as an attachment to this analysis.*)
4. Complete the FEMA BCA assessment to ensure overall cost-effectiveness.
5. Identify additional local partners that can provide letters of support for the project.
6. Once the details for the new LASII program through NCDEQ-DWI are available, we will provide additional feedback to the Town to prepare for an application in the Spring of 2022.

Funding Analysis
Town of Oak Island - Ocean Drive Drainage Study
July 2021

Source	BRIC - FEMA	FMA - FEMA	Stormwater - DWI	Open Grants - Golden LEAF
Project Eligibility	* All elements conditionally eligible * Can include pre-award costs	* All elements conditionally eligible * Can include pre-award costs	* All elements conditionally eligible * Cannot cover expenses already paid	* Most elements conditionally eligible * Cannot cover grant/funding adminsitration or land/easment acquisition (but can be part of match)
Application Deadline	1/29/2022 (Estimated)	1/29/2022 (Estimated)	New funding to be awarded in three rounds 4/29/2022 9/30/2022 4/28/2023	Rolling Application Period
Award Date	Estimated 6/2022	Estimated 6/2022	Estimated 7/2022 2/2023 7/2023	3-6 months from full application
Match Requirements	25% match from non-federal sources	25% match from non-federal sources	Match requirements unknown at this time	No specific match requirements
Maximum Grant Award	$50 million	$30 million	$15 million (***construction***) $500,000 (***planning***)	$500,000
Period of Performance	36 months	48 months	24 months to construction contract execution	Based on approved project schedule
Partners	Needed for competitive application	Needed for competitive application	None	Needed for competitive application
Post-Project Requirements	Needed for competitive application	Needed for competitive application	None	Reports on economic factors (job creation/retention, etc.)
Other Requirements	* NEPA/Historic Preservation Compliance * FEMA-approved Hazard Mitigation Plan	* NEPA/Historic Preservation Compliance * FEMA-approved Hazard Mitigation Plan * Located in a state with at least 1 federally-declared disaster within last 7 years	* ARPA funded new Stormwater State Reserve Fund * Other requirements unknown at this time	* Projects must align with Golden LEAF's priortity focus areas * Economic factors are important

BRIC Technical Criteria

This program support material provides detailed information about the eight technical evaluation criteria that will be used in the Building Resilient Infrastructure and Communities (BRIC) national competition. The conditions that must be met to receive the point allotment for each criterion are described below. Additionally, application instructions are included for each respective criterion to guide information submission in FEMA Grants Outcomes (FEMA GO).



BRIC National Competition Technical Criteria and Point Values

Background

As described in Section E.1.a (Application Review Information – Application Evaluation Criteria, Programmatic Criteria) of the BRIC Notice of Funding Opportunity (NOFO), FEMA will use technical evaluation criteria to score subapplications submitted to the national competition. As referenced in the NOFO:

> *"If needed based on the number of subapplications submitted to the BRIC program, FEMA will use the technical evaluation criteria scoring as a program priority screening tool for the qualitative evaluation review. FEMA will send subapplications valued up to twice the amount of available funding to the BRIC qualitative evaluation panel. FEMA will ensure that at least one eligible subapplication from each Applicant will be sent to the qualitative evaluation panel for review.*
>
> *The technical evaluation criteria offer incentives for elements valued by FEMA. In order to ensure transparency and efficiency in competition project selection, technical evaluation criteria are binary point awards; projects either receive the full points allotted or zero points for each criterion."*

FEMA developed several of the technical evaluation criteria based upon factors it is required to consider by statute in addition to comments received through summer of 2019 stakeholder engagement efforts. For example, comments indicated that stakeholders strongly support prioritizing projects that integrate nature-based solutions, incentivizing building code improvements, and promoting previous Hazard Mitigation Assistance (HMA) Advance Assistance efforts.

For more information on BRIC and stakeholder engagement efforts, please visit https://www.fema.gov/bric. Application instructions are included below for each respective criterion to guide information submission in FEMA GO. More information on navigating the new FEMA GO system and the full application process can be found at https://www.fema.gov/grants/guidance-tools/fema-go.

Technical Criterion 1: Infrastructure Project (20 points)

To receive the point allotment for this criterion, the subapplication must explain how the project mitigates natural hazard risk to critical physical structures, facilities, and systems that provide support to a community, its population, and its economy. The following statements are provided as examples that a community might submit in a subapplication to describe how their project is an infrastructure project:

- Through the proposed nature-based solution that will reduce risk from high-intensity rainfall events, we will be providing enhanced protection to our wastewater treatment plant, which supplies fresh water to our community of 30,000 people.
- Retrofitting our food bank to have stronger structural integrity and the ability to operate off-grid will ensure a critical service in our community can remain operational following an earthquake.

Applicants/subapplicants should include this information in the Scope of Work Section of FEMA GO.

Technical Criterion 2: Mitigating Risk to One or More Lifelines (15 points)

To receive the point allotment for this criterion, the subapplication must indicate that the project will mitigate risk to at least one of the seven Community Lifelines to enable the continuous operation of critical government and business functions essential to human health and safety or economic security.

Community Lifelines are the most fundamental services in the community that, when stabilized, enable all other aspects of society to function. More information on Community Lifelines can be found at https://www.fema.gov/lifelines and in the Community Lifelines Implementation Toolkit. The seven Community Lifelines are shown in the graphic below.

FEMA Community Lifelines

To better understand how mitigation projects can incorporate Community Lifelines concepts, please refer to the Mitigation Action Portfolio (MAP) at https://www.fema.gov/bric. The following MAP projects offer examples for each of the seven Community Lifelines:

- Safety and Security: Spring Creek (South Dakota) Drainage Improvement Project
- Food, Water, Shelter: Renovation of Alexander Theater (St. Croix)
- Health and Medical: Mercy Hospital (Missouri) Rebuild
- Energy (Power & Fuel): Blue Lake Rancheria Tribe (California) Microgrid
- Communications: ConnectArlington (Virginia) Communication Infrastructure Upgrades
- Transportation: La Guardia Airport (New York) Flood Control
- Hazardous Materials: Washington DOT Landslide Mitigation Action Plan and Rail Corridor Improvements

Applicants/subapplicants should include this information in the Scope of Work Section of FEMA GO.

Technical Criterion 3: Incorporation of Nature-Based Solutions (10 points)

To receive the point allotment for this criterion, the subapplication must indicate and describe how the project incorporates one or more nature-based solutions, which are sustainable environmental management practices that restore, mimic, and/or enhance nature and natural systems or processes and support natural hazard risk mitigation as well as economic, environmental, and social resilience efforts. Nature-based solutions use approaches that include, but are not limited to, restoration of grasslands, rivers, floodplains, wetlands, dunes, and reefs; living shorelines; soil stabilization; aquifer storage and recovery; and bioretention systems.

Applicants/subapplicants should include this information in the Scope of Work Section and Cost Effectiveness Section of FEMA GO.

Technical Criterion 4: Applicant has Mandatory Building Code Adoption Requirement (20 points)

For Applicants and subapplicants to receive the point allotment for this criterion, the Applicant must have adopted codes based on either the 2015 or 2018 versions of both the **International Building Code (IBC)** and the **International Residential Code (IRC)** model codes published by the International Code Council (ICC). The following adoption status combinations are the only ones that qualify for the point allotment:

- 2015 version of both the IBC and IRC
- 2018 version of both the IBC and IRC

- 2015 version of the IBC and 2018 version of the IRC
- 2018 version of the IBC and 2015 version of the IRC

If an Indian tribal government (federally recognized) has not adopted the code as listed above, the tribe must demonstrate alternative compliance with IBC and IRC (2015 or 2018) or be covered under another jurisdiction's (state or territory) code adoption status in order to receive the point allotment.

Applicants/subapplicants should include this information in the Evaluation Section of FEMA GO. Additionally, Applicants/subapplicants should attach documentation verifying adoption status. Information about Applicant adoption status may be found in the following examples of reference documents, which also represent acceptable adoption status verification documents that can be included as an attachment to the application:

- State, territory, or tribal legislation or code that demonstrates adoption status
- Insurance Services Office's (ISO's) *National Building Code Assessment Report – Building Code Effectiveness Grading Schedule* (2019 Edition)
- ICC's *Our Most Up to Date Adoption Chart: State Adoptions* located under the "Code Adoption Resources" tab of the ICC Advocacy page (https://www.iccsafe.org/advocacy/)

Technical Criterion 5: Subapplicant has Building Code Effectiveness Grading Schedule (BCEGS) Rating of 1 to 5 (15 points)

The BCEGS is an independent assessment of a community's building code adoption and enforcement activities, resulting in a score of 1 (best) to 10. For more information on BCEGS, please visit the ISO-Mitigation website at https://www.isomitigation.com/bcegs/.

To receive the point allotment for this criterion, a subapplicant at the local level (including those located in territories) must have a BCEGS rating between 1 and 5 (considered by FEMA as a disaster-resistant code) when the application is submitted. To receive the point allotment for this criterion, a state or territory acting as a subapplicant must:

- Have a class ranking between 1 and 5 on both the Commercial and Residential BCEGS State Averages as indicated on the respective State Page in ISO's *National Building Code Assessment Report – Building Code Effectiveness Grading Schedule* (2019 Edition); or
- Submit a BCEGS score provided by ISO (for territories and the District of Columbia)

Subapplicants at the state or territory level may submit documentation verified by ISO that provides more updated information on their BCEGS rating, if applicable. BCEGS scores for tribal Applicants/subapplicants are required but can be dependent on the relationship between the local municipality and the tribal entity that determines how building code requirements are managed.

The best source for relevant information at the community level is the local building inspector or code enforcement office.

Bureau States

Bureau states have their own insurance rating organization that is not part of ISO. To receive the point allotment for this criterion, a subapplicant at the state or territory level for the five Bureau states not included in *ISO's National*

Building Code Assessment Report – Building Code Effectiveness Grading Schedule (2019 Edition) must provide a state-verified BCEGS score at the state level. For subapplicants at the local level within Bureau states, BCEGS scores should be provided by the state. BCEGS Bureau state contact information is as follows:

Hawaii Insurance Bureau, Inc.
715 South King Street, Suite 320
Honolulu, HI 96813-4118
808-531-2771

Idaho Surveying and Rating Bureau, Inc.
5440 Franklin Road, Suite 101
P.O. Box 6430
Boise, ID 83707
208-343-5483

Property Insurance Association of Louisiana
433 Metairie Road, Suite 400
Metairie, LA 70005
504-831-6930

Mississippi State Rating Bureau
2685 Insurance Center Drive
Jackson, MS 39216-5231
or
P.O. Box 5231
Jackson, MS 39296-5231
601-981-2915

Washington Surveying and Rating Bureau
200 1st Avenue W, Suite 500
Seattle, WA 98119-4219
206-217-9772

If a subapplicant does not have a BCEGS score, a survey to obtain one can be requested. **BCEGS surveys are provided at no cost, do not negatively impact credit ratings, and can take 2 to 4 months to complete. Communities intending to apply for BRIC funding are encouraged to initiate the process as soon as possible.** To request a BCEGS survey, please refer to the submission instructions referenced on the ISO-Mitigation website at https://www.isomitigation.com/bcegs/. Questions about the BCEGS survey can be directed to BCEGS_Info@verisk.com.

Applicants/subapplicants should include this information in the Evaluation Section of FEMA GO.

Technical Criterion 6: Application Generated from a Previous FEMA HMA Advance Assistance Award (10 points)

To receive the point allotment for this criterion, a subapplicant must indicate the project was generated from a previous FEMA HMA Advance Assistance award and the award is directly related to the current proposal. HMA Advance Assistance provides Applicants and subapplicants resources to develop mitigation strategies and obtain data to prioritize, select, and develop complete applications in a timely manner.[1]

This type of grant may have been awarded through the Hazard Mitigation Grant Program (HMGP), Flood Mitigation Assistance (FMA), or Pre-Disaster Mitigation (PDM) grant program at any time since HMA's Advance Assistance award inception.

Applicants/subapplicants should include this information in the Evaluation Section of FEMA GO.

Technical Criterion 7: Increased Non-Federal Cost Share (5 points)

To receive the point allotment for this criterion, a subapplicant must indicate the non-federal cost share exceeds 25 percent.

Applicants/subapplicants should include this information in the Budget Section of FEMA GO.

Technical Criterion 8: Designation as a Small Impoverished Community (5 points)

To receive the point allotment for this criterion, local government subapplicants must document their status as a small impoverished community (a community of 3,000 or fewer individuals identified by the applicant that is economically disadvantaged, with residents having an average per capita annual income not exceeding 80 percent of the national per capita income, based on best available data[2]). A state, territory, or Indian tribal government (federally recognized) serving as a subapplicant must document the small impoverished status of the community in which the project is planned to receive the point allotment for this criterion.

Population information can be found through the U.S. Census website. For the most current information on the national income, see http://www.bea.gov.

Applicants/subapplicants should include this information in the Budget Section in FEMA GO and attach required support documentation.

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1 This definition is derived from the Advance Assistance description on page 22 of the Hazard Mitigation Assistance Guidance (HMA Guidance; 2015), which is available at https://www.fema.gov/grants/mitigation/hazard-mitigation-assistance-guidance-and-addendum-fy15.

2 This definition is derived from the Robert T. Stafford Disaster Relief and Emergency Assistance Act, as amended by the Disaster Recovery Reform Act of 2018.

BRIC Qualitative Criteria

This program support material provides detailed information about the six qualitative evaluation criteria that will be used in the Building Resilient Infrastructure and Communities (BRIC) national competition. Information to both guide Applicants and subapplicants in the development of their subapplications and to assist panelists in the qualitative review of projects is described below. Additionally, application instructions are included for each respective criterion to guide information submission in FEMA Grants Outcomes (FEMA GO).

BRIC National Competition Qualitative Criteria and Point Values

Background

As described in Section E.1.a (Application Review Information – Application Evaluation Criteria, Programmatic Criteria) of the BRIC Notice of Funding Opportunity (NOFO), FEMA will convene a National Review Panel to score subapplications submitted to the national competition based on a qualitative review. The BRIC national competition National Review Panel will include FEMA Regional Office and Headquarters staff, as well as representatives from state, local, tribal, and territorial (SLTT) governments and other federal agencies. As referenced in the NOFO:

> *"If needed based on the number of subapplications submitted to the BRIC program, FEMA will use the technical evaluation criteria scoring as a program priority screening tool for the qualitative evaluation review. FEMA will send subapplications valued up to twice the amount of available funding to the BRIC qualitative evaluation panel. FEMA will ensure that at least one eligible subapplication from each Applicant will be sent to the qualitative evaluation panel for review.*
>
> *In order to increase transparency in decision-making while building capability and partnerships, FEMA will convene a National Review Panel (NRP) to score subapplications based on qualitative evaluation criteria. The qualitative criteria are narrative submissions to allow subapplicants the flexibility to fully explain the strengths of the proposed project. Qualitative evaluation criteria have graded scales of point scoring."*

FEMA

FEMA developed the qualitive evaluation criteria based upon comments received through summer of 2019 stakeholder engagement efforts. For example, comments indicated support for holistic project evaluation beyond economic metrics alone as well as for incentivizing partnerships and high-quality community engagement.

For more information on BRIC and stakeholder engagement efforts, please visit https://www.fema.gov/bric.

Evaluation Process and Scoring

The panelists will leverage their mitigation experience and expertise during the review to assess the degree to which subapplications meet the six BRIC qualitative evaluation criteria (based on the scoring in Table 1). The subapplication's final qualitative score will be calculated by averaging the qualitative scores from each panelist. The six criteria include the following: (1) Risk Reduction/Resiliency Effectiveness, (2) Future Conditions, (3) Implementation Measures, (4) Population Impacted, (5) Outreach Activities, and (6) Leveraging Partners.

Table 1: To what degree does the subapplication meet the criterion?

Scoring Option	Description
Not at all	The subapplication does not address the criterion at all, or minimal references to the criterion are made that include no substantive information.
Minimally	The subapplication addresses the criterion, but information in the subapplication may be confusing, unclear, and/or incorrect. The degree to which the subapplication demonstrates the criterion has been met is weak.
Partially	The subapplication addresses the criterion, but the subapplication may lack clarity and/or strong support, have some minor inconsistencies, or not address all components of the criterion. The degree to which the subapplication demonstrates the criterion has been met is mediocre.
Mostly	Although the subapplication may include a few minor inconsistencies or areas that need more clarity, there is strong support for most components of the criterion. The degree to which the subapplication demonstrates the criterion has been met is acceptable.
Entirely	The subapplication is clear, concise, and complete; provides examples; and is supported by data. It addresses all components of the criterion and may have a particularly compelling narrative. The degree to which the subapplication demonstrates the criterion has been met is excellent.
Exceeds	In addition to addressing all components of the criterion and being clear, concise, complete, and supported by data, the subapplication articulates the transformative impact of the project in catalyzing broader efforts (such as legislative action) as they relate to the criterion. The degree to which the subapplication demonstrates the criterion has been met is beyond excellent.

The National Review Panel will apply the scoring options listed in Table 1 to all six qualitative criteria. However, point values associated with each scoring option vary among criteria, depending on the total possible points for each criterion. The graded scoring and point scales for each criterion are included below.

Application instructions are included below for each respective criterion to guide information submission in FEMA GO. More information on navigating the new FEMA GO system and the full application process can be found at https://www.fema.gov/grants/guidance-tools/fema-go.

Prompts are outlined for each qualitative criterion to serve as a helpful starting point for Applicants and subapplicants. These prompts are designed to clarify terms and provide guiding questions for Applicants and subapplicants to consider as they write the subapplication. This information will be provided to panelists to foster a common frame of reference. Please note that answering every question, while informative, will not necessarily guarantee an "Exceeds" score. Finally, prompts included here are by no means mutually exclusive or exhaustive; any additional information to support the merit of the subapplication is welcome. This information supplements the information regarding qualitative evaluation criteria that can be found in Section E.1.a (Application Review Information – Application Evaluation Criteria, Programmatic Criteria) of the BRIC NOFO.

Qualitative Criterion 1: Risk Reduction/Resiliency Effectiveness (35 possible points)

The subapplication details how the project will effectively reduce risk and increase resilience (including the benefits quantified in the BCA), realize ancillary benefits, and leverage innovation.

Not at all	Minimally	Partially	Mostly	Entirely	Exceeds
0	7	14	21	28	35

Applicants and subapplicants should include Risk Reduction/Resiliency Effectiveness information in the Scope of Work Section of FEMA GO.

Prompts for Risk Reduction/Resiliency Effectiveness Criterion

- Resilience refers to the ability to prepare for anticipated hazards, adapt to changing conditions, and withstand and recover rapidly from disruption.[1] How will the proposed project improve resilience? For example, a project designed to retrofit a library to serve as a tornado shelter could include tornado (and other hazards) preparedness, resilience, and mitigation information. This could enhance the community's resilience by educating the public about the natural hazard risks they face, as well as build a culture of preparedness.
- How will the proposed project reduce risk(s) and to what level? For example, a proposed project could be designed to provide 100-year-level flood protection to a neighborhood with 250 people, 135 homes, 15 publicly owned structures that support several Community Lifelines, and a variety of cultural, historic, and environmental resources. Additionally, subapplicants may have high Building Code Effectiveness Grading Schedule (BCEGS) scores that show a commitment to reducing risk through strong building code adoption and enforcement activities.
- Ancillary benefits refer to benefits other than the project's primary risk reduction objective which may be identified in the Hazard Mitigation Plan, Scope of Work, and Benefit-Cost Analysis. These are benefits related

[1] This definition is used by the National Institute of Standards and Technology.

to water/air quality, habitat creation, energy efficiency, economic opportunity, reduced social vulnerability, cultural resources, public health, mental health, etc. What ancillary benefits will the project provide and how? Does the project consider multiple hazards (e.g., wind/storm surge, wildfire/mudslides) to address risks beyond the proposal's primary risk reduction objective?

- Innovation in one community can look very different from innovation in another community. How does the project leverage or demonstrate innovation for your community? What new ideas or approaches is the project incorporating? For example, a proposed project in a rural community that has seen an increase in development and impervious surface might include nature-based solutions that have not previously been used.

Qualitative Criterion 2: Future Conditions (15 possible points)

The subapplication describes how the project will anticipate future conditions (population/demographic/climate changes, sea level rise,[2] etc.) and cites data sources, assumptions, and models.

Not at all	Minimally	Partially	Mostly	Entirely	Exceeds
0	3	6	9	12	15

Applicants and subapplicants should include Future Conditions information in the Evaluation Section of FEMA GO.

Prompts for Future Conditions Criterion

- What anticipated future conditions are relevant for the project? Examples of future conditions include, but are not limited to, the following: expected population growth or shrinkage, land use and development shifts, aging population, shifts in income or employment, changes in housing needs, sea level rise, more intense rainfall events, increasing storm frequency, etc.
- How is the project responsive to any identified anticipated changes? Does the project integrate the consideration of future conditions into design, planning, and operations workflows?
- How was the project informed by, or connected to, plans and planning efforts and their assessment of future conditions? Relevant plans may include Hazard Mitigation Plans, Comprehensive Plans, Climate Adaptation Plans, Long-Range Transportation Plans, Small Area Plans, etc.
- What data sources and assumptions are used to guide the project? For example, when citing a sea level rise projection, what time period and what scenario of sea level rise are assumed?

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[2] Applicants and subapplicants may use any valid source that is based on recognized sea level rise estimation methods for sea level rise. Several federal government sources are available for relative sea level rise data along coastal areas. Some of these sources include, but are not limited to, the National Oceanic and Atmospheric Administration Center for Operational Oceanographic Products and Services' Mean Annual SLR Trend Data (https://tidesandcurrents.noaa.gov/sltrends/sltrends.html) and the U.S. Army Corps of Engineers Sea-Level Change Curve Calculator (Version 2019.21) (http://corpsmapu.usace.army.mil/rccinfo/slc/slcc_calc.html).

Qualitative Criterion 3: Implementation Measures (15 possible points)

The subapplication adequately describes how the costs and schedule will be managed, how the project will be successfully implemented, and how innovative techniques to facilitate implementation will be incorporated. The project's Scope of Work identifies sufficient technical and managerial staff and resources to successfully implement this project.

Not at all	Minimally	Partially	Mostly	Entirely	Exceeds
0	3	6	9	12	15

Applicants and subapplicants should include Implementation Measures information in the Scope of Work Section of FEMA GO.

Prompts for Implementation Measures Criterion

- Does the application inspire confidence that the project can be completed successfully as designed, given the stated implementation measures?
- What potential implementation challenges and obstacles are identified (e.g., technical, political, financial, public support) and what innovative implementation solutions are proposed? Innovative implementation techniques in one community can look very different from those in another community.
- Are the proposed project costs and schedule realistic? How do project cost estimates and the schedule identify and properly address potential challenges and obstacles?
- What pre- and post-implementation monitoring strategies are proposed for the project? What specific evaluation elements are proposed to measure progress and ensure the project is executed as designed?
- What technical and managerial staff and resources are available to successfully implement the project? How will anticipated staff and resource gaps be filled?
- Are examples of successfully completed projects included to demonstrate effective implementation measures?

Qualitative Criterion 4: Population Impacted (15 possible points)

The project subapplication demonstrates community-wide benefits and identifies the proportion of the population that will be impacted. The application also describes how impacts (positive or negative) to socially vulnerable populations informed project selection and design.

Not at all	Minimally	Partially	Mostly	Entirely	Exceeds
0	3	6	9	12	15

Applicants and subapplicants should include the Population Impacted information in the Scope of Work Section of FEMA GO.

Prompts for Population Impacted Criterion

- Community size, scale, and definition can look very different in different local contexts. What does “community-wide” mean in the context of the proposed project?
- What percent of the population will directly benefit from the project (i.e., experience direct community-wide benefits)? How is this estimate calculated?
- What is the extent of the project’s expected direct and indirect impacts? How will the project reduce cascading impacts to Community Lifelines, residents, businesses, public services, infrastructure, and natural systems?
- Who are the most vulnerable members of the community where the project is proposed? How will the project negatively impact vulnerable members of the community? How will the project positively impact vulnerable members of the community? Impacts can be directly related to the risk reduction activity or indirectly related, such as with ancillary impacts (i.e., social, environmental, economic impacts).

Qualitative Criterion 5: Outreach Activities (5 possible points)

The subapplication describes outreach activities appropriate to the project that advance mitigation. The application also outlines the types of community planning processes leveraged during project conception and design and identifies the level of public support obtained during the engagement process.

Not at all	Minimally	Partially	Mostly	Entirely	Exceeds
0	1	2	3	4	5

Applicants and subapplicants should also include information about their Outreach Activities in the Scope of Work Section of FEMA GO.

Prompts for Outreach Activities Criterion

- To what extent did stakeholders and/or stakeholder groups contribute to this project?
- What planning processes were leveraged during the development of the project proposal to advance mitigation? How did the project planning process ensure that the most vulnerable members of the community were involved in the planning and decision-making processes?

- What information (e.g., resiliency goals and outcomes, partnership opportunities, project implementation progress) will be shared with the public? What public outreach and engagement strategies will be used to disseminate project information to and gather feedback from stakeholders and members of the community?
- What support or conflicts emerged through the project planning process? How will conflicts be resolved as the project is implemented?
- What are the linkages between your hazard mitigation plan and local land use requirements and how does the linkage make your community more resilient?

Qualitative Criterion 6: Leveraging Partners (15 possible points)

The project subapplication incorporates state, tribal, private, and local community partnerships that will enhance its outcome and describes the extent of those partnerships such as having an increased non-federal cost share, multi-jurisdictional projects, etc.

Not at all	Minimally	Partially	Mostly	Entirely	Exceeds
0	3	6	9	12	15

Applicants and subapplicants should include information about Leveraging Partners in the Evaluation Section of FEMA GO.

Prompts for Leveraging Partners Criterion

- Partnerships can take many different forms. For example, partners may contribute financially, support and promote the proposed project, help generate community-wide awareness of the risks the proposal is designed to address, etc. What partners were involved in the project design? How did partners contribute to the application? What partners will contribute to the implementation of the project?
- To what extent were non-governmental organizations, universities, private organizations, or other government entities consulted for advice or assistance? How has collaboration with surrounding jurisdictions supported project development?
- To what extent have other federal programs or funding sources been leveraged for the project? To what extent have partners provided funding that increases the non-federal cost share?
- How have partnerships been used to increase community resiliency? What potential exists for partnerships to continue beyond implementation of the project?

FEMA Fact Sheet

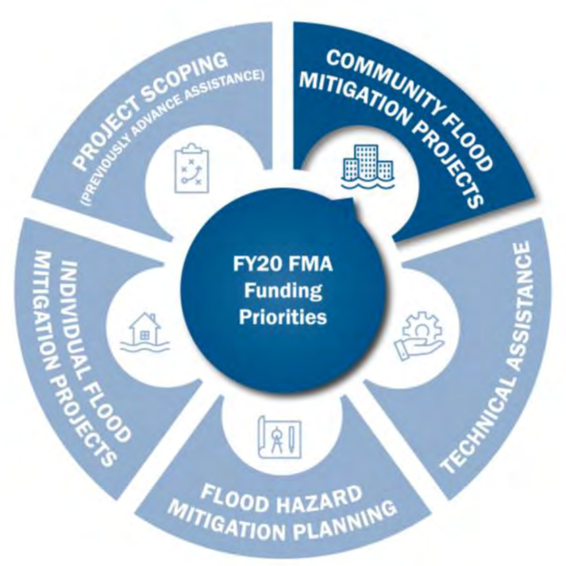
FMA Community Flood Mitigation

The Flood Mitigation Assistance (FMA) program makes federal funds available to reduce or eliminate the risk of repetitive flood damage to buildings and structures insured under the National Flood Insurance Program (NFIP). This fact sheet provides detailed information on community flood mitigation projects eligible under the FMA program.

Overview

Community flood mitigation (CFM) projects are one of five FMA program priorities in fiscal year (FY) 2020. CFM projects, under FMA, address community flood risk for the purpose of reducing NFIP flood claim payments. Out of $160 million in total funding for FY 2020, FEMA has set-aside $70 million for the federal cost share of CFM projects.

FEMA will select the highest scored eligible CFM project subapplication(s) based on the FEMA scoring criteria (described below). Each subapplication should not exceed $30 million in federal cost share. Additionally, projects will be evaluated to ensure they will provide benefits to the NFIP in accordance with Title 44 of the Code of Federal Regulations Part 79 and the *Hazard Mitigation Assistance Guidance* (HMA Guidance).



FY20 FMA Funding Priorities

Required Subapplication Elements

All community flood mitigation project subapplications must:

- Use the **Community Flood Control** code/activity type within FEMA's grant application system to be considered,
- Be designated as a community flood mitigation project in the subapplication title, **"Community Flood Mitigation Project,"** and
- Prove that the proposed project benefits NFIP-insured properties by **submitting a benefitting area map** and associated geospatial file(s) (e.g., shapefile, KML/KMZ, geodatabase, or other geographic information system [GIS]-enabled document) delineating:
  - Proposed project footprint boundary,
  - Area benefitting from project, and
  - Active NFIP policies (if data available).

FEMA

For more information on developing a benefitting area map, please consult the *Geospatial File Eligibility Criteria* Job Aide at https://www.fema.gov/sites/default/files/2020-08/fema_geospatial-eligibility-criteria-flood-mitigation-grant-applications.pdf.

Eligible Community Flood Mitigation Projects

The following non-exhaustive list represents some eligible CFM projects. Remember, projects must benefit NFIP-insured properties in order to be deemed eligible under the FMA program. Examples projects include, but are not limited to:

- Localized flood control
- Floodwater storage and diversion
- Floodplain and stream restoration
- Stormwater management
- Wetland restoration/creation

Community Flood Mitigation Projects Scoring Criteria

For FY 2020, CFM subapplications submitted to FMA will be scored and selected based on FEMA scoring criteria. The following table outlines the specific criteria with a brief description of each. More information on eligibility and scoring criteria can be found within the FY 2020 FMA NOFO.

Final Priority Scoring Criteria for Community Flood Mitigation Projects & Project Scoping		
Priority	**Description**	**Total Points**
NFIP Insured Multiple Loss Communities	Communities with 50 or more Repetitive Loss (RL) or Severe Repetitive Loss (SRL) structures and have received NFIP claims in a county that has received an Individual Assistance declaration for flood in the past 10 years.	Up to 200
NFIP Policy Holder	Points will be assessed for every NFIP policy that is active as of the FMA application start date (Section D, Application and Submission Information, Key Dates and Times) and is verified within the benefitting area of the project. (5 per NFIP Policy).	5 x Each NFIP Policy
Severe Repetitive Loss (SRL) and Repetitive Loss (RL) Properties	Points will be assessed for SRL or RL structure that is verified within the benefitting area of the project (5 per RL and 10 per SRL property).	5 x each RL 10 x each SRL
Private-Partnership Cost Share	Cost share taken on by private organizations/businesses emphasizing community participation, collaboration, and investment. Points will be assigned based on percentage of private cost share invested.	150
Community Rating System (CRS) Participation	The CRS recognizes and encourages community floodplain-management activities that exceed the minimum National Flood Insurance Program standards. Depending on the level of participation, flood insurance premium rates for policyholders can be reduced up to 45%. Highest weight will be assigned to class 1 and descending through lower classes. (Graded Scale: 1 = 100, 2 = 90, 3 = 80, 4 = 70, 5 = 60, 5 = 50, 6 = 40, 7 = 30, 8 = 20, 9 = 10)	10-100
Advance Assistance Generated Project (Projects Only)	Application generated from a previous FEMA HMA Advance Assistance Award.	20
Cooperating Technical Partners Program (CTP) Participation	The CTP is a qualified partnership program in which communities commit to collaborate in maintaining up-to-date flood hazard maps and other flood hazard information. Points will be assigned to CTP participating communities.	30

Period of Performance

Under the FMA program, projects typically have a period of performance of 36 months to achieve project completion. However, given the complexity of the CFM projects, the period of performance for CFM projects is 48 months, starting on the date of the Recipient’s federal Award.

More information on the period of performance and other programmatic requirements can be found in the FY 2020 FMA Notice of Funding Opportunity (NOFO) or the FMA website at https://www.fema.gov/flood-mitigation-assistance-grant-program.

Community Flood Mitigation Projects within FEMA GO

The new FEMA Grants Outcomes (FEMA GO) grants management system will be used for the FMA program, and is where FMA Applicants and subapplicants will submit, track, and manage all applications. The eGrants system will not be used to process FMA applications or subapplications. This section provides a brief synopsis on how to submit community flood mitigation subapplications in FEMA GO, including information on selecting the correct activity type and an overview of the required narrative questions. For more information on navigating the new FEMA GO system and the full application process, please reference the FEMA GO guide at https://www.fema.gov/grants/guidance-tools/fema-go.

The following section offers tips on selecting and submitting a community flood mitigation subapplication within FEMA GO.

- ***"Subapplication Title"***
  - Include "Community Flood Mitigation Project" in the Subapplication title.
- ***Choose the "Subapplication Type"***
  - Select the "Project" Subapplication Type within FEMA GO to begin.
- ***"Scope of Work" Section***
  - Select the Primary Activity Type "Flood control".
  - Select the sub-activity type "Community flood control".
  - Select a Primary Community Lifeline; if applicable, select secondary and tertiary lifelines as well.
  - *Q: Geographic areas description*
    - In this section describe the project area and the benefitting area to the best of your ability.
    - Note: Ensure you attach your project area and benefitting area maps to your Subapplication.

Additional Resources

The links below provide additional information related to the FMA Program and resources to assist Applicants and subapplicants in their development of FMA projects.

- HMA Guidance: https://www.fema.gov/grants/mitigation/hazard-mitigation-assistance-guidance-and-addendum-fy15
- FMA Program Homepage: https://www.fema.gov/grants/mitigation/floods
- Job Aide: New Geospatial File Eligibility Criteria in Flood Mitigation Grant Applications https://www.fema.gov/sites/default/files/2020-08/fema_geospatial-eligibility-criteria-flood-mitigation-grant-applications.pdf

Appendix C

Construction Project Cost Estimates

Ocean Drive Drainage Study Cost Estimate

Date: 6/22/2021 **Site 1: E. Beach Drive @ 74th St**

ITEM NO.	ITEM DESCRIPTION	SCHEDULED QUANTITIES	UNIT	UNIT PRICE	TOTAL AMOUNT
1	Mobilization (10% of Total Cost)	1	LS	$17,040.00	$17,040.00
2	Clearing and Grubbing (Including shrub removal)	1	LS	$2,000.00	$2,000.00
3	Furnish and Install Infiltration System (Chambers, 18" Height)	21	EA	$1,000.00	$21,000.00
4	Furnish and Install Infiltration System (Stone with Geotextile)	100	TON	$65.00	$6,500.00
5	Excavate and Remove Soil Excess Material	90	CY	$20.00	$1,800.00
6	Dune Replanting	1	LS	$6,000.00	$6,000.00
7	15" RCP Storm Drain Pipe (Includes Pavement Removal and Replacement where applicable)	160	LF	$110.00	$17,600.00
8	Storm Drain Inlet/Storm Drain Structure @ Inlet to Infiltration System	4	EA	$4,500.00	$18,000.00
9	Permanent Inlet Filter Protection	3	EA	$1,500.00	$4,500.00
10	Pump Station Complete with Wet Well, Control Panel, Pump(s), Check Valve, and Testing	1	LS	$75,000.00	$75,000.00
11	4" PVC Force Main (Includes Pavement Removal and Replacement where applicable)	175	LF	$40.00	$7,000.00
12	Bollards	4	EA	$500.00	$2,000.00
13	Traffic Control	1	LS	$4,000.00	$4,000.00
14	Erosion Control	1	LS	$5,000.00	$5,000.00
				Project Subtotal	$187,440.00
				30% Contingency	$56,232.00

Total Project Cost Estimate = $243,700.00

*Easement and Professional costs are not included within this estimate

Ocean Drive Drainage Study Cost Estimate

Date: 6/22/2021 **Site 2: E. Beach Drive @ 76th St**

ITEM NO.	ITEM DESCRIPTION	SCHEDULED QUANTITIES	UNIT	UNIT PRICE	TOTAL AMOUNT
1	Mobilization (10% of Total Cost)	1	LS	$22,785.00	$22,785.00
2	Clearing and Grubbing (Including shrub removal)	1	LS	$3,000.00	$3,000.00
3	Furnish and Install Infiltration System (Chambers, 18" Height)	36	EA	$1,000.00	$36,000.00
4	Furnish and Install Infiltration System (Stone with Geotextile)	170	TON	$65.00	$11,050.00
5	Excavate and Remove Soil Excess Material	150	CY	$20.00	$3,000.00
6	Dune Replanting	1	LS	$10,000.00	$10,000.00
7	15" RCP Storm Drain Pipe (Includes Pavement Removal and Replacement where applicable)	290	LF	$110.00	$31,900.00
8	Storm Drain Inlet/Storm Drain Structure @ Inlet to Infiltration System	4	EA	$4,500.00	$18,000.00
9	Permanent Inlet Filter Protection	3	EA	$1,500.00	$4,500.00
10	Pump Station Complete with Wet Well, Control Panel, Pump(s), Check Valve, and Testing	1	LS	$90,000.00	$90,000.00
11	6" PVC Force Main (Includes Pavement Removal and Replacement where applicable)	120	LF	$70.00	$8,400.00
12	Bollards	4	EA	$500.00	$2,000.00
13	Traffic Control	1	LS	$4,000.00	$4,000.00
14	Erosion Control	1	LS	$6,000.00	$6,000.00
				Project Subtotal	$250,635.00
				30% Contingency	$75,190.50
				Total Project Cost Estimate =	**$325,800.00**

*Easement and Professional costs are not included within this estimate

Ocean Drive Drainage Study Cost Estimate

Date: 6/22/2021 **Site 3: Ocean Drive @ 79th St**

ITEM NO.	ITEM DESCRIPTION	SCHEDULED QUANTITIES	UNIT	UNIT PRICE	TOTAL AMOUNT
1	Mobilization (10% of Total Cost)	1	LS	$26,235.00	$26,235.00
2	Clearing and Grubbing (Including shrub removal)	1	LS	$4,000.00	$4,000.00
3	Furnish and Install Infiltration System (Chambers, 18" Height)	42	EA	$1,000.00	$42,000.00
4	Furnish and Install Infiltration System (Stone with Geotextile)	190	TON	$65.00	$12,350.00
5	Excavate and Remove Soil Excess Material	170	CY	$20.00	$3,400.00
6	Dune Replanting	1	LS	$12,000.00	$12,000.00
7	15"-18" RCP Storm Drain Pipe (Includes Pavement Removal and Replacement where applicable)	360	LF	$120.00	$43,200.00
8	Storm Drain Inlet/Storm Drain Structure @ Inlet to Infiltration System	6	EA	$4,500.00	$27,000.00
9	Permanent Inlet Filter Protection	5	EA	$1,500.00	$7,500.00
10	Pump Station Complete with Wet Well, Control Panel, Pump(s), Check Valve, and Testing	1	LS	$90,000.00	$90,000.00
11	6" PVC Force Main (Includes Pavement Removal and Replacement where applicable)	70	LF	$70.00	$4,900.00
12	Bollards	4	EA	$500.00	$2,000.00
13	Traffic Control	1	LS	$6,000.00	$6,000.00
14	Erosion Control	1	LS	$8,000.00	$8,000.00
				Project Subtotal	$288,585.00
				30% Contingency	$86,575.50

Total Project Cost Estimate = $375,200.00

*Easement and Professional costs are not included within this estimate

Ocean Drive Drainage Study Cost Estimate

Date: 6/22/2021

Site 4: Ocean Drive @ Barbee Blvd

ITEM NO.	ITEM DESCRIPTION	SCHEDULED QUANTITIES	UNIT	UNIT PRICE	TOTAL AMOUNT
1	Mobilization (10% of Total Cost)	1	LS	$23,860.00	$23,860.00
2	Clearing and Grubbing (Including shrub removal)	1	LS	$2,500.00	$2,500.00
3	Furnish and Install Infiltration System (Chambers, 18" Height)	18	EA	$1,000.00	$18,000.00
4	Furnish and Install Infiltration System (Stone with Geotextile)	80	TON	$65.00	$5,200.00
5	Excavate and Remove Soil Excess Material	70	CY	$20.00	$1,400.00
6	Dune Replanting	1	LS	$8,000.00	$8,000.00
7	15"-18" RCP Storm Drain Pipe (Includes Pavement Removal and Replacement where applicable)	540	LF	$120.00	$64,800.00
8	Storm Drain Inlet/Storm Drain Structure @ Inlet to Infiltration System	5	EA	$4,500.00	$22,500.00
9	Permanent Inlet Filter Protection	4	EA	$1,500.00	$6,000.00
10	Pump Station Complete with Wet Well, Control Panel, Pump(s), Check Valve, and Testing	1	LS	$90,000.00	$90,000.00
11	6" PVC Force Main (Includes Pavement Removal and Replacement where applicable)	60	LF	$70.00	$4,200.00
12	Bollards	4	EA	$500.00	$2,000.00
13	Traffic Control	1	LS	$6,000.00	$6,000.00
14	Erosion Control	1	LS	$8,000.00	$8,000.00
				Project Subtotal	$262,460.00
				30% Contingency	$78,738.00
				Total Project Cost Estimate =	**$341,200.00**

*Easement and Professional costs are not included within this estimate

Ocean Drive Drainage Study Cost Estimate

Date: 6/22/2021 **Site 5: E. Pelican Drive R/W @ 77th**

ITEM NO.	ITEM DESCRIPTION	SCHEDULED QUANTITIES	UNIT	UNIT PRICE	TOTAL AMOUNT
1	Mobilization (10% of Total Cost)	1	LS	$48,020.00	$48,020.00
2	Clearing and Grubbing (Including shrub removal)	1	LS	$6,000.00	$6,000.00
3	Furnish and Install Infiltration System (Chambers, 18" Height)	102	EA	$1,000.00	$102,000.00
4	Furnish and Install Infiltration System (Stone with Geotextile)	420	TON	$65.00	$27,300.00
5	Excavate and Remove Soil Excess Material	380	CY	$20.00	$7,600.00
6	E. Pelican Drive R/W Site Stabilization with Grass	1	LS	$5,000.00	$5,000.00
7	15"-18" RCP Storm Drain Pipe (Includes Pavement Removal and Replacement where applicable)	850	LF	$120.00	$102,000.00
8	Storm Drain Inlet/Storm Drain Structure @ Inlet to Infiltration System	10	EA	$4,500.00	$45,000.00
9	Permanent Inlet Filter Protection	8	EA	$1,500.00	$12,000.00
10	Pump Station Complete with Wet Well, Control Panel, Pump(s), Check Valve, and Testing	1	LS	$100,000.00	$100,000.00
11	6" PVC Force Main (Includes Pavement Removal and Replacement where applicable)	690	LF	$70.00	$48,300.00
12	Bollards	4	EA	$500.00	$2,000.00
13	Traffic Control	1	LS	$8,000.00	$8,000.00
14	Erosion Control	1	LS	$15,000.00	$15,000.00
				Project Subtotal	$528,220.00
				30% Contingency	$158,466.00
				Total Project Cost Estimate =	**$686,700.00**

*Easement and Professional costs are not included within this estimate

Ocean Drive Drainage Study Cost Estimate

Date: 6/22/2021 **Site 6: E. Pelican Drive R/W @ 79th**

ITEM NO.	ITEM DESCRIPTION	SCHEDULED QUANTITIES	UNIT	UNIT PRICE	TOTAL AMOUNT
1	Mobilization (10% of Total Cost)	1	LS	$38,015.00	$38,015.00
2	Clearing and Grubbing (Including shrub removal)	1	LS	$6,000.00	$6,000.00
3	Furnish and Install Infiltration System (Chambers, 18" Height)	90	EA	$1,000.00	$90,000.00
4	Furnish and Install Infiltration System (Stone with Geotextile)	370	TON	$65.00	$24,050.00
5	Excavate and Remove Soil Excess Material	340	CY	$20.00	$6,800.00
6	E. Pelican Drive R/W Site Stabilization with Grass	1	LS	$5,000.00	$5,000.00
7	15"-18" RCP Storm Drain Pipe (Includes Pavement Removal and Replacement where applicable)	385	LF	$120.00	$46,200.00
8	Storm Drain Inlet/Storm Drain Structure @ Inlet to Infiltration System	6	EA	$4,500.00	$27,000.00
9	Permanent Inlet Filter Protection	5	EA	$1,500.00	$7,500.00
10	Pump Station Complete with Wet Well, Control Panel, Pump(s), Check Valve, and Testing	1	LS	$100,000.00	$100,000.00
11	6" PVC Force Main (Includes Pavement Removal and Replacement where applicable)	680	LF	$70.00	$47,600.00
12	Bollards	4	EA	$500.00	$2,000.00
13	Traffic Control	1	LS	$8,000.00	$8,000.00
14	Erosion Control	1	LS	$10,000.00	$10,000.00
				Project Subtotal	$418,165.00
				30% Contingency	$125,449.50
				Total Project Cost Estimate =	**$543,600.00**

*Easement and Professional costs are not included within this estimate

Ocean Drive Drainage Study Cost Estimate

Date: 6/22/2021 **Site 7: Bldg #801 to NCDOT Storm Drainage System**

ITEM NO.	ITEM DESCRIPTION	SCHEDULED QUANTITIES	UNIT	UNIT PRICE	TOTAL AMOUNT
1	Mobilization (10% of Total Cost)	1	LS	$32,860.00	$32,860.00
2	Site Stabilization with Grass	1	LS	$5,000.00	$5,000.00
3	15"-18" RCP Storm Drain Pipe (Includes Pavement Removal and Replacement where applicable)	580	LF	$120.00	$69,600.00
4	Storm Drain Inlet	4	EA	$4,500.00	$18,000.00
5	Permanent Inlet Filter Protection	4	EA	$1,500.00	$6,000.00
6	Pump Station Complete with Wet Well, Control Panel, Pump(s), Check Valve, and Testing	1	LS	$100,000.00	$100,000.00
7	6" PVC Force Main (Includes Pavement Removal and Replacement where applicable)	1,600	LF	$70.00	$112,000.00
8	Traffic Control	1	LS	$8,000.00	$8,000.00
9	Erosion Control	1	LS	$10,000.00	$10,000.00
				Project Subtotal	$361,460.00
				30% Contingency	$108,438.00
				Total Project Cost Estimate =	**$469,900.00**

*Easement and Professional costs are not included within this estimate

Ocean Drive Drainage Study Cost Estimate

Date: 6/22/2021

Site 8: SWRF 5209 E. Yacht Drive

ITEM NO.	ITEM DESCRIPTION	SCHEDULED QUANTITIES	UNIT	UNIT PRICE	TOTAL AMOUNT
1	Mobilization (5% of Total Cost)	1	LS	$100,370.00	$100,370.00
2	R/W Site Stabilization with Grass	1	LS	$15,000.00	$15,000.00
3	15"-18" RCP Storm Drain Pipe (Includes Pavement Removal and Replacement where applicable)	1,800	LF	$120.00	$216,000.00
4	Storm Drain Inlet	17	EA	$4,500.00	$76,500.00
5	Permanent Inlet Filter Protection	17	EA	$1,500.00	$25,500.00
6	Pump Station Complete with Wet Well, Control Panel, Pump(s), Check Valve, and Testing	3	LS	$100,000.00	$300,000.00
7	4" PVC Force Main (Includes Pavement Removal and Replacement where applicable)	450	LF	$40.00	$18,000.00
8	6" PVC Force Main (Includes Pavement Removal and Replacement where applicable)	720	LF	$70.00	$50,400.00
9	10" PVC Force Main (Includes Pavement Removal and Replacement where applicable)	11,000	LF	$110.00	$1,210,000.00
10	Bollards	12	EA	$500.00	$6,000.00
11	Traffic Control	1	LS	$15,000.00	$15,000.00
12	Erosion Control	1	LS	$20,000.00	$20,000.00
13	Clean and Remove Sludge from SWRF (Sludge will be removed using exist. sludge force main)	1	LS	$15,000.00	$15,000.00
14	Decommission SWRF (Remove Excess Piping, Excess Pumps to be removed by Town staff) and Convert to Stormwater Treatment	1	LS	$25,000.00	$25,000.00
15	Fine Screen to filter Stormwater and remove remaining sand/debris particles	1	EA	$15,000.00	$15,000.00
				Project Subtotal	$2,107,770.00
				30% Contingency	$632,331.00
				Total Project Cost Estimate =	**$2,740,100.00**

*Easement and Professional costs are not included within this estimate

Appendix D

Infiltration System and Pump Calculations

<u>Infiltration System Calculations</u>

Example Calculations using Site 1 – E. Beach Drive @ 74th St

Depth to Seasonally High Water Table (SHWT)

The required depth to the SHWT was determined using the following parameters:

$$d_{SHWT} = d_d + d_{DIS} + d_s - m_d$$

Where:
d_{SHWT} = Required depth to the SHWT (ft) per Geotech report
d_d = Depth of cover (sand/soil material) above top of Infiltration System (ft)
d_{DIS} = Depth of the Infiltration System (including chambers and stone layers) (ft)
d_s = Depth of separation between bottom of stone layer and SHWT (ft)
m_d = Depth of raised mound above Depth of existing dune elevation @ low point (ft)

d_d = 1.0 ft
d_{DIS} = 2.5 ft
d_s = 1.0 ft
m_d = 2.5 ft

$$d_{SHWT} = 1.0\,ft + 2.5\,ft + 1.0\,ft - 2.5\,ft = 2.0\,ft$$

For Site 1 to be a feasible option, the depth to SHWT as found in the Geotech Report (Appendix A) must equal or exceed 2.0 feet.

Number of Potential Chambers

The number of potential chambers within the Infiltration System was determined using the following parameters:

$$n = \frac{(L-2)}{L_c} * R$$

Where:
n = number of chambers
L = length of provided area (ft)
L_c = length of chambers (ft)
R = number of rows

It is assumed each chamber is on average 7.75′ feet long. The number of potential rows of chambers factored in a 3.25-foot width for the selected chamber, 1-foot separation between chambers, and a 1-foot border on all sides.

L = 60 ft
L_c = 7.75 ft
R = 3

$$n = \frac{(60\,ft - 2\,ft)}{7.75\,ft} * 3 = 21\ chambers$$

Maximum Infiltration Capacity and Pump Capacity
The maximum infiltration capacity was determined using the following parameters:

$$q_i = \frac{S_a * K}{u}$$

Where:
q_i = maximum infiltration capacity (cfs)
S_a = Surface Area of Infiltration System (sf)
K = Hydraulic Conductivity (in/hr)
u = unit conversion (43,200 $\frac{in*s}{ft*hr}$)

S_a = 900 sf
K = 26.0 in/hr
u = 43,200 $\frac{in*s}{ft*hr}$

$$q_i = \frac{900\,sf * 26\,in/hr}{43{,}200\,\frac{in*s}{ft*hr}} = 0.54\,cfs = 243\,gpm$$

The capacity at which the pump will be utilized is the ratio of the maximum infiltration capacity and pumps capacity.

$$\%\ capacity = \frac{q_i}{q_p}$$

Where:
q_i = maximum infiltration capacity (gpm)
q_p = maximum pump capacity (gpm)

It is assumed the pump will produce flow equivalent to the maximum infiltration capacity. The provided pump capacity has a maximum flow rate of 398 gallons per minute.

q_i = 243 gpm
q_p = 398 gpm

$$\% \, capacity = \frac{243 \, gpm}{398 \, gpm} = 61\%$$

Time to No Ponded Water

The time until there is no water ponded within the road was determined using the following parameters:

$$t = \frac{V}{q_i * u}$$

Where:

t = time (hours)

V = volume of ponded water (cf)

q_i = maximum infiltration capacity (cfs)

u = unit conversion (3600 $\frac{s}{hr}$)

V = 6875 cf

q_i = 0.63 cfs

$$t = \frac{6875 \, cf}{0.54 \, cfs * 3600 \, \frac{s}{hr}} = 3.53 \, hours = 212 \, minutes$$

Project Name:	Ocean Drive Drainage Study
Prepared By:	Jason Sesler
Checked By (PE):	Marc Horstman
Date:	2/11/2021

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Site 1: E. Beach Drive @ 74th St

Site Specifications		
Provided Surface Area (SA)	900	sf
Provided Length	60	ft
Provided Width	15	ft
Depth of Ex. Ground Elev. to SHWT, assumed per Geotech report	2.00	ft
Depth of Mound Height Above Ex. Dune Elev. at low point	2.50	ft
Boring # from Geotechnical Report	N/A	
Hydraulic Conductivity (K) (Estimated, Lowest Value Borings #7-#11)	26.0	in/hr
Max Ponded Street Water Volume	6,875	cf

Ponded Water Stage Storage Calculations				
Elevation	Stage	Area	Volume Inc.	Volume Cu.
ft	ft	sq ft	cf	cf
5	0	12,500	0	
5.5	0.5	15,000	6,875	6,875

SA = DV / (K/12/FS*T)

Infiltration and Pumping System		
Infiltration Rate (Within Infiltration System Surface Area)	0.54	cfs
	243.12	gpm
Pump Capacity	398.00	gpm
% Capacity of Pump	61%	
Chamber Length	7.75	ft
Chamber Width	3.25	ft
Separation between Rows and Perimeter Border Width	1.00	ft
Depth of Cover over Infiltration System	1.00	ft
Depth of Chamber with stone layers (Infiltration System)	2.50	ft
Depth of Separation between bottom of stone layer and SHWT	1.00	ft
Number of Possible Chambers Per Row	7	
Number of Possible Rows	3	
Total Number of Chambers	21	
Storage Volume Provided of Infiltration System (Approximte)	1,000	cf

Design Volume (DV) =	6,875	cu ft
K =	26.00	in/hr
Factor of Safety (FS) =	2	
Max Time Allowed (T) =	72	hrs
Min. Surface Area (SA) =	88	sf
Surface Area Provided =	900	sf
Draw Down Time (Infiltration with FS) =	7.05	hrs

Dune Infiltration System			
Required Surface Area	88	sf	Good
Required Depth	4.5		Good
Provided Depth	4.5		
Time to Pump Street free of Water (Rounded & No Factor Safety)	3.6	hours	
	216	minutes	

Project Name:	Ocean Drive Drainage Study
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Checked By (PE):	Marc Horstman
Date:	2/11/2021

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Site 2: E. Beach Drive @ 76th St

Site Specifications		
Provided Surface Area (SA)	1,540	sf
Provided Length	55	ft
Provided Width	28	ft
Depth of Ex. Ground Elev. to SHWT per Geotech report	2.00	ft
Depth of Mound Height Above Ex. Dune Elev. at low point	2.50	ft
Boring # from Geotechnical Report	7	
Hydraulic Conductivity (K)	26.0	in/hr
Max Ponded Street Water Volume	28,125	cf

Ponded Water Stage Storage Calculations				
Elevation	Stage	Area	Volume Inc.	Volume Cu.
ft	ft	sq ft	cf	cf
5.5	0	35,000	0	
6.25	0.75	40,000	28,125	28,125

$$SA = \frac{DV}{(K/12/FS*T)}$$

Design Volume (DV) =	28,125	cu ft
K =	26.00	in/hr
Factor of Safety (FS) =	2	
Max Time Allowed (T) =	72	hrs
Min. Surface Area (SA) =	361	sf
Surface Area Provided =	1,540	sf
Draw Down Time (Infiltration with FS) =	16.86	hrs

Infiltration and Pumping System		
Infiltration Rate (Within Infiltration System Surface Area)	0.93	cfs
	416.00	gpm
Pump Capacity	590.00	gpm
% Capacity of Pump	71%	
Chamber Length	7.75	ft
Chamber Width	3.25	ft
Separation between Rows and Perimeter Border Width	1.00	ft
Depth of Cover over Infiltration System	1.00	ft
Depth of Chamber with stone layers (Infiltration System)	2.50	ft
Depth of Separation between bottom of stone layer and SHWT	1.00	ft
Number of Possible Chambers Per Row	6	
Number of Possible Rows	6	
Total Number of Chambers	36	
Storage Volume Provided of Infiltration System (Approximte)	1,700	cf

Dune Infiltration System			
Required Surface Area	361	sf	Good
Required Depth	4.5		Good
Provided Depth	4.5		
Time to Pump Street free of Water (Rounded & No Factor Safety)	8.5	hours	
	510	minutes	

Project Name:	Ocean Drive Drainage Study
Prepared By:	Jason Sesler
Checked By (PE):	Marc Horstman
Date:	2/11/2021

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Site 3: Ocean Drive @ 79th St

Site Specifications		
Provided Surface Area (SA)	1,768	sf
Provided Length	52	ft
Provided Width	34	ft
Depth of Ex. Ground Elev. to SHWT per Geotech report	2.00	ft
Depth of Mound Height Above Ex. Dune Elev. at low point	2.50	ft
Boring # from Geotechnical Report	9	
Hydraulic Conductivity (K)	28.3	in/hr
Max Ponded Street Water Volume	31,313	cf

Ponded Water Stage Storage Calculations				
Elevation	Stage	Area	Volume Inc.	Volume Cu.
ft	ft	sq ft	cf	cf
6	0	39,500	0	
6.75	0.75	44,000	31,313	31,313

Infiltration and Pumping System		
Infiltration Rate (Within Infiltration System Surface Area)	1.16	cfs
	519.29	gpm
Pump Capacity	590.00	gpm
% Capacity of Pump	88%	
Chamber Length	7.75	ft
Chamber Width	3.25	ft
Separation between Rows and Perimeter Border Width	1.00	ft
Depth of Cover over Infiltration System	1.00	ft
Depth of Chamber with stone layers (Infiltration System)	2.50	ft
Depth of Separation between bottom of stone layer and SHWT	1.00	ft
Number of Possible Chambers Per Row	6	
Number of Possible Rows	7	
Total Number of Chambers	42	
Storage Volume Provided of Infiltration System (Approximte)	2,000	cf

$$SA = \frac{DV}{(K/12/FS*T)}$$

Design Volume (DV) =	31,313	cu ft
K =	28.27	in/hr
Factor of Safety (FS) =	2	
Max Time Allowed (T) =	72	hrs
Min. Surface Area (SA) =	369	sf
Surface Area Provided =	1,768	sf
Draw Down Time (Infiltration with FS) =	15.04	hrs

Dune Infiltration System			
Required Surface Area	369	sf	Good
Required Depth	4.5		Good
Provided Depth	4.5		
Time to Pump Street free of Water (Rounded & No Factor Safety)	7.6	hours	
	456	minutes	

Project Name:	Ocean Drive Drainage Study
Prepared By:	Jason Sesler
Checked By (PE):	Marc Horstman
Date:	2/11/2021

Site 4: Ocean Drive @ Barbee Blvd

Site Specifications		
Provided Surface Area (SA)	700	sf
Provided Length	50	ft
Provided Width	14	ft
Depth of Ex. Ground Elev. to SHWT per Geotech report	2.50	ft
Depth of Mound Height Above Ex. Dune Elev. at low point	2.00	ft
Boring # from Geotechnical Report	11	
Hydraulic Conductivity (K)	27.8	in/hr
Max Ponded Street Water Volume	13,500	cf

Ponded Water Stage Storage Calculations				
Elevation	Stage	Area	Volume Inc.	Volume Cu.
ft	ft	sq ft	cf	cf
6.5	0	25,000	0	
7	0.5	29,000	13,500	13,500

Infiltration and Pumping System		
Infiltration Rate (Within Infiltration System Surface Area)	0.45	cfs
	202.04	gpm
Pump Capacity	590.00	gpm
% Capacity of Pump	34%	
Chamber Length	7.75	ft
Chamber Width	3.25	ft
Separation between Rows and Perimeter Border Width	1.00	ft
Depth of Cover over Infiltration System	1.00	ft
Depth of Chamber with stone layers (Infiltration System)	2.50	ft
Depth of Separation between bottom of stone layer and SHWT	1.00	ft
Number of Possible Chambers Per Row	6	
Number of Possible Rows	3	
Total Number of Chambers	18	
Storage Volume Provided of Infiltration System (Approximte)	900	cf

$$SA = \frac{DV}{(K/12/FS*T)}$$

Design Volume (DV) =	13,500	cu ft
K =	27.78	in/hr
Factor of Safety (FS) =	2	
Max Time Allowed (T) =	72	hrs
Min. Surface Area (SA) =	162	sf
Surface Area Provided =	700	sf
Draw Down Time (Infiltration with FS) =	16.66	hrs

Dune Infiltration System			
Required Surface Area	162	sf	Good
Required Depth	4.5		Good
Provided Depth	4.5		
Time to Pump Street free of Water (Rounded & No Factor Safety)	8.4	hours	
	504	minutes	

Project Name:	Ocean Drive Drainage Study
Prepared By:	Jason Sesler
Checked By (PE):	Marc Horstman
Date:	2/11/2021

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Site 5: E. Pelican Drive R/W @ 77th

Site Specifications		
Provided Surface Area (SA)	4,020	sf
Provided Length	134	ft
Provided Width	30	ft
Depth of Ex. Ground Elev. to SHWT per Geotech report (Estimated)	2.50	ft
Depth of Prop. Mound Height Above Ex. Elev. at low point	2.00	ft
Boring # from Geotechnical Report	3-4	
Hydraulic Conductivity (K) (Estimated Based upon Boring #3-#4)	12.0	in/hr
Max Ponded Street Water Volume	35,000	cf

Infiltration and Pumping System		
Infiltration Rate (Within Infiltration System Surface Area)	1.12	cfs
	501.19	gpm
Pump Capacity	920.00	gpm
% Capacity of Pump	54%	
Chamber Length	7.75	ft
Chamber Width	3.25	ft
Separation between Rows and Perimeter Border Width	1.00	ft
Depth of Cover over Infiltration System	1.00	ft
Depth of Chamber with stone layers (Infiltration System)	2.50	ft
Depth of Separation between bottom of stone layer and SHWT	1.00	ft
Number of Possible Chambers Per Row	17	
Number of Possible Rows	6	
Total Number of Chambers	102	
Storage Volume Provided of Infiltration System (Approximte)	4,700	cf

Infiltration System			
Required Surface Area	972	sf	Good
Required Depth	4.5		Good
Provided Depth	4.5		
Time to Pump Street free of Water (Rounded & No Factor Safety)	8.8	hours	
	528	minutes	

Ponded Water Stage Storage Calculations				
Elevation	Stage	Area	Volume Inc.	Volume Cu.
ft	ft	sq ft	cf	cf
Ponded Volume from Sites #1-#2				35,000

$$SA = \frac{DV}{(K/12/FS*T)}$$

Design Volume (DV) =	35,000	cu ft
K =	12.00	in/hr
Factor of Safety (FS) =	2	
Max Time Allowed (T) =	72	hrs
Min. Surface Area (SA) =	972	sf
Surface Area Provided =	4,020	sf
Draw Down Time (Infiltration with FS) =	17.41	hrs

Project Name:	Ocean Drive Drainage Study
Prepared By:	Jason Sesler
Checked By (PE):	Marc Horstman
Date:	2/11/2021

Site 6: E. Pelican Drive R/W @ 79th

Site Specifications		
Provided Surface Area (SA)	3,600	sf
Provided Length	120	ft
Provided Width	30	ft
Depth of Ex. Ground Elev. to SHWT per Geotech report	3.50	ft
Depth of Prop. Mound Height Above Ex. Elev. at low point	1.00	ft
Boring # from Geotechnical Report	5-6	
Hydraulic Conductivity (K) (Lowest Value of Boring #5-#6)	14.6	in/hr
Max Ponded Street Water Volume	31,313	cf

Ponded Water Stage Storage Calculations				
Elevation	Stage	Area	Volume Inc.	Volume Cu.
ft	ft	sq ft	cf	cf
Ponded Volume from Site #3				31,313

Infiltration and Pumping System		
Infiltration Rate (Within Infiltration System Surface Area)	1.22	cfs
	546.08	gpm
Pump Capacity	920.00	gpm
% Capacity of Pump	59%	
Chamber Length	7.75	ft
Chamber Width	3.25	ft
Separation between Rows and Perimeter Border Width	1.00	ft
Depth of Cover over Infiltration System	1.00	ft
Depth of Chamber with stone layers (Infiltration System)	2.50	ft
Depth of Separation between bottom of stone layer and SHWT	1.00	ft
Number of Possible Chambers Per Row	15	
Number of Possible Rows	6	
Total Number of Chambers	90	
Storage Volume Provided of Infiltration System (Approximte)	4,200	cf

SA = DV / (K/12/FS*T)

Design Volume (DV) =	31,313	cu ft
K =	14.60	in/hr
Factor of Safety (FS) =	2	
Max Time Allowed (T) =	72	hrs
Min. Surface Area (SA) =	715	sf
Surface Area Provided =	3,600	sf
Draw Down Time (Infiltration with FS) =	14.30	hrs

Infiltration System			
Required Surface Area	715	sf	Good
Required Depth	4.5		Good
Provided Depth	4.5		
Time to Pump Street free of Water (Rounded & No Factor Safety)	7.2	hours	
	432	minutes	

Project Name:	Ocean Drive Drainage Study
Prepared By:	Jason Sesler
Checked By (PE):	Marc Horstman
Date:	2/11/2021

Site 7: Bldg #801 to NCDOT Storm Drainage System

Site Specifications				
Max Ponded Street Water Volume	13,500	cf		
Pumping System				
Pump Rate (Assumed)	500.00	gpm		
	1.11	cfs		
Pump Capacity	610.00	gpm		
% Capacity of Pump	82%			
Time to Pump Street free of Water (Rounded & No Factor Safety)	3.4	hours		
	204	minutes		
Ex. Storm Drain Pipe Capacity (South side of E. Oak Island Drive @ Womble St)				
Ex. Pipe Slope (Assumed)	0.01	ft/ft	1.00	percent
Ex. Pipe Dia.	1.25	feet	15	inches
Ex. Pipe N Value	0.024	CMP		
Ex. Pipe Capacity From Ex. Inlet #1	3.51	cfs		
Ex. Inlet #1 Flow Receives (Approximate)	6.21	cfs	Ex. Pipe Undersized	
Ex. Storm Drain Pipe Capacity (North side of E. Oak Island Drive along Womble St)				
Ex. Pipe Slope (Approximate)	0.005	ft/ft	0.50	percent
Ex. Pipe Dia.	2	feet	24	inches
Ex. Pipe N Value	0.012	HDPE		
Ex. Pipe Capacity From Ex. Inlet #3 to Outlet	17.38	cfs		
Ex. Storm Drain System Flow Receives (Approximate)	149.10	cfs	Ex. Pipe Undersized	

Ponded Water Stage Storage Calculations				
Elevation	Stage	Area	Volume Inc.	Volume Cu.
ft	ft	sq ft	cf	cf
Ponded Volume from Site #4				13,500

Project Name:	Ocean Drive Drainage Study
Prepared By:	Jason Sesler
Checked By (PE):	Marc Horstman
Date:	7/14/2021

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Site 8: Satellite Water Reclamation Facility (SWRF)

Site Specifications		
Max Ponded Street Water Volume Site #4	13,500	cf
Max Ponded Street Water Volume Site #3 & #4	44,813	cf
Max Ponded Street Water Volume Site #1-#4	79,813	cf

Pumping System from Site 4		
Pump Rate (Assumed)	105.00	gpm
	0.23	cfs
Pump Capacity	280.00	gpm
% Capacity of Pump	38%	
Time to Pump Street free of Water (Rounded & No Factor Safety)	16.1	hours
	966	minutes

Pumping System from Site 3 for Site 3 & 4		
Pump Rate (Assumed)	350.00	gpm
	0.78	cfs
Pump Capacity	480.00	gpm
% Capacity of Pump	73%	
Time to Pump Street free of Water (Rounded & No Factor Safety)	16.0	hours
	960	minutes

Pumping System from Site 2 for Site 1-4		
Pump Rate (Assumed)	550.00	gpm
	1.23	cfs
Pump Capacity	720.00	gpm
% Capacity of Pump	76%	
Time to Pump Street free of Water (Rounded & No Factor Safety)	18.1	hours
	1086	minutes

Ponded Water Stage Storage Calculations					
	Elevation	Stage	Area	Volume Inc.	Volume Cu.
	ft	ft	sq ft	cf	cf
Ponded Volume from Site 1					6,875
Ponded Volume from Site 2					28,125
Ponded Volume from Site 3					31,313
Ponded Volume from Site 4					13,500

Total Ponded Volume (Site 1-4)	79,813	cf
	597,100	gallons
Available Storage Volume SWRF (Tanks)	321,900	gallons
Available Storage Volume(Infiltration)/day (Basins)	283,300	gallons
Additional Available Storage (Assumed) Above Normal Pool Elevation (Basins)	201,000	gallons
Total Volume Available	605,200	gallons
Total Volume + Additional Volume Available	806,200	gallons
Anoxic Tank (2 @ 10,500 gallons each)	21,000	gallons
Aeration Tank (2 @ 42,000 gallons each)	84,000	gallons
Membrane Tank (2 @ 5,420 gallons each)	10,840	gallons
Effluent Storage Tank	131,000	gallons
Elevated Storage Tank	75,000	gallons

High Rate Infiltration Basin #1	8.45	gpd/sqft
	0.53	acres
	195,083	gpd
	135.47	gpm
Surface Area:	23,087	sqft
Additional Volume (Assumed, Approx.)	15,468	cf
	115,800	gallons
High Rate Infiltration Basin #2	5.19	gpd/sqft
	0.39	acres
	88,170	gpd
	61.23	gpm
Surface Area:	16,988	sqft
Additional Volume (Assumed, Approx.)	11,382	cf
	85,200	gallons

Appendix E

NCSU Extension Publication

Dune Infiltration Systems for Reducing Stormwater Discharge to Coastal Recreational Beaches

NC STATE EXTENSION

Introduction

Before stormwater was recognized as a major contributor to the transport and delivery of pollutants to surface waters, many coastal towns constructed storm sewer systems that discharged runoff without treatment onto the beach or into the ocean. Untreated stormwater often contains high levels of bacteria, which could place swimmers at risk of illness after a rainfall. An innovative Dune Infiltration System (DIS) has been developed

to help prevent the polluted stormwater from reaching the ocean. The DIS reduces out flows from existing stormwater beach discharge pipes by diverting stormwater beneath the sand dunes. As the stormwater in filtrates into the subsurface sand, bacteria are filtered as they move with groundwater beneath the dunes. Three of these systems have been installed in Kure Beach, NC, and have been highly successful in reducing stormwater discharge to the recreational beach areas. The goal of this factsheet is to introduce this technology to coastal towns that want to reduce the potential impact of stormwater discharge to their beaches.

Compared to most states, coastal water quality in North Carolina is relatively high, ranking fourth in the nation according to the 2012 National Resource Defense Council's Testing the Waters report (NRDC, 2012). But as population and tourism continue to increase near our beaches, new development and increased imperviousness generate more stormwater runoff. Houses, hotels, and parking lots are the primary impervious surfaces associated with coastal development (Figure 1), but new or improved highway and bridge systems that enable residents and tourists to reach these popular destinations also produce runoff.

If you have noticed an exposed pipe on the beach, chances are it was there to discharge stormwater (Figure 2). Stormwater management plans for many coastal towns were developed years ago.

Many towns have existing infrastructure that allows the stormwater to flow into sounds or the ocean through stormwater discharge pipes. These pipes can be numerous and vary in size, depending on the watershed area and land-use characteristics. Pipes that discharge to beaches can be fully exposed or covered with sand during various times of the year.

It has been well documented that stormwater carries pollutants that can be detrimental to the aquatic environment and to human health. This places environmental pressure on our coastal water resources and increases health concerns for people who use these waters for recreational purposes. The main human health concerns come from fecal bacteria that are washed into stormwater systems following storms. Fecal bacteria originating from the intestines of warm-blooded animals (birds, mammals both domesticated and wild, and humans) pose health risks. The NC Recreational Water Quality Program (NC RWQ), which monitors about 240 coastal locations, has shown that after rainfall events, discharge from these pipes often exceeds state and federal bacteria limits considered safe for human contact. Direct human contact with the stormwater or the area that receives the discharge can lead to symptoms of gastrointestinal, respiratory, ear, eye, nose, and skin infections (Griffin et al., 2003). In an effort to protect swimmers, the NC RWQ has an extensive water-quality sampling protocol that allows advisories and alerts to be issued when bacterial limits are exceeded. Beaches commonly have signs posted warning swimmers not to go near these stormwater discharge pipes (Figure 3). Obviously, coastal towns that have frequent advisories could eventually see a downturn in tourism and its associated revenue. Also, despite sign postings and advisories, the warnings are often unheeded (Figure 4), so reducing the frequency of untreated stormwater discharge to beach areas should be a priority.

Figure 1. Development in coastal towns increases stormwater runoff that is often discharged to the ocean.

Figure 2. Stormwater discharge pipes are found in many coastal towns in NC. Note the beach scour that is indicative of out ow from a recent storm event.

Figure 3. A permanent sign warning beachgoers to avoid swimming near this stormwater pipe when it is actively discharging.

Figure 4. Despite warnings, contact with discharging stormwater often still occurs.

A Potential Solution – The Dune Infiltration System

Sand filters have proved to be an effective means to capture bacteria in stormwater (Galli, 1990; Barrett, 2003) and are rated “High” as a stormwater control measure (SCM) for bacteria removal by the North Carolina Division of Water Quality (2007). Many North Carolina beaches have extensive sand dune systems that could be used to filter stormwater in a manner similar to constructed sand filters. Diversion of stormwater from existing pipes and into the dunes was the principle that guided the development of the Dune Infiltration System (DIS).

How does it work?

Before these coastal areas were developed, rainfall easily infiltrated into the sandy soils common to these locations, and portions recharged shallow groundwater. The DIS is designed to recapture this natural process by collecting stormwater runoff and providing an opportunity for infiltration into the sand. To accomplish this, flow from the existing beach discharge pipes is diverted into open-bottomed chambers located beneath the sand dunes. Once it enters the chambers, the stormwater in filtrates into the sand and spreads out laterally beneath the dunes. It mixes with the groundwater, which then moves downslope beneath the surface of the sand towards the ocean. The groundwater mixed with the stormwater then discharges slowly beneath the ocean. Bacteria concentrations in the stormwater are immediately diluted by the groundwater. As it moves with the groundwater, bacteria can then be filtered between particles of sand beneath the surface of the dunes, where they eventually die off due to environmental stresses and predation by other microorganisms (Hathaway and Hunt, 2008). Like other SCMs, it would be impractical to design a DIS large enough to capture all runoff produced from every storm. Therefore, during extremely intense rainfall events, stormwater exceeding the DIS capacity is allowed to bypass the system and discharge to the ocean through the existing discharge pipe.

Is it difficult to design and construct?

The DIS was developed to be a low-cost, low-tech system that could be easily designed by an engineer and implemented by the public works department of any coastal town. Installation of the system is no more difficult than any common stormwater, water distribution, or sewer project that towns frequently construct or repair. The ideal site for the DIS has an elevated dune system with an annual mean water table that is several feet below the surface. Since the system will be located within the dunes (which is in the Ocean Hazard Area of Environmental Concern (AEC)), a Coastal Area Management Act (CAMA) minor development permit must be granted by the NC Division of Environment and Natural Resources Coastal Resources Commission (CRC). This permit must be obtained before the project can begin, and it will authorize the temporary disturbance to the dune system.

A watershed assessment by an engineer must be completed to determine runoff rates that will enter the DIS from a storm of selected rainfall intensity. Since the system relies on in filtration, the ability of the sand to transport water (hydraulic conductivity) must also be determined by direct measurement, or estimated based on local soil survey data. Values should be high, ideally exceeding 50 inches per hour. Darcy's equation (Haan et al., 1994) can then be used as a simple estimate to determine the area required for in filtration for the targeted storm event. The number of chambers required to provide the area needed for in filtration can then be calculated, but this number can vary depending on the manufacturer and type of chamber chosen. More detailed information on design can be found in Bright et al. (2011), Price (2011), and Price et al. (2012).

To divert stormwater from the beach discharge pipe into the chambers, a diversion can be placed either in a vault buried within the dunes or by retrofitting an existing stormwater drop inlet upslope of the dunes. Once diverted, the stormwater is transported to the chambers through a pipe distribution system, appropriately sized and installed at a proper slope to accommodate calculated peak flow rates. Larger pipe sizes are favored to reduce the potential for clogging, and multiple clean-out pipes should be incorporated in the distribution system to facilitate maintenance. To provide an outlet for the bypass flow, existing beach discharge pipes should be left in place and connected to the downstream end of the diversion structure.

Open-bottomed chambers available on the market are generally constructed of high-density polyethylene (HDPE), which makes them sturdy but lightweight (Figure 5). They can be purchased in various sizes and arranged beneath the dunes in a number of ways. Based on our current experience, however, using larger chambers arranged in a linear fashion parallel to the ocean currently appears to be the most efficient method to disperse the stormwater across the dune (Figure 6). Note the diversion, the distribution pipe, and the two banks of chambers installed at a depth of 5 ft in a linear fashion parallel to the beach.

To install the chambers, a trench through the dunes must be excavated down to a target elevation, generally dictated by the elevation of the stormwater beach discharge pipe that enters the dunes. As the trench is dug with a backhoe, a 12-in.-deep layer of gravel is poured into the bottom to provide increased in filtration and system stability. The chambers are then placed on top of the stone layer (Figure 7). After all of the chambers are installed and secured, they are covered with a geotextile fabric to reduce sand intrusion around the top and sides. The chambers are then covered with a minimum of 1.5 ft of sand and replanted with native dune vegetation.

With proper planning, these systems can be installed in about one week by a crew that includes five to eight public works staff and a qualified backhoe operator. January through March is the best time to install these systems because it avoids sea-turtle nesting season (between May and October in North Carolina) and is the low season for tourists. Constructing the system in the late winter also minimizes the time that the disturbed dune areas remain unvegetated, as dune vegetation should be replanted in the spring (Rogers and Nash, 2003). Replanting can be accomplished by the public works crew, by volunteers, or by a local company who specializes in dune restoration.

Figure 5. An example of the type of chamber that can be used for the DIS.

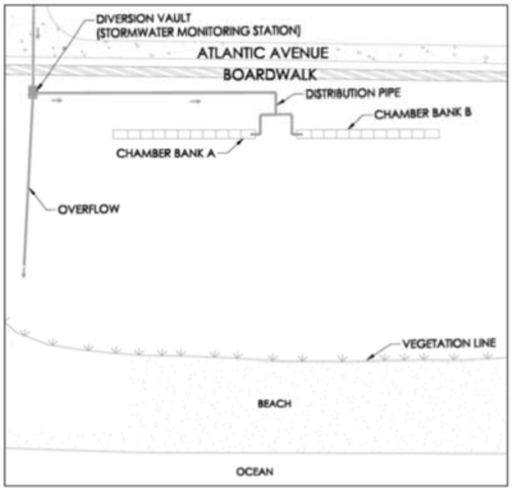

Figure 6. Schematic of DIS installed at L Ave at Kure Beach, NC. Chambers were installed 75 ft upslope of beach/vegetation line and 160 ft from the mean tide line of ocean. Linear distance of dune required for chamber installation at this site was 115 ft.

Figure 7. Installation of a DIS at Kure Beach, NC.

Kure Beach, NC – A Demonstration Study

The Town of Kure Beach was proactive in looking for ways to reduce stormwater entering its beach areas. The town, the NC Department of Transportation, and the NC State University Biological & Agricultural Engineering department began a partnership in 2005 to develop a potential solution, and the result was the Dune Infiltration System. Three DISs have been installed at Kure Beach. The first two, installed in 2006 by the Kure Beach Public Works Department (KBPWD), were located near L and M avenues, and they treated stormwater from two discharge pipes that drained a combined total of 12 acres. Vertical infiltration rates through the sand were measured with a double-ring in filtrometer to be 140 in/hr. (Bright et al., 2011). The systems were designed to in filtrate storms with intensities up to 0.5 in/hr. Each system contained two subsurface independent banks of open-bottomed HDPE chambers (StormChambers, HydroLogic Solutions Inc., Occoquan, Va). Each chamber was 3.5 ft high, 5.0 ft wide, and 8.2 ft long. Site L was constructed with 12 chambers (492 sq. ft. of in filtration area), and Site M had 22 chambers (902 sq. ft. of infiltration area).

Short-term monitoring during the first year of operation indicated that the two systems worked well; they captured and treated about 97 percent of the stormwater generated from 12 acres of watershed and significantly reduced incoming fecal bacteria concentrations through infiltration into the dunes (Bright et al., 2011). But intensified and longer-term data collection and the addition of an experimental control were necessary to verify these initial results before this system could be recommended with confidence for more widespread implementation. The results of three additional years of monitoring (2007-2010) at Site L and M, and one year of monitoring of a third system (Site K – constructed in 2009 also by the KBPWD), are presented in this fact sheet. Findings are summarized in Figure 8 and Table 1.

The DIS installations at sites L and M demonstrated a 100 percent and 96 percent stormwater capture rating during the three-year period, consistent with results observed during the first year of operation (Table 1). This meant nearly all of the runoff generated from these two watersheds was treated in the DISs and not discharged directly to the ocean.

Enterococci were used as an indicator of the presence of fecal bacteria in stormwater and groundwater samples. This is the same indicator used by the NC RWQ in its beach sampling protocol. In general, these bacteria are not hazardous to humans, but their presence has been correlated with the existence of potentially hazardous organisms (Myers et al., 2007). Using fecal indictor bacteria like enterococci also negates the need to test for multiple organisms that may be present in samples. Results are reported in Most Probable Number (MPN) per 100 mL of sample.

Fecal bacteria in the stormwater exceeded North Carolina's single sample maximum for enterococci (104 MPN/100 mL) in more than 70 percent of samples collected. Median concentrations that entered the systems at sites L and M were 185 and 435 MPN/100 mL, respectively. On occasion, concentrations in the stormwater were greater than 1000 MPN/100 mL (Figure 8), but high enterococci values are also common at other locations and are not unique to the Kure Beach site.

More than 200 groundwater samples were collected from wells installed in the dunes downslope from the DISs at sites L and M. More than 120 groundwater samples were collected from a control dune (where no DIS was installed) to compare groundwater quality in areas with and without a DIS. Fecal bacteria concentrations in the groundwater beneath the dunes, which received in filtrated stormwater after it owed into the DISs, were low (5 MPN/100 mL) and similar to those measured in the control dunes at the dune-beach interface (Table 1). Occasional spikes in bacteria concentrations were observed near the DIS, but spikes were also noted in the control, suggesting that some fecal bacteria may be entering the groundwater from other sources. Water table elevations beneath the systems rose as expected following in filtration events, but they returned to pre-storm levels within a few hours to several days. Because water table impacts were temporary, no major differences were observed between the mean groundwater elevation beneath the DISs and in the control dunes that received no direct stormwater input. In addition, the dune elevations did not show any impact from the stormwater in filtration and remained stable. Vegetation that was donated from a nursery at nearby Carolina Beach and planted by volunteers and a public works crew thrived on each site (Figure 9).

The performance observed at sites L and M was far better than expected, suggesting the systems may have been larger than required. A third DIS was designed to test how it treated stormwater from a larger, more impervious watershed that generated a larger fecal bacteria load. Located at K Avenue in Kure Beach, near the downtown area and pier, the Site K system was larger than the two previously installed DISs (26 chambers to capture rainfall events with intensities < 0.5 in/ hr) and was placed deeper in the dunes (and closer to the normal water table) because of the elevations of the existing storm sewer infrastructure. This system collected runoff from three outfalls, near a location that had occasionally received swimming advisories from NC RWQ for high enterococci concentrations.

In the year following construction, the system at Site K achieved an 80 percent stormwater capture rating (Table 1). Stormwater entered this system at a greater volume, was more frequently contaminated with excessive fecal bacteria (94 percent of the samples exceeded 104 MPN/100 mL enterococci), and had a much higher median value of enterococci (977 MPN/100 mL) than at sites L and M (Figure 8). This was attributed to the more urban watershed that drained to the system.

Table 1. Hydrologic and bacteria removal performance of the three Dune Infiltration Systems operating in Kure Beach, NC.

	SITE L	SITE M	SITE K	CONTROL DUNES
Year Installed	2006	2006	2009	—
Watershed Area (acres)	4.2	8.1	8.3	—
Number of Stormwater Discharge Pipes	1	1	3	—
Number of Chambers	12	22	26	—
Infiltration Area (ft^2)	492	902	1066	
DIS Invert Elevation (ft)[1]	9.4	11.4	7.5	—
Total Stormwater Flow (ft^3)	132,642	398,855	934,212	—
Total Overflow (ft^3)	0	15,468	185,756	—
Stormwater Treated (ft^3)	132,642	382,387	748,459	—
% Stormwater Capured	100%	96%	80%	—
Median (Max) Groundwater Enterococci Concentration (MPN/100mL)	185 (89,680)	435 (3,076)	977 (24,196)	—
Median (Max) Groundwater Enterococci Concentration All Wells (MPN/100 mL)	4 (945)	5 (3,063)	16 (4,839)	5 (429)
Median (Max) Groundwater Concentration at Dune/Beach Interface (MPN/100mL)	4 (271)	5 (3,064)	7 (177)	5 (254)

NOTE: Site L, Site M, and control data collected from 2008 to 2010. Site K data collected from 2009 to 2010.

[1] Feet above mean sea level referenced to NGVD88 vertical datum.

More than 130 samples were collected from the groundwater surrounding the Site K DIS, and together they had a relatively low median enterococci concentration of 16 MPN/100 mL. It was noted that near the chambers of the DIS (where in filtration occurred), the geometric mean of the groundwater enterococci (62 MPN/100 mL) was significantly higher than at the same location in the control dunes. However, it appeared that these concentrations effectively decreased as the water moved laterally beneath the dunes, because concentrations of enterococci in the groundwater at the dune-beach interface (7 MPN/100 mL) were similar compared to the control dunes. Water table elevations did not appear to be impacted for long periods of time, and mean elevations were similar to those observed in the control dunes. Because the system was installed deeper in the dunes, the water table rose to the invert elevation of the infiltration chambers more frequently at Site K. However, the total impact to the system was only 33 hours during the first year and did not appear to have a detrimental effect on the performance and stability of the system. As was observed in the older systems at sites L and M, the dune structure remained stable, and vegetation was reestablished on the dunes within the first growing season following construction (Figure 10).

Construction costs associated with these DIS demonstration sites were low in comparison to many other SCMs. It cost $22,000 to install both the systems at sites L and M to treat runoff from 12 acres, or about $1,800 per acre. The system at Site K was more expensive ($24,000 or $2,900 per acre) because it was larger (to treat runoff from a more impervious 8.3 acre watershed) and required additional construction costs to accommodate multiple stormwater discharge pipes. These costs include materials (stone, chambers, pipes, etc.) and backhoe operation, but do not include engineering design or labor costs associated with the Kure Beach public works staff. In addition, the chambers were provided to the demonstration study at a reduced cost. Improved cost estimates will be provided in the future as more of these systems are constructed.

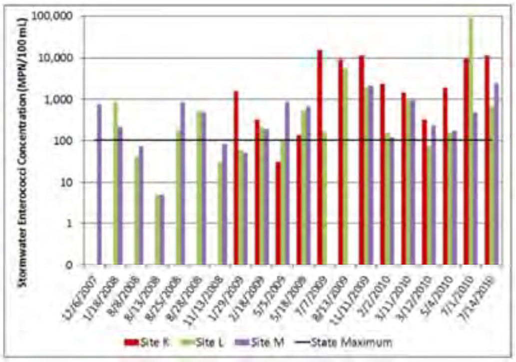

Figure 8. Concentrations of the fecal bacteria indicator enterococci in stormwater samples entering the DISs at Kure Beach. Values indicated on the y-axis are on a logarithmic scale. Samples from the K avenue site were available beginning in 2009.

Figure 9. Replanted vegetation on the dunes will quickly reestablish following installation of a DIS.

Figure 10. View from the Kure Beach Pier of the dunes where the K Avenue DIS was installed. Note the vegetation reestablishment on the landward side of the dune fence. Also in view are signs indicating the location of the over ow discharge pipes.

Figure 11. Sign describing project.

Summary

Based on these results, Dune Infiltration Systems are a successful, low-cost, and low-tech solution for diminishing stormwater discharge and associated fecal bacteria loads to recreational beaches. During our study, all stormwater flow associated with Site L's watershed was captured and treated by the DIS. Stormwater flows at Site M were reduced by 96 percent and by 80 percent at Site K. Overall, each system performed better than or as expected in reducing untreated stormwater discharge onto the beach. Indicator bacteria concentrations were reduced by 98 percent between the influent stormwater and the groundwater at the dune-beach interface. Median groundwater enterococci concentrations were similar at the dune-beach interface to those measured beneath a control dune that did not have a DIS. Removal of bacteria from the infiltrated stormwater was thought to be due to adsorption and entrapment around sand particles, followed by natural die-off, desiccation, and predation by other microbes.

These systems appear to have no negative effects on dune stability or groundwater systems when used to treat runoff from smaller watersheds (<10-15 acres). They can also provide excellent opportunities for environmental outreach in these high-visibility areas, and coastal towns that incorporate these systems may receive positive media coverage that boosts tourism.

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Additional Resources

- A Sandy Solution – NC State University College of Agriculture and Life Sciences Perspectives Magazine 2007
- A Buried Treasure – NC State University Results Magazine – Winter 2011
- NC Recreational Water Quality (NCRWQ) Program - find out more about sites sampled around North Carolina, how sampling occurs, and how to avoid illnesses when swimming in natural bodies of water.
- NCRWQ Stormwater Drainpipe Signage Factsheet
- National Resource Defense Council Testing the Waters 2012 Report
- National Resource Defense Council Testing the Waters 2011 Report – North Carolina (references the Dune Infiltration System)
- Dune planting guidance – The Dune Book by Spencer Rogers and David Nash (2003)
- Information on Sea Turtle Nesting Season – US Fish and Wildlife Service
- NC State University - Stormwater website

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Appendix F

Site Photos

Typical Dune Elevation/Configuration Example

Photo 1: View of Typical Dune configuration looking North-East.

Photo 2: View of Typical Dune configuration looking North-East.

Sites 1-2: 74^{th} St. and 76^{th} St @ E. Beach Drive

Photo 3: Site 1 @ 74^{th} St. View of potential site looking South-West.

Photo 4: Site 2 @ 76^{th} St. View of potential site looking South.

Sites 3-4: 79th St. and Barbee Blvd @ Ocean Drive

Photo 5: Site 3 @ 79th St. View of potential site looking North-East.

Photo 6: Site 4 @ Barbee Blvd. View of potential site looking South-West.

Sites 5 & 7: E. Pelican Drive R/W and Bldg #801

Photo 7: Site 5 @ E. Pelican Drive R/W and 77th St. View of potential site looking East.

Photo 8: Site 7 @ Bldg # 801 @ Womble St. View of site looking South-East.

Site 7: NCDOT Storm Drain System along Womble St.

Photo 9: Ex. Inlet @ E. Oak Island Drive and Womble St. View looking North-West.

Photo 10: Ex. Outlet @ Womble St. and Elizabeth Dr. View looking North-East.

Site 8: Satellite Water Reclamation Facility (SWRF)

Photo 11: Pumps and Piping inside SWRF.

Photo 12: Membrane tank inside SWRF.

Site 8: High-Rate Infiltration System

Photo 13: Ex. Infiltration Basin @ golf course for reclaimed water from SWRF.

Photo 14: Ex. Infiltration Basin @ golf course for reclaimed water from SWRF.

Examples of Ponding Stormwater

Photo 15: Site 2 area @ 76th St. and E. Beach Drive. View of ponding looking South-East.

Photo 16: Site 3 area @ 79th St. and Ocean Drive. View of ponding looking South-East.

Examples of Ponding Stormwater

Photo 17: Site 3 area @ Crowell St. and Ocean Dr. View of ponding looking North-West.

Photo 18: Site 4 area @ Barbee Blvd. and Ocean Dr. View of ponding looking North-West.