NORTH CAROLINA
Environmental Quality

ROY COOPER
Governor
MICHAEL S. REGAN
Secretary
BRAXTON C. DAVIS
Director

CRC-19-33

October 29, 2019

MEMORANDUM

TO: Coastal Resources Commission
FROM: Mike Lopazanski
SUBJECT: Consideration of Public Comment & Adoption of 15A NCAC 7H .0309 – Extension of Ocean Stormwater Outfalls

In response to a request from the Town of Nags, first the CRAC and then the Commission began consideration of rulemaking related to the extension of existing ocean outfalls in conjunction with a beach nourishment project. Under existing rules, ocean outfalls are considered development and are not authorized as exceptions to rules prohibiting development seaward of the applicable setback or first line of stable and natural vegetation. However, existing outfalls (26 structures) are currently "grandfathered," having been installed prior to subsequent limitations on oceanfront development under your rules. While grandfathered, the rules do not allow for extension of existing outfalls since any expansion is also considered new development and requires a variance to be issued by the Commission, as has been done in the past. This creates a hardship and potential public safety hazard when beaches are widened through beach nourishment. During discussions with the CRAC, it was suggested that there be an allowance for lengthening and shortening of existing outfall pipes within authorized dimensions, including routine maintenance and repairs due to weather exposure or storm damage.

NCDOT, the Division of Water Resources and Shellfish Sanitation's Recreational Water Quality program were consulted on this issue and all were supportive of providing local governments with the ability to extend existing outfalls without requiring a Commission variance. Shellfish Sanitation specifically reported that if the outfalls could not be removed, extending them further past the swimming zone would be a public health benefit.

Under the proposed amendments, requests for extensions will be reviewed through the CAMA Major Permitting process by the appropriate state and federal agencies. Once a permit is approved, NCDOT or the local government may extend or shorten the outfall within the permitted dimensions without the need for a new permit application each time. The proposed amendments will:

- Authorize shortening or lengthening outfall structures within the authorized dimensions will be considered maintenance under 15A NCAC 07K .0103.
- Allow extension of outfalls below mean low water
- Shortening or lengthening outfall structures within authorized dimensions, in response to changes in beach width, as a maintenance activity.
- Prohibit outfall extensions that prevent pedestrian or vehicular access along the beach.
- Only apply to existing stormwater outfalls that are owned or maintained a state agency or local government.

The public comment period ran from July 17 to September 18, 2019 with public hearings held on September 17th and 18th. The Division received one objection from the NC Coastal Federation (attached) due to concerns that stormwater runoff degrades water quality, causes health problems, and that dune infiltration systems could be designed and implemented by the public works department of coastal towns. An existing dune stormwater infiltration system in the Town of Kure Beach was cited as an example of an innovative design. The NC Coastal Federation further stated that while extension of outfalls might be the only practical alternative due to site specific conditions, the Commission should encourage local agencies to "consider all practical alternatives before simply allowing pipes to be extended in length;" "encourage through its permit process that the applicants install the best environmental alternative while taking into account its cost-effectiveness;" "retrofit the existing outfalls with the goal of protecting and improving coastal water quality;" and "keep the public agencies and private landowners at the same standard rather than setting a lower bar for the agencies by allowing them to move the outfalls farther into the ocean."

The Coastal Federation proposed specific alternative rule language as follows:
"(h) Existing stormwater outfalls within the Ocean Hazard AEC that are owned and maintained by a State or local government agency, may be modified subject to the provisions contained within 15A NCAC O7J.0200, as well as applicable state and federal water quality requirements. The applicant shall identify practical alternatives of modifications it has considered and demonstrate that it has selected an alternative that best protects water quality as well as public health and safety. Alternatives that shall be considered include upstream watershed retrofits that reduce the volume of stormwater being discharged
by the outfall, dune and beach infiltration systems, and/or extending the length of the outfall."

The Kure Beach infiltration system project referenced the Nc Coastal Federation required the Town to obtain a variance from the Commission, as the proposed work was inconsistent with the oceanfront setback and static line. The Division supported the Town's petition and the Commission granted the variance in 2008. Given the support of the Division of Water Resources, NC DOT and Shellfish Sanitation for the currently proposed amendments and that the Division will continue to be supportive of local initiatives to address alternatives strategies for existing outfalls, Staff recommend adoption of the proposed amendments. The proposed effective date of this amendment is February 1, 2020.

PROPOSED AMENDMENT TO 15A NCAC 7H .0309 - OCEAN STORMWATER OUTFALLS

15A NCAC 07H .0309 USE STANDARDS FOR OCEAN HAZARD AREAS: EXCEPTIONS

(a) The following types of development shall be permitted seaward of the oceanfront setback requirements of Rule .0306(a) of ~~the Subchapter~~ this Section if all other provisions of this Subchapter and other state and local regulations are met:

(1) campsites;
(2) driveways and parking areas with clay, packed sand or gravel;
(3) elevated decks not exceeding a footprint of 500 square feet;
(4) beach accessways consistent with Rule .0308(c) of this ~~Subchapter;~~ Section;
(5) unenclosed, uninhabitable gazebos with a footprint of 200 square feet or less;
(6) uninhabitable, single-story storage sheds with a foundation or floor consisting of wood, clay, packed sand or gravel, and a footprint of 200 square feet or less;
(7) temporary amusement stands;
(8) sand fences; and
(9) swimming pools.

In all cases, this development shall be permitted only if it is landward of the vegetation line or static vegetation line, whichever is applicable; involves no alteration or removal of primary or frontal dunes which would compromise the integrity of the dune as a protective landform or the dune vegetation; has overwalks to protect any existing dunes; is not essential to the continued existence or use of an associated principal development; is not required to satisfy minimum requirements of local zoning, subdivision or health regulations; and meets all other non-setback requirements of this Subchapter.

(b) Where application of the oceanfront setback requirements of Rule .0306(a) of this ~~Subchapter~~ Section would preclude placement of permanent substantial structures on lots existing as of June 1, 1979, buildings shall be permitted seaward of the applicable setback line in ocean erodible areas, but not inlet hazard areas or unvegetated beach areas, if each of the following conditions are met:

(1) The development is set back from the ocean the maximum feasible distance possible on the existing lot and the development is designed to minimize encroachment into the setback area;
(2) The development is at least 60 feet landward of the vegetation line or static vegetation line, whichever is applicable;
(3) The development is not located on or in front of a frontal dune, but is entirely behind the landward toe of the frontal dune;
(4) The development incorporates each of the following design standards, which are in addition to those required by Rule .0308(d) of this ~~Subchapter.~~ Section.
    (A) All pilings shall have a tip penetration that extends to at least four feet below mean sea level;
    (B) The footprint of the structure shall be no more than 1,000 square feet, and the total floor area of the structure shall be no more than 2,000 square feet. For the purpose of this Section, roof-covered decks and porches that are structurally attached shall be included in the calculation of footprint;
    (C) Driveways and parking areas shall be constructed of clay, packed sand or gravel except in those cases where the development does not abut the ocean and is located landward of a paved public street or highway currently in use. In those cases concrete, asphalt or turfstone may also be used;
    (D) No portion of a building's total floor area, including elevated portions that are cantilevered, knee braced or otherwise extended beyond the support of pilings or footings, may extend oceanward of the total floor area of the landward-most adjacent building. When the geometry or orientation of a lot precludes the placement of a building in line with the landward most adjacent structure of similar use, an average line of construction shall be determined by the Division of Coastal Management on a case-by-case basis in order to determine an ocean hazard setback that is landward of the vegetation line, static vegetation line or measurement line, whichever is applicable, a distance no less than 60 feet.
(5) All other provisions of this Subchapter and other state and local regulations are met. If the development is to be serviced by an on-site waste disposal system, a copy of a valid permit for such a system shall be submitted as part of the CAMA permit application.

(c) Reconfiguration and development of lots and projects that have a grandfather status under Paragraph (b) of this Rule shall be allowed provided that the following conditions are met:

(1) Development is setback from the first line of stable natural vegetation a distance no less than that required by the applicable exception;

(2) Reconfiguration shall not result in an increase in the number of buildable lots within the Ocean Hazard AEC or have other adverse environmental consequences.

For the purposes of this Rule, an existing lot is a lot or tract of land which, as of June 1, 1979, is specifically described in a recorded plat and which cannot be enlarged by combining the lot or tract of land with a contiguous lot(s) or tract(s) of land under the same ownership. The footprint is defined as the greatest exterior dimensions of the structure, including covered decks, porches, and stairways, when extended to ground level.

(d) The following types of water dependent development shall be permitted seaward of the oceanfront setback requirements of Rule .0306(a) of this Section if all other provisions of this Subchapter and other state and local regulations are met:

(1) piers providing public access; and

(2) maintenance and replacement of existing state-owned bridges and causeways and accessways to such bridges.

(e) Replacement or construction of a pier house associated with an ocean pier shall be permitted if each of the following conditions is met:

(1) The ocean pier provides public access for fishing and other recreational purposes whether on a commercial, public, or nonprofit basis;

(2) Commercial, non-water dependent uses of the ocean pier and associated pier house shall be limited to restaurants and retail services. Residential uses, lodging, and parking areas shall be prohibited;

(3) The pier house shall be limited to a maximum of two stories;

(4) A new pier house shall not exceed a footprint of 5,000 square feet and shall be located landward of mean high water;

(5) A replacement pier house may be rebuilt not to exceed its most recent footprint or a footprint of 5,000 square feet, whichever is larger;

(6) The pier house shall be rebuilt to comply with all other provisions of this Subchapter; and

(7) If the pier has been destroyed or rendered unusable, replacement or expansion of the associated pier house shall be permitted only if the pier is being replaced and returned to its original function.

(f) In addition to the development authorized under Paragraph (d) of this Rule, small scale, non-essential development that does not induce further growth in the Ocean Hazard Area, such as the construction of single family piers and small scale erosion control measures that do not interfere with natural oceanfront processes, shall be permitted on those non-oceanfront portions of shoreline that exhibit features characteristic of an Estuarine Shoreline. Such features include the presence of wetland vegetation, and lower wave energy and erosion rates than in the adjoining Ocean Erodible Area. Such development shall be permitted under the standards set out in Rule .0208 of this Subchapter. For the purpose of this Rule, small scale is defined as those projects which are eligible for authorization under 15A NCAC 07H .1100, .1200 and 07K .0203.

(g) Transmission lines necessary to transmit electricity from an offshore energy-producing facility may be permitted provided that each of the following conditions is met:

(1) The transmission lines are buried under the ocean beach, nearshore area, and primary and frontal dunes, all as defined in Rule ~~07H .0305,~~ .0305 of this Section, in such a manner so as to ensure that the placement of the transmission lines involves no alteration or removal of the primary or frontal dunes; and

(2) The design and placement of the transmission lines shall be performed in a manner so as not to endanger the public or the public's use of the beach.

(h) Existing stormwater outfalls within the Ocean Hazard AEC that are owned or maintained by a State agency or local government, may be extended oceanward subject to the provisions contained within 15A NCAC 07J .0200. Outfalls may be extended below mean low water, and may be maintained in accordance with 15A NCAC 07K .0103. Shortening or lengthening of outfall structures within the authorized dimensions, in response to changes in beach width, is considered maintenance under 15A NCAC 07K .0103. Outfall extensions may be marked with signage, and shall not prevent pedestrian or vehicular access along the beach. This Paragraph does not apply to existing stormwater outfalls that are not owned or maintained by a State agency or local government.

History Note: *Authority G.S. 113A-107(a); 113A-107(b); 113A-113(b)(6)a; 113A-113(b)(6)b; 113A-113(b)(6)d; 113A-124;*
Eff. February 2, 1981;

Amended Eff. June 1, 2010; February 1, 2006; September 17, 2002 pursuant to S.L. 2002-116; August 1, 2000; August 1, 1998; April 1, 1996; April 1, 1995; February 1, 1993; January 1, 1991; April 1, 1987.

September 16, 2019

Dr. Braxton Davis
400 Commerce Avenue
Morehead City, NC 28557
Email: Braxton.Davis@ncdenr.org

RE: 15 NCAC 07H.0309 (h) Use Standards For Ocean Hazard Areas: Exceptions

Dear Dr. Davis,

On behalf of the North Carolina Coastal Federation, please accept the following comments on the proposed oceanward extension of existing stormwater outfalls within Ocean Hazard Areas of Environmental Concern.

The Coastal Federation is a non-profit organization dedicated to protecting and restoring the North Carolina coast. Our organization represents 16,000 supporters statewide and works with the public, state and federal agencies and local governments to communicate and collaborate towards solutions that lead to the stewardship and resiliency of our coast. Since 1982, the federation has been working with coastal communities and other partners to protect and restore coastal water quality and natural habitats, which are intricately tied to our coastal economy. By focusing primarily, but not exclusively on natural and productive estuarine shorelines, oyster and salt marsh habitat restoration, coastal management and cleaning the estuaries of marine debris, we strive to support and enhance the coastal natural environment. In doing so, we continue to promote stronger and more resilient coastal communities.

The Coastal Resources Commission (CRC) proposes to allow local and state governments to extend existing stormwater outfalls seaward if beaches are widened and move polluted stormwater further offshore. This may be the only practical option at some existing ocean outfalls due to site specific conditions. However, in many locations dune infiltration systems are a practical and environmentally-preferable alternative. This method helps to reduce beach swimming advisories that are inconsistent with the requirements of the federal Clean Water Act.

The federation encourages the CRC to:

- Require consideration of all practical alternatives before simply allowing pipes to be extended in length;
- Encourage through its permit process that the applicants install the best environmental alternative while taking into account its cost-effectiveness;
- Work with state and local agencies so as they serve as a role model:
    - Retrofit the existing outfalls with the goal of protecting and improving coastal water quality.

- Keep the public agencies and private landowners at the same standard rather than setting a lower bar for the agencies by allowing them to move the outfalls farther into the ocean.

The Stormwater Runoff Degrades Water Quality and Causes Public Health Problems
Stormwater runoff has been recognized as the major source of pollution of coastal waters. It contains high levels of bacteria that pose environmental and public health risk. Increased urban sprawl and residential and commercial development have created a pathway for the stormwater to reach our state's waters. This land use change increased the surface of impervious cover conveniently acting as transport and delivery method for pollutants contained in the stormwater runoff.

North Carolina holds an enviable fifth place in the nation for its good beach water quality.[1] However, increased storm activity and rapid urbanization of surrounding landscapes could change this status. Climate change is increasing extreme storm events that carry catastrophic amounts of rainfall. Recent study that looked at data since 1898 found that six of the seven highest precipitation events in coastal North Carolina in that record have occurred within the last 20 years.[2] In addition, the state's population has almost doubled since the 1990 reaching around 10.3 million residents according to 2018 U.S. Census Data. The resulting urbanization is expected to continue for the foreseeable future.

Stormwater management in coastal towns was developed decades ago and is in dire need of upgrading. The federation applauds the CRC for taking steps to remove stormwater outfalls from the beaches. However, we believe that extending the outfalls farther into the ocean will only compound rather than solve the problems caused by stormwater. Pushing the bacteria-laden stormwater deeper into the ocean can have unintended negative consequences to aquatic environment and can pose wider human health risks. Therefore, the federation urges the CRC to investigate the feasibility of implementing Dune Infiltration Systems as a solution to removing stormwater outfalls from recreational beaches.

Dune Infiltration Systems are Cost-Effective and Successful
Dune Infiltration Systems are an innovative method that prevents stormwater from reaching the ocean. They divert the runoff from stormwater pipes beneath the dunes allowing the stormwater to infiltrate through the sand. Beneath the dunes the stormwater is captured into an open-bottom chamber. From there the stormwater slowly infiltrates into sand and spreads out laterally reaching the groundwater. When mixed with groundwater the bacteria concentrations are diluted posing no threat to groundwater quality.

This nature-mimicking process has been proven successful and cost-effective. According to the N.C. State University Dune Infiltration Systems are low-cost systems that could be easily designed by an engineer and implemented by the public works department of a coastal town.[3]

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[1] Natural Resource Defense Council. Testing the waters 2014: A guide to water quality at vacation beaches. https://www.nrdc.org/resources/testing-waters-2014-guide-water-quality-vacation-beaches
[2] Paerl, H. W., Hall, N. S., Hounshell, A. G., Luettich, R. A., Rossignol, K. L., Osburn, C. L., & Bales, J. (2019). Recent increase in catastrophic tropical cyclone flooding in coastal North Carolina, USA: Long-term observations suggest a regime shift. *Scientific reports*, *9*(1), 10620.
[3] N.C. State Extension. Dune Infiltration Systems for Reducing Stormwater Discharge to Coastal Recreational Beaches. https://content.ces.ncsu.edu/dune-infiltration-systems-for-reducing-stormwater-discharge-to-coastal-recreational-beaches

Kure Beach in North Carolina is a case in point. The town has installed three Dune Infiltration Systems. Three-year monitoring of the sites showed that the systems captured 80 – 100 percent stormwater runoff (Figure 1). In addition, monitoring also showed that there was no significant increase in indicator bacteria usually associated with stormwater in the groundwater around the infiltration sites.[4] The total cost for the three systems was $46,000 for a treatment of around 20 acres, or an average of $2,300 per acre.[5]

	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.

Figure 1: Hydrologic and bacteria removal performance of the three Dune Infiltration Systems operating in Kure Beach, NC. Source: Dune Infiltration Systems for Reducing Stormwater Discharge to Coastal Recreational Beaches, N.C. State Extension.

The town of Kure Beach is so impressed by the performance of its existing dune infiltration systems that it is currently working to retrofit six additional ocean outfalls located on the beach. The recent feasibility study (attached to this letter) shows that this alternative is cost-effective, practical, and would result in significant water quality improvements.

The ocean outfalls rule change that the CRC is currently considering should encourage this type of progressive thinking. Rather than relaxing the permitting rules for outfalls extension, the CRC should allow easier and more straightforward permit process for the installation of dune infiltration systems and similar nature-based approaches.

[4] Ibid.
[5] Ibid.

Stormwater Outfalls Extensions Can Be Much More Expensive Than Dune Infiltration
Myrtle Beach, South Carolina has extended beach stormwater outfalls into the ocean. However, the unfinished project carries a staggering price. Each outfall runs 1200 ft into the ocean and costs between $6 and $20 million.[6] Since 2000 the town has spent over $50 million to install four outfall extensions.[7] The town officials expect the 12 new outfalls to take 35 additional years to fund and construct for a price of $150 million.[8]

Recommendation
The currently proposed rule revision will discourage the application of better, cost-effective environmentally-preferable alternatives. Therefore, the federation recommends the following proposed rule change language:

(h) Existing stormwater outfalls within the Ocean Hazard AEC that are owned and maintained by a State or local government agency, may be modified subject to the provisions contained within 15A NCAC O7J .0200, as well as applicable state and federal water quality requirements. The applicant shall identify practical alternatives of modifications it has considered, and demonstrate that it has selected an alternative that best protects water quality as well as public health and safety. Alternatives that shall be considered include upstream watershed retrofits that reduce the volume of stormwater being discharged by the outfall, dune and beach infiltration systems, and/or extending the length of the outfall.

Conclusion
Eliminating stormwater drainage from public recreational beaches is a daunting yet necessary step for protecting public health and aquatic marine environment, and enhancing water quality. The CRC has an opportunity to incite a better environmental response and propel the state and local governments to a position of a role model. Novel, cost-effective and successful technique, such as Dune Infiltration System is available and, unless proven unfeasible, should be a required technique for stormwater outfall removal.

Thank you for taking our comments under consideration.

Sincerely,

Ana Zivanovic-Nenadovic
Senior Policy Analyst

[6] The Municipal, 2018. Myrtle Beach banishes flooding with deepwater ocean outfalls. http://www.themunicipal.com/2018/09/myrtle-beach-banishes-flooding-with-deepwater-ocean-outfalls/
[7] Ibid.
[8] Stormwater Report. 2018. South Carolina Municipalities find success with site-specific stormwater management plans. https://stormwater.wef.org/2018/01/south-carolina-municipalities-find-success-site-specific-stormwater-management-plans/

FINAL REPORT
NOT FOR CONSTUCTION
PLANNING DOCUMENT ONLY

SOLUTIONS FOR A CHANGING WORLD

NORTH CAROLINA
PROFESSIONAL
SEAL
038624
ENGINEER
JONATHAN D. HINKLE

2019-06-12

DocuSigned by:
Jonathan Hinkle
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TOWN OF KURE BEACH
STORMWATER INFILTRATION FEASIBILITY STUDY FOR
CLEAN WATER MANAGEMENT TRUST FUND PLANNING GRANT

NANCY AVERY | TOWN CLERK
KURE BEACH TOWN HALL, 117 SETTLERS LANE, KURE BEACH, NC 28449 | N.AVERY@TOKB.ORG

Contents

LDSI, Inc prepared this report for:

Town of Kure Beach

Partners

North Carolina Coastal Federation
www.nccoast.org

North Carolina State University
Biological & Agricultural Engineering Department
www.bae.ncsu.edu

Cover photo Davis Road outfall taken January 2019.

1. Executive Summary

LDSI, Inc assisted the Town of Kure Beach with a Clean Water Management Trust Fund Planning Grant which analyzed the feasibility of installing stormwater infiltration at the following outfalls:

- E – Avenue (no outfall the team switched to the Davis Road Outfall)
- F – Avenue
- G – Avenue
- H – Avenue
- I – Avenue
- J – Avenue

The project tasks included:

- Identify feasibility of stormwater infiltration system installation at alternative locations, such as between the dunes and the end of the beach access parking areas,
- Develop a typical infiltration system schematic,
- Develop a monitoring plan,
- Develop cost opinions for installation of the infiltration systems,
- Compile a list of funding sources.

Photo 1: Davis Road Stormwater Outfall During Discharge Event

The design team consisted of LDSI as the lead designer, with consulting assistance from the NCSU Biological and Agricultural Engineering Department, NC DOT Hydraulics Engineering Division, and the NC Coastal Federation. The team analyzed site conditions, soils data, topographic information, water quality data, ground water data, and recommended alternatives at each site. LDSI will prepare preliminary designs and cost estimates for each site. All six outfall locations were analyzed and deemed feasible for installation of stormwater infiltration system. As explained below within the multi-criteria design matrix, some of the sites are more feasible than others. The highest ranking and targeted outfall selected by the team was located at G-Avenue. It is the expectation that the Town will use the feasibility study to determine whether to pursue one or more of the sites and pursue funding for the final design and construction of the infiltration systems. LDSI and the other partners on the project would like to draw attention that this is a feasibility study only; further analysis is needed prior to the development of construction documents.

2. Background and Purpose

2.1 Introduction

Photo 2: Showing location of underground storm drain.

LDSI, Inc was contracted by the Town of Kure Beach to perform a feasibility analysis on six (6) of their stormwater outfalls. It should be noted that the figures and values within this report are to a feasibility study level and more analysis needs to be done during the design phase of this project. This phase intends to provide an assessment of the physical parameters at each of the six outfalls and the feasibility to infiltration the stormwater similar to what was done at L, M, and K. The team plans to expand on the results that were achieved at the previously installed outfalls and the results reported within the ASCE technical paper *Feasibility of a Dune Infiltration System to Protect North Carolina Beaches From Fecal Bacteria Contaminated Stormwater*.

> *Storm water ocean outfalls discharging into recreational waters pose a human health threat because of increased potential exposure to bacteria and other pathogens. The dune infiltration system (DIS) was designed and implemented at two ocean outfall sites in response to concerns by the North Carolina Department of Transportation and the town of Kure Beach, North Carolina The systems were designed to divert storm water runoff from 1.9 ha (4.7 acre) and 3.2 ha (8.0 acre) watersheds into the beach dunes. Following construction, data were collected from 25 storms during March through October 2006. The systems captured a combined total of nearly 1;800 m3 (63;500 ft3), or 95% of the influent storm water runoff—a significant reduction of runoff volume and peak flow discharging directly onto the beach ($p < 0{:}0001$). Fecal coliform and enterococci concentrations were measured in the inflowing storm water runoff and groundwater downslope of the systems. Both groundwater bacteria concentrations near the systems were significantly lower than the bacteria concentrations in the inflowing storm water ($p < 0{:}001$). Furthermore, groundwater fecal coliform concentrations after implementing the DISs were statistically similar to preconstruction levels ($p < 0{:}05$). The initial results are promising, and the system should be considered for more widespread use. However, further comprehensive research is recommended to more thoroughly understand the viability of the DIS as a stormwater best management practice and the fate and transport of the bacteria within the dunes. (T. Bright, M. Burchell, W. Hunt, and W. Price)*

Photo 3: Erosion from overflow area after Hurricane Florence

2.2 Purpose and Need

Tourism, beach and swimming activities along the Atlantic Ocean are the mainstays of Kure Beach as a recreation destination and are integral to the town's economic health. According to the State of North Carolina, 600,000 tourists visited Kure Beach between March and November of 2014. The population of New Hanover County, including Kure Beach, is projected to double by 2025; this will bring increased tourism and development. These factors will lead to increased potential for bacterial contaminants and other stormwater pollutants to enter the recreational beach areas following a rain event. For instance, on 9.29.2016, NCDEQ issued a swimming alert for two Kure Beach locations south of the Avenue K pier. Water quality officials found bacteria levels in the ocean water that exceeded the state's and EPA recreational water quality standards. According to the press release, officials believed that the stormwater runoff from heavy rainfall, as well as extreme tidal conditions, contributed to the high bacteria counts. With increased population, climate change, and aging infrastructure, it is imperative that Kure Beach and other coastal towns work to divert bacterial pollutants from the beach and the Atlantic Ocean.

2.3 Goals and Objectives

The goal is to reduce the frequency and duration that stormwater with high levels of bacteria enters the recreational beach area, thus protecting Kure Beach's greatest environmental and economic asset – recreational beach areas along the Atlantic Ocean. The installation of stormwater infiltration systems is proven to:

- Reduce stormwater discharge.
- Reduce bacteria discharged.
- Reduce the potential of human contact with polluted stormwater runoff.
- Complement existing stormwater infrastructure.

Photo 4: NC DOT signage at completed dune infiltration system at K – Avenue.
(Photo courtesy of Town of Kure Beach.)

Having already shown to be successful at L, M, & K Avenues the goal of the infiltration project is to analyze the expansion of the footprint of these success stories.

3. Water Quality Analysis

A small number of water quality samples were collected from 1) the Kure Beach stormwater system to provide a snapshot of bacteria concentrations currently discharged from the outfalls and compare that to 2) the groundwater surrounding the three existing dune infiltration systems (DISs). Samples were collected and transported on ice to Environmental Chemists, Inc. in Wilmington N.C. While this provided some valuable information of the quality of the stormwater and a glimpse of how the existing DISs continue to perform, a much more rigorous sampling regime similar to what was used in our previous studies and described in Price et al. (2013) and Burchell et al. (2013) would be required to make more defensible comparisons.

Enterococcus indicator bacteria concentrations in the stormwater sampled was above the NC single sample maximum threshold of 104 MPN/100mL for recreational contact waters at K avenue that drains to one of the existing DISs, and was even higher at J Avenue and I Avenue that drains to two of the outfalls targeted for new systems in this study. These values are similar to those obtained during continuous pre- and post-construction stormwater sampling as part of the original DIS study (Price et al., 2013; Burchell et al., 2013). Note, the flow at M avenue is continuous from infiltration from an unknown source with low bacteria content.

Location	Enterococcus (MPN/100mL)		
	4/11/2019	4/11/2019	5/9/2019
M Ave	2	13	3
K Ave	30	291	----
J Ave	>2420	>2420	>2420
I Ave	----	1120	----

Table 1: Enterococcus concentrations measured in surface water in the stormwater system leading to outfalls at M avenue, K avenue, J avenue, and I Avenue.

Groundwater samples were collected from original wells used to determine the performance of the original DISs. Samples were collected just down slope of the systems to intercept the groundwater moving toward the ocean (- MID locations, Table 2). Wells located 25 m down slope of the systems (-25 locations, Table 2) were at the dune/beach interface. Unfortunately, many had been destroyed during beach erosion and were not sampled. Samples were collected using sterile disposable bailers.

With one exception, (M-25 on 5/9/2019), groundwater *Enterococcus* values were below the recreational water quality contact standard. Although these values were just a snapshot of groundwater bacterial concentrations, they were similar to those obtained in our original more rigorous study. These are the values we would expect to see surrounding new systems that could be installed at Kure Beach.

Location	Enterococcus (MPN/100mL)	
	4/11/2019	5/9/2019
K-MID	36*	5.5*
K-25	4	29.5
L-MID	1*	1*
L-25	----	----
M-MID	1.5*	8.5*
M-25	5*	192*
Control-MID	1	3
Control-25	----	----

*Table 2 Enterococcus concentrations measured in groundwater at (-MID) and 25 m downslope (-25) of the existing dune infiltration systems at K avenue, L Avenue, M avenue, and within the Control dunes. Note * indicates the average of two wells sampled.*

4. Hydrology Modeling

LDSI analyzed all watersheds to the various outfalls utilizing GIS, stormwater inventory, LiDAR, and zoning information. The team utilized the Department of Environmental Quality (DEQ) approved "Simple Method" to size the volume of infiltration basins.

$$Design\ Volume = 3{,}630\ x\ R_D\ x\ R_V x\ A$$

$$R_D = Design\ Storm\ Depth\ (in) = 1\ inch\ for\ this\ project$$

$$A = Watershed\ Area\ (acres)$$

$$R_V\ \big(Runoff\ coefficient\ (unitless)\big) = 0.05 + 0.9\ x\ I_A$$

$$I_A = Impervious\ Fraction\ (unitless)$$

The following table summarizes the findings of the hydrology modeling.

Outfall Location	Area (Acres)	Design Volume (CuFt)
Davis Road	8.1	17,348
F – Avenue	8.6	18,419
G – Avenue	2.6	5,568
H – Avenue	7.8	16,705
I – Avenue	6.8	14,564
J – Avenue	8.3	17,776

Table 3: Summary of Hydrology Modeling

Groundwater elevations beneath the dune are a critical component to determine whether infiltration systems are a feasible option at Kure Beach and other locations. Based on the proximity to the other locations, the team felt that the data from the K Avenue site would be sufficient to provide reference information for the other locations for the feasibility study. Figure 1 shows hourly water table elevations from upslope and downslope of the K avenue DIS during February-May 2019. Two locations were monitored to 1) show the general slope of groundwater flow at this location from the bulkhead that protects Atlantic Avenue (Figure 1 – Blue line) and just downslope of the DIS (Figure 1, Green Line), and 2) determine the average elevation of the groundwater at this location in the dunes as a proxy to where the new infiltration systems will be installed.

Monitoring does show a slight a gradient of groundwater flow towards the ocean, as indicated by the higher elevation of the groundwater near the bulkhead compared to the groundwater near the DIS. Also evident, is the increased tidal influence of the groundwater near the DIS, which is closer to the ocean. This tidal fluctuation slows the groundwater flow through the dunes, and during infiltration events, increases residence time and improves water quality treatment potential.

Mean groundwater elevations in the mid dunes was 2.6 feet above MSL, with a maximum depth of 6 feet following an infiltration event, and a minimum level of 1.3 ft. These values are consistent to prior monitoring at the site.

The higher above the mean water table the system is installed, the more efficient it will be in infiltrating stormwater and removing bacteria. However, the invert of the existing stormwater pipe entering the dunes drives the elevation of where the system can be installed. The Site K DIS was installed with an invert elevation of 7.5 feet above MSL, which for this site allowed for 4.5 – 5 feet of sand beneath the dunes for infiltration. While Kure Beach has high dune elevations and low water table elevations within the dunes to accommodate infiltration systems, the feasibility for infiltration future systems at Kure Beach will be strongly tied to the invert elevations of the stormwater pipes at each location evaluated.

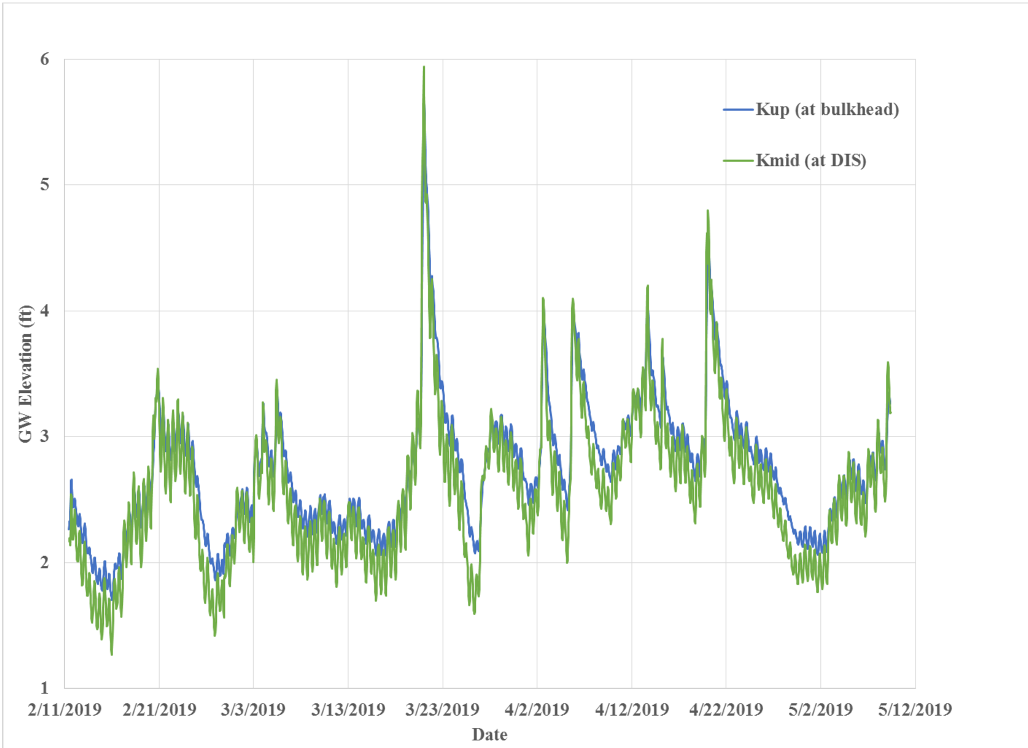

Figure 1: Groundwater elevations around the existing DIS at K avenue, to be used as a guide for conditions expected in the dunes at other locations in Kure Beach under consideration for new infiltration systems

5. Hydraulic Modeling & Sizing of Infiltration Systems

Photo 5: By-pass structure within existing infrastructure.

The LDSI team utilized a continuous simulation model to analyze the impacts of the installation of a dune infiltration system at the various outfalls. These simulations included a study period of 1995 to 2005. The simulations are based on one-hour steady state snapshots throughout the time period. The team utilized these modeling efforts to size the systems and check the effects on the existing infrastructure.

It should be noted that the sixth parameter as shown in Table 5 *Summary of Decision Matrix*, "Depth of Pipe at Dune" is the depth of the existing stormwater system. The base of the infiltration systems was modeled at 3.5 FT to 4.5 FT (NAVD), this is to allow drainage from the existing system into the infiltration system. The groundwater during the modeled period had an average elevation of approximately 2.6 FT (NAVD), providing a separation between the system of approximately one foot. Based on analysis there are periods of time that groundwater would be within the infiltration system and other times that the separation between the system and groundwater exceeds the modeled one foot. The team would like to draw attention that additional modeling would be required during the design phase as this was ground water extrapolated from monitoring data conducted by NCSU at the K – Avenue monitoring site, site specific data will be required during the design of each site.

Outfall	Area Available	# of Hours Analyzed	# of Hours with Infiltration	% of Time with Infiltration	# of Hours in By-pass	% of Time in Bypass
Davis Road	0.04	96,335	12,301	13%	238	0.25%
F – Avenue	0.09	96,335	10,818	11%	237	0.25%
G – Avenue	0.03	96,335	8,759	9%	22	0.02%
H – Avenue	0.05	96,335	10,838	11%	297	0.31%
I – Avenue	0.05	96,335	11,017	11%	165	0.17%
J – Avenue	0.08	96,335	10,991	11%	235	0.24%

Table 4: Summary of Continuous Modeling Efforts

The team analyzed not only the proposed infiltration system, but the affect the system would have on the existing stormwater infrastructure. The freeboard at Fort Fisher Blvd. was used as a control when evaluating the system, with the limited area for infiltration and watershed characteristics a by-pass box will be necessary at each outfall. The sizing of a by-pass weir at each outfall is dependent these parameters and necessary to minimize flooding potential on Fort Fisher Blvd. as well as ensure the infiltration area is not overloaded. All of the outfalls were analyzed with by-pass weirs in order to ensure capacity during large storm events for the safety of Fort Fisher Blvd. After discussion with NCSU, LDSI developed a concept of being able to manage the height of this weir which would allow for maintenance as well as ensure that there are no determents to the integrity of the dunes. Therefore, within the weir inside of the by-pass box there will be a series of flashboard riser style adjustments that can be made in order to allow for this management and maintenance.

6. Multi-Criteria Decision Matrix

Following the analysis and sizing, the team developed a decision matrix to analyze the project against themselves in order to prioritize funding/priorities.

Multi-Criteria Decision

	Davis	F Avenue	G Avenue	H Avenue	I Avenue	J Avenue	Multiplier
Watershed Size	8.1	8.6	2.6	7.8	6.8	8.3	5
Area Required/Available for Infiltration	0.04	0.09	0.03	0.05	0.05	0.08	11
Hours to Infiltrate the Design Storm	83.9	33.4	32.3	54.7	46.0	37.8	9
Percent of time with Infiltration	12.8%	11.2%	9.1%	11.3%	11.4%	11.4%	3
Percent of time with By-Pass	0.2%	0.2%	0.0%	0.3%	0.2%	0.2%	10
Depth of Ex Pipe at Dune (FT)	3.7	6.0	6.5	7.6	7.8	6.2	8
Depth of Ex Pipe to Groundwater (assume GW@ 2 MSL) (FT)	3.9	5.0	5.1	3.9	3.8	5.1	2
Depth of Pipe Below Fort Fisher BLVD	7.1	6.2	6.4	6.3	6.9	6.8	1
Percent of Storms By-Passed	4.0%	4.0%	0.4%	5.0%	2.8%	4.0%	4
Freeboard at Fort Fisher Blvd	0.76	0.48	5.68	0.09	1.90	1.45	6
Project Cost (PLANNING LEVEL)	$ 83,480.59	$143,996.17	$84,965.50	$102,814.90	$104,241.24	$148,788.18	7
Ranking	**4**	**6**	**1**	**3**	**2**	**5**	

****All values are based on 1-hour rainfall and continuous simulation model with a data range from 1995 to 2005**

Table 5: Summary of Decision Matrix

Note: Depth of Pipe at Dune is the depth of the existing pipe infrastructure below the average dune surface, depth to groundwater is the depth of the existing pipe infrastructure to the GW assumed at 2 MSL.

As shown by several of the ranking questions the importance of being able to be implemented within the existing infrastructure were key components within the evaluation. The G – Avenue outfall ranked first within the matrix due to the watershed size, the existing topography characteristics, as well as depth of existing infrastructure.

7. Monitoring Plan

Conditions at each of the site locations we evaluated were somewhat different than the original sites. Most notably, the first row of houses in these locations are not separated from the dunes like they were by Atlantic Avenue at sites K, L, and M avenue. Additionally, the infiltration systems will likely be installed lower in the dunes, closer to the groundwater, than at the original sites, because the elevations of the existing stormwater pipes entering the dunes are lower. Therefore, post-construction monitoring of these sites will remain an important component of these projects.

As at the previous sites, continuous stormwater flow monitoring during the first year in the diversion chambers will be important to check our watershed runoff models, and provide estimates of the amount of runoff treated and the percentage of time overflow events occurred. This type of monitoring was used in our previous work to show that 97% of the stormwater from the watersheds that drained to L and M, and 80% of the stormwater that drained to K, was captured in the DIS. Storm event Enterococcus sampling of water entering the system should also be employed to determine runoff characteristics, and could be used for source tracking.

Groundwater monitoring wells equipped with continuous water level dataloggers will be critical since the system will be installed deeper and the beachfront properties are not as isolated as at the previous sites. A transect of 3-4 wells perpendicular to each new system installed will provide the data needed to evaluate how the groundwater responds, particularly closest to the beachfront houses, following infiltration events. We have investigated the potential of use of real-time water level measurements like those employed by USGS to remotely observe changes in groundwater during rainfall events. If adjustable weirs are employed in the diversion boxes, this type of data could allow the Town to make real-time decisions to divert water away from the infiltration systems in the unlikely event that groundwater levels are too high.

8. Funding Opportunities

There are several potential funding options for implementing the Town's stormwater outfall infiltration projects. Some of these are included in the table below.

Name	Funding Cycle	Application Deadline(s)
North Carolina's Clean Water Management Trust Fund (CWMTF)	1 – per year	Early February
EPA Section 319 Grant Program	1 – per year	Early May
Water Resource Development Grant	2 – per year	Late June, Late December
Clean Water State Revolving Fund (CWSRF) Loan	NA	NA
Stormwater Utility Fee	NA	NA

Table 6 Summary of funding opportunities.

The following sources were utilized for this list of funding opportunities: The Environmental Finance Center at the University of North Carolina, Chapel Hill Methods and Strategies for Financing Green Infrastructure, and Individual web sites from funding sources.

8.1 NC's Clean Water Management Trust Fund (CWMTF)

Overview: This funding source was established by the General Assembly in 1996 as a non-regulatory organization with a focus on protecting and restoring the State's land and water resources. Grants are awarded to non-profit and governmental organizations to protect land for natural, historical and cultural benefit, limit encroachment on military installations, restore degraded streams, and develop and improve stormwater treatment technology.

According to the Environmental Finance Center at the University of North Carolina, Chapel Hill the available resources for this program are greatly reduced and can no longer fund conventional stormwater or wastewater projects but this makes the fund a good opportunity for green infrastructure projects like the dune infiltration systems.

Award Decision Range: Annual award ranges vary with the total funding statewide at approximately 25 million. Innovative stormwater projects are generally awarded less than acquisition projects.

Cycles: CWMTF has one grant cycle per year. The application form is available in early December through the Online Grants Management System. For example, the application deadline for 2019 was February 4th, and final award decisions will be made in the fall of 2019.

Information: https://cwmtf.nc.gov/

8.2 EPA Section 319 Grant Program

Overview: Through Section 319(h) of the Clean Water Act, the U.S. Environmental Protection Agency provides states with funding to reduce nonpoint source pollution. Funds may be used to conduct watershed restoration projects such as stormwater and agricultural best management practices and restoration of impaired streams. Section 319 grant projects must be used to help restore waterbodies currently impaired by nonpoint source pollution in areas with approved watershed restoration plans. It is recommended that the Town of Kure Beach consider development of a watershed restoration plan to become eligible for the Section 319 funding.

Award Decision Range: North Carolina typically receives around $1 million for competitive funding of watershed restoration projects

Cycles: Late January: Request for Proposals released, Early May: 319 Grant Application deadline, Early June: Applicants notified whether they will be invited for in-person interviews, Late June: Notified applicants interviewed in Raleigh; selected projects announced, January of following year: Projects may start (estimated, depending on grant award date to NCDEQ and time for contract preparation)

Information: https://deq.nc.gov/about/divisions/water-resources/water-planning/nonpoint-source-planning/319-grant-program/recent-319

8.3 Water Resource Development Grant

Overview: This grant program provides cost-share grants and technical assistance to local governments. Applications for grants are accepted for seven eligible project types: general navigation, recreational navigation, water management, stream restoration, water-based recreation, Natural Resources Conservation Service Environmental Quality Incentives Program (EQIP) stream restoration projects and feasibility/engineering studies. The non-navigation projects are collectively referred to as state and local projects.

Award Decision: Range $10,000 ~ $200,000

Cycles: There are two grant application cycles per fiscal year for state and local projects. The current spring 2019 grant cycle began Jan.1 and applications are due by June 30. The second cycle is from July 1 – December 31.

Contact: Amin Davis amin.davis@ncdenr.gov

Information:
https://files.nc.gov/ncdeq/Water%20Resources/documents/WRDG%20WSN%20New%20Bern%20102317_A%20Davis.pdf

8.4 Clean Water State Revolving Fund (CWSRF) Loan

The North Carolina State Water Infrastructure Authority (SWIA) overseas a number of water and wastewater loan and grant programs including the joint state/federal (EPA) funded Clean Water State Revolving Fund (CWSRF). According to the UNC Environmental Finance Center report entitled Methods and Strategies for Financing Green Infrastructure, local governments can obtain loans at rates as low as 0% for 20 years to fund eligible projects including stormwater projects.

8.5 Stormwater Utility Fee

Under North Carolina law, stormwater fees can be used to cover a wide range of stormwater quality and quantity programs. Kure Beach currently implements a stormwater utility fee.

9. Conclusion and Recommendations

LDSI evaluated the all six (6) outfalls and deemed them feasible for the installation of an infiltration system. The recommendation is for the Town to seek funding for installation and design of all six. It is the belief of LDSI that the installation of these systems will add to the resiliency of the Town and improve water quality for its residents, tourists, and aquatic species within the area. During the design of each outfall infiltration system it is highly recommended that the following occur:

- Installation of monitoring wells at each planned dune location,
- A groundwater hydrology be conducted to estimate impact of design,
- Soils analysis,
- Monitoring of installed system,
- Re-evaluation of infrastructure following hurricane events.

The summary of planning-level cost information and estimated design cost is shown below.

Outfall Location	Design Costs	Construction Costs
Davis Street	$20,870	$83,480
F - Avenue	$35,999	$143,996
G - Avenue	$21,241	$84,965
H - Avenue	$25,703	$102,814
I - Avenue	$26,060	$104,241
J - Avenue	$37,197	$148,788
Total	**$167,072**	**$668,287**

Table 7: Summary of Future Costs

FEASIBILITY STUDY

FOR

KURE BEACH DUNE INFILTRATION

PREPARED BY

LDSI, INC,

NORTH CAROLINA COASTAL FEDERATION, &

NORTH CAROLINA STATE UNIVERSITY BIOLOGICAL AND AGRICULTURAL ENGINEERING

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NORTH CAROLINA STATE UNIVERSITY
BIOLOGICAL AND AGRICULTURAL ENGINEERING
MICHAEL BURCHELL, PhD, PE
CAMPUS BOX 7625
RALEIGH, NC 27695-7625
Ph: 919.513.7348
MIKE_BURCHELL@NCSU.EDU

PROPERTY LOCATION
POC: 34° 45' 41.4"N"; LONG: 78° 43' 32.3"W.
BLADEN COUNTY, NORTH CAROLINA

North Carolina Coastal Federation

NEWPORT OFFICE: 3609 HWY 24
NEWPORT, NC 28570
PH: 252.393.8185
WEBSITE: WWW.NCCOAST.ORG

CHARLOTTE OFFICE: 508 WEST 5TH ST., SUITE 125,
CHARLOTTE NC 28202
KINSTON OFFICE: 804 FAIRFIELD AVE.,
KINSTON NC 28504
PHONE: 704.337.8329 | FAX: 704.308.3153
WEBSITE: WWW.LDSI-INC.COM | NC FIRM #: C-1925

NC STATE UNIVERSITY

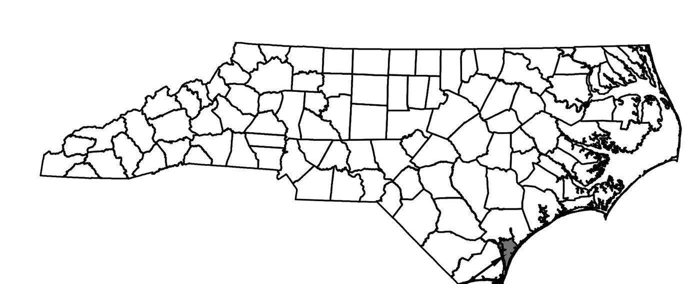
BAE DEPARTMENT: CAMPUS BOX 7625
RALEIGH, NC 27695-7625
PH: 919.513.7348
WEBSITE: WWW.BAE.NCSU.EDU

VICINITY MAP
NTS.

PROJECT DESCRIPTION:

THE TEAM CONSISTS OF LDSI AS THE LEAD DESIGNER; WITH CONSULTING ASSISTANCE FROM THE NCSU BIOLOGICAL AND AGRICULTURAL ENGINEERING DEPARTMENT; NC DOT HYDRAULICS ENGINEERING DIVISION, AND THE NC COASTAL FEDERATION. LDSI HAS WORKED WITH NORTH CAROLINA COASTAL FEDERATION ON NUMEROUS PROJECTS AND IS PLEASED TO PARTNER ON THIS PROJECT. LDSI'S PROJECT MANAGER HAS ALSO WORKED WITH NCSU'S BIOLOGICAL AND AGRICULTURAL ENGINEERING STAFF IN THE PAST. THE TEAM WILL ANALYZE SITE CONDITIONS, SOILS DATA, AND TOPOGRAPHIC INFORMATION AND MAKE RECOMMENDATIONS FOR PRACTICABLE ALTERNATIVES AT EACH SITE, AND LDSI WILL PREPARE PRELIMINARY DESIGNS AND COST ESTIMATES FOR EACH SITE.

North Carolina 811 www.nc811.org



LOCATION MAP
NTS.

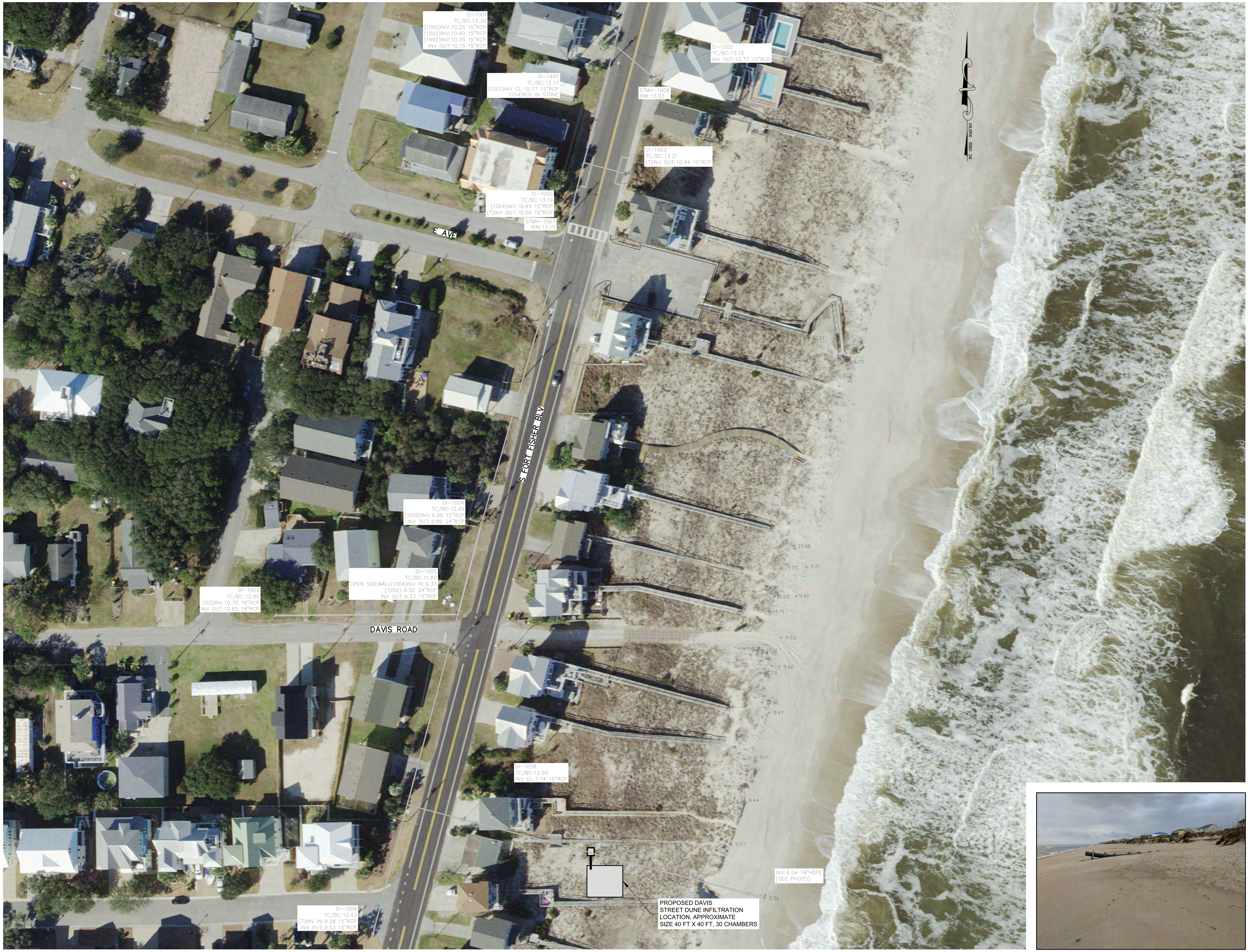
ISSUED FOR: ISSUE FOR 95% REVIEW & PLANNING

No.	DATE	DESCRIPTION	BY	APVD
		NOT FOR CONSTRUCTION		

DSGN: JDH | DR: JDH | CHK: DBB | APVD: JDH | DATE: 5/31/2019

KURE BEACH DUNE INFILTRATION FEASIBILITY STUDY CWMTF PLANNING GRANT

PROJECT #: 4518040



Vicinity Map - Not to Scale

Point Legend:

Symbol	Abbr	Description
SW	STMH	Storm Water Manhole
	CI	Curb Inlet
	DI	Drop Inlet

Line Legend:

Symbol	Description
	Road Centerline
	Storm Pipe

NOT FOR CONSTRUCTION

ISSUED FOR: PRELIMINARY REVIEW

Clean Water Management Trust Fund [CWMTF] Dune Infiltration Exhibit

prepared for:

Town of Kure Beach

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1			##/##/##
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Text Scale: 1"=40

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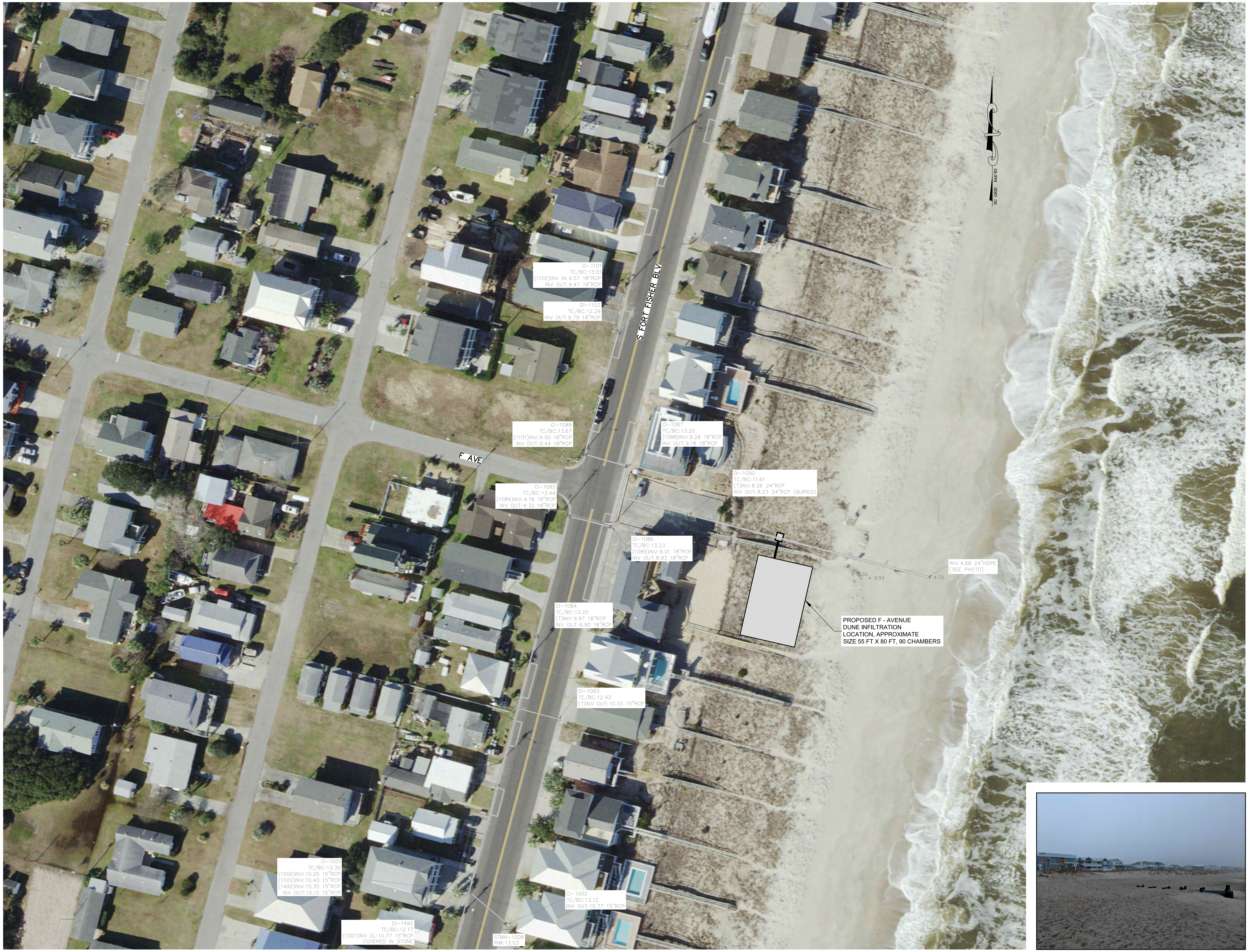
Project Number: 4518040
Drawn By: JDH
Reviewed By:
Sealed By:

Plot Date: 2019-05-31

Sheet 1 of 7



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	CI	Curb Inlet
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Line Legend:

Symbol	Description
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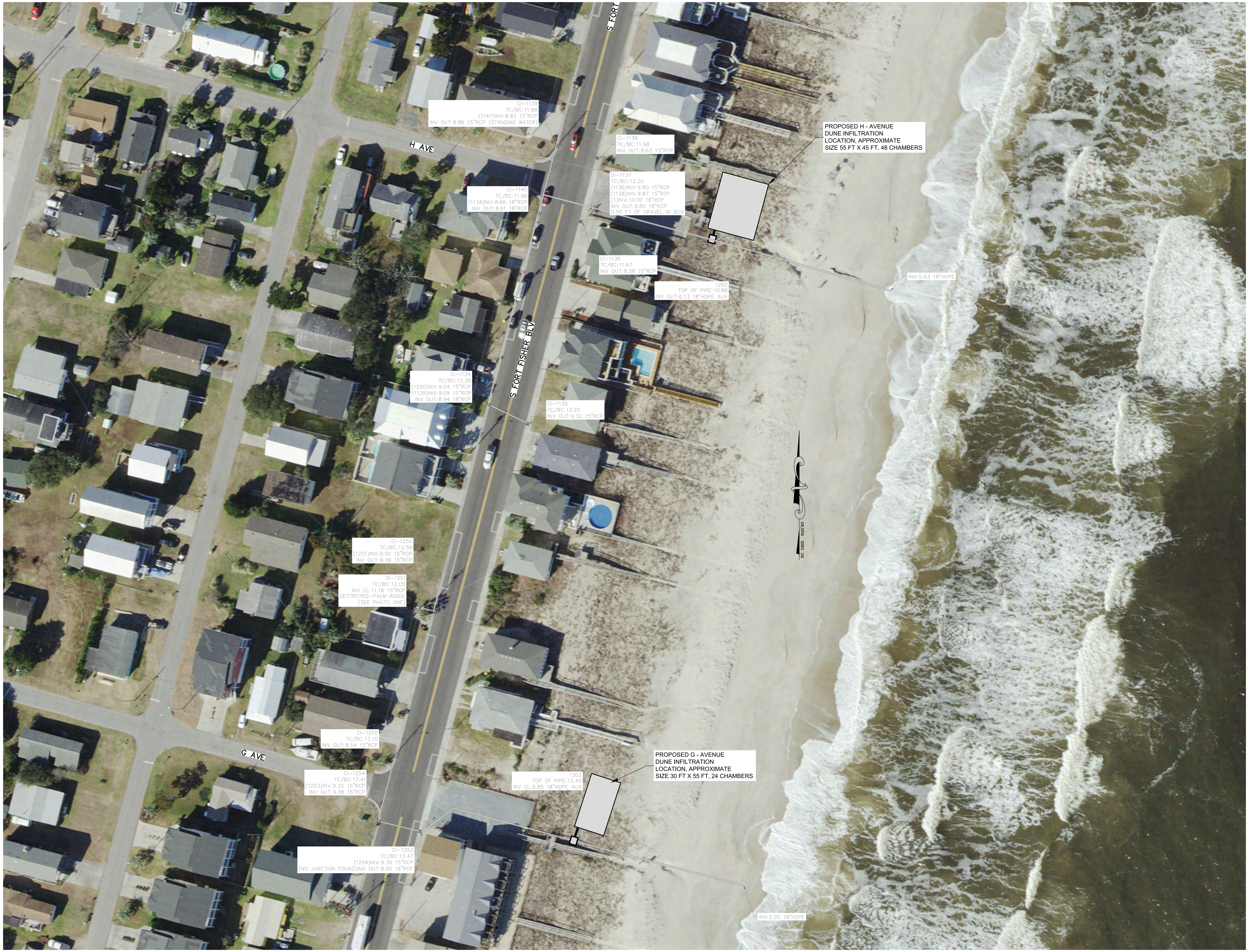

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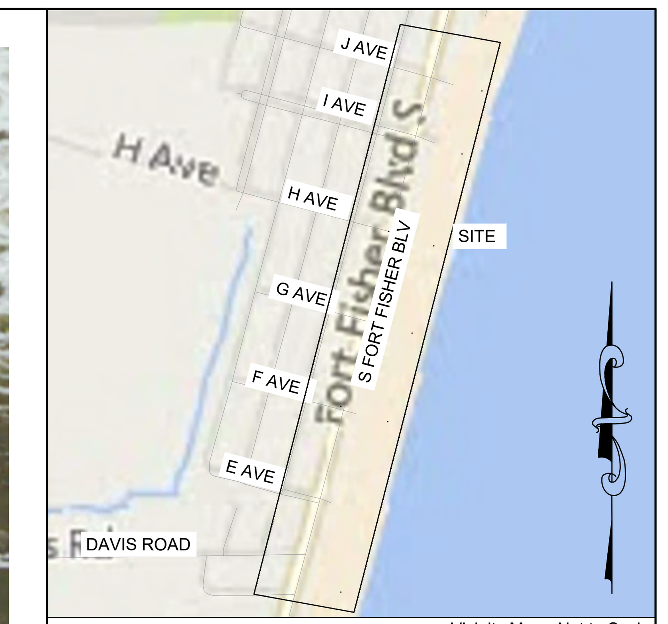

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Project Number: 4518040	
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Reviewed By:	Sheet 5 of 7
Sealed By:	

EXAMPLE OF INFILTRATION INSTALLATION PLAN VIEW

SCALE: 1" = 20 '

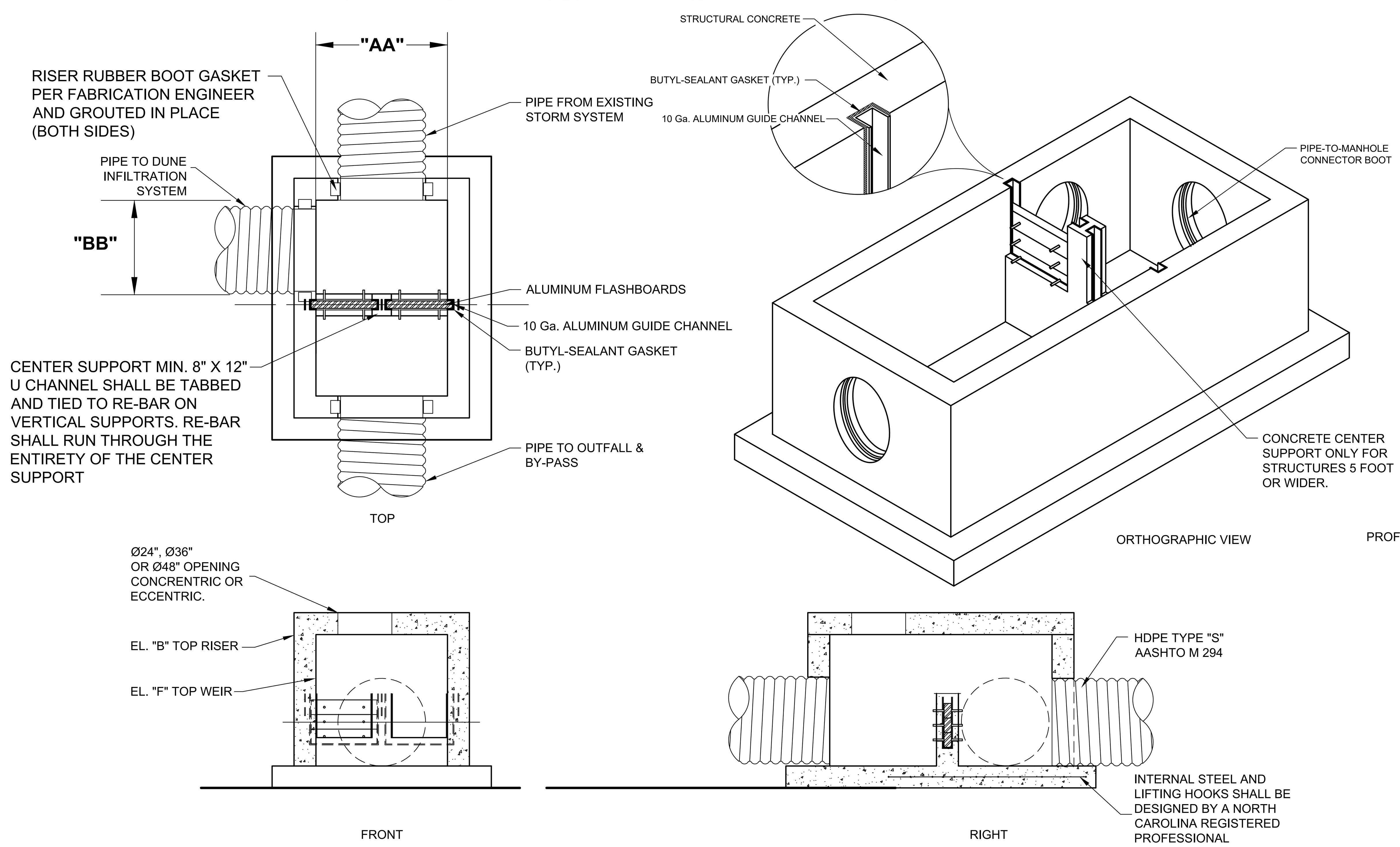
Vicinity Map - Not to Scale

Point Legend:

Symbol	Abbr	Description
	STMH	Storm Water Manhole
	CI	Curb Inlet
	DI	Drop Inlet

Line Legend:

Symbol	Description
	Road Centerline
	Storm Pipe

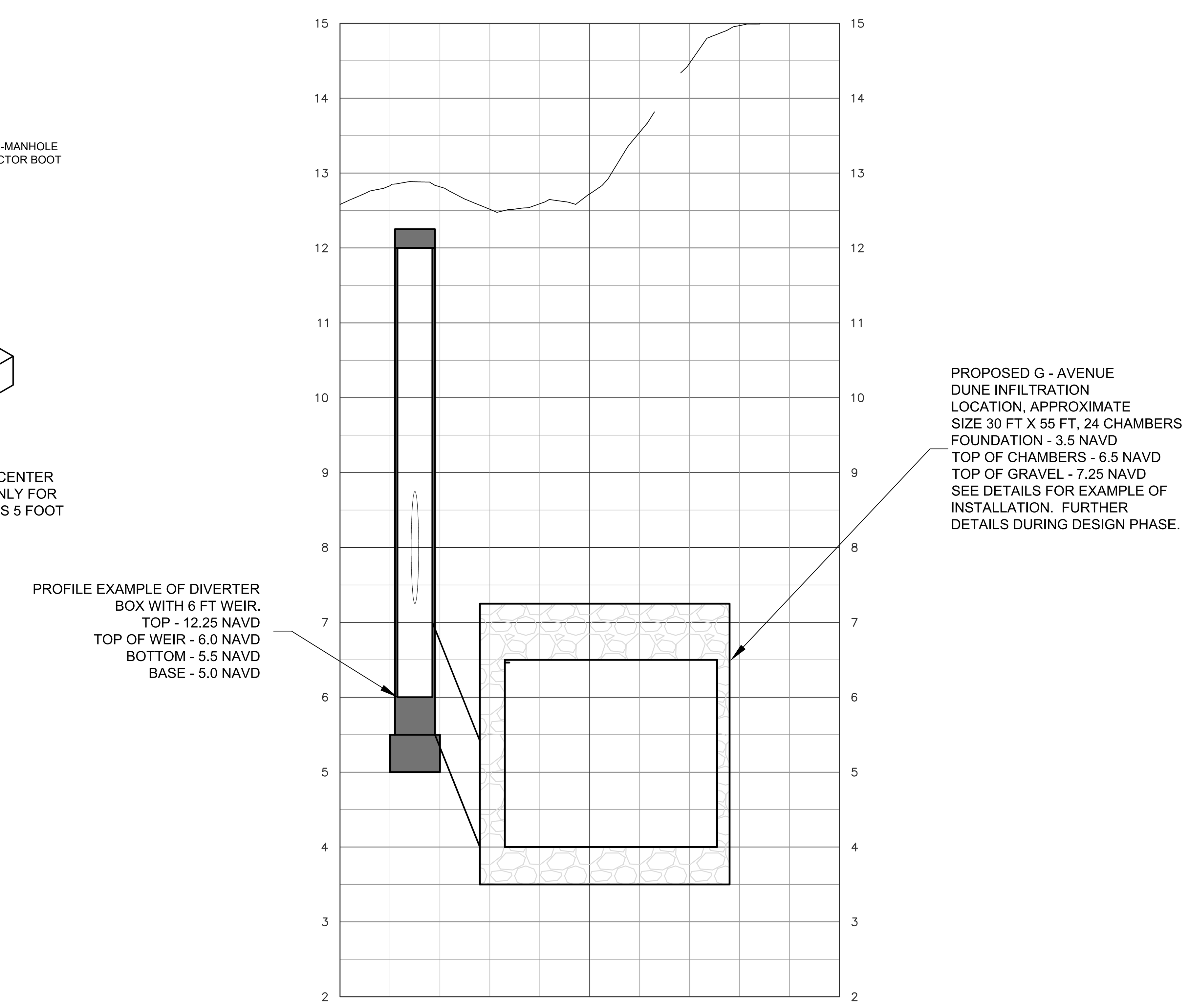


CONCRETE DIVERTER DETAIL

NTS.

NOTE:

ALL DIMENSIONS SHOWN ARE MINIMUM. FABRICATION ENGINEER SHALL SIZE STRUCTURES IN ACCORDANCE WITH THEIR CALCULATIONS, MAINTAINING THE WEIR LENGTH SPECIFIED WITHIN THE TABLE BELOW.



EXAMPLE OF INFILTRATION INSTALLATION PROFILE VIEW

SCALE: 1" = 20' (H); 1" = 1.5' (V)

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ISSUED FOR: PRELIMINARY REVIEW

Clean Water Management Trust Fund [CWMTF] Dune Infiltration Exhibit

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Town of Kure Beach

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Project Number: 4518040	
Drawn By: JDH	
Reviewed By:	
Sealed By:	Sheet 6 of 7

STORMTECH CHAMBER SPECIFICATIONS

1. CHAMBERS SHALL BE STORMTECH DC-780.
2. CHAMBERS SHALL BE MADE FROM VIRGIN, IMPACT-MODIFIED POLYPROPYLENE COPOLYMERS.
3. CHAMBER ROWS SHALL PROVIDE CONTINUOUS, UNOBSTRUCTED INTERNAL SPACE WITH NO INTERNAL SUPPORT PANELS THAT WOULD IMPEDE FLOW OR LIMIT ACCESS FOR INSPECTION.
4. THE STRUCTURAL DESIGN OF THE CHAMBERS, THE STRUCTURAL BACKFILL, AND THE INSTALLATION REQUIREMENTS SHALL ENSURE THAT THE LOAD FACTORS SPECIFIED IN THE AASHTO LRFD BRIDGE DESIGN SPECIFICATIONS, SECTION 12.12, ARE MET FOR: 1) LONG-DURATION DEAD LOADS AND 2) SHORT-DURATION LIVE LOADS, BASED ON THE AASHTO DESIGN TRUCK WITH CONSIDERATION FOR IMPACT AND MULTIPLE VEHICLE PRESENCES.
5. CHAMBERS SHALL MEET THE REQUIREMENTS OF ASTM F2418-16, "STANDARD SPECIFICATION FOR POLYPROPYLENE (PP) CORRUGATED WALL STORMWATER COLLECTION CHAMBERS".
6. CHAMBERS SHALL BE DESIGNED AND ALLOWABLE LOADS DETERMINED IN ACCORDANCE WITH ASTM F2787, "STANDARD PRACTICE FOR STRUCTURAL DESIGN OF THERMOPLASTIC CORRUGATED WALL STORMWATER COLLECTION CHAMBERS".
7. ONLY CHAMBERS THAT ARE APPROVED BY THE SITE DESIGN ENGINEER WILL BE ALLOWED. THE CHAMBER MANUFACTURER SHALL SUBMIT THE FOLLOWING UPON REQUEST TO THE SITE DESIGN ENGINEER FOR APPROVAL BEFORE DELIVERING CHAMBERS TO THE PROJECT SITE:
   a. A STRUCTURAL EVALUATION SEALED BY A REGISTERED PROFESSIONAL ENGINEER THAT DEMONSTRATES THAT THE SAFETY FACTORS ARE GREATER THAN OR EQUAL TO 1.95 FOR DEAD LOAD AND 1.75 FOR LIVE LOAD, THE MINIMUM REQUIRED BY ASTM F2787 AND BY AASHTO FOR THERMOPLASTIC PIPE.
   b. A STRUCTURAL EVALUATION SEALED BY A REGISTERED PROFESSIONAL ENGINEER THAT DEMONSTRATES THAT THE LOAD FACTORS SPECIFIED IN THE AASHTO BRIDGE DESIGN SPECIFICATIONS, SECTION 12.12, ARE MET. THE 50 YEAR CREEP MODULUS DATA SPECIFIED IN ASTM F2418 OR ASTM F2922 MUST BE USED AS PART OF THE AASHTO STRUCTURAL EVALUATION TO VERIFY LONG-TERM PERFORMANCE.
   c. STRUCTURAL CROSS SECTION DETAIL ON WHICH THE STRUCTURAL EVALUATION IS BASED.
8. CHAMBERS AND END CAPS SHALL BE PRODUCED AT AN ISO 9001 CERTIFIED MANUFACTURING FACILITY.

INSPECTION & MAINTENANCE

STEP 1) INSPECT ISOLATOR ROW FOR SEDIMENT
- A. INSPECTION PORTS (IF PRESENT)
  - A.1. REMOVE/OPEN LID ON NYLOPLAST INLINE DRAIN
  - A.2. REMOVE AND CLEAN FLEXSTORM FILTER IF INSTALLED
  - A.3. USING A FLASHLIGHT AND STADIA ROD, MEASURE DEPTH OF SEDIMENT AND RECORD ON MAINTENANCE LOG
  - A.4. LOWER A CAMERA INTO ISOLATOR ROW FOR VISUAL INSPECTION OF SEDIMENT LEVELS (OPTIONAL)
  - A.5. IF SEDIMENT IS AT, OR ABOVE, 3" (80 mm) PROCEED TO STEP 2. IF NOT, PROCEED TO STEP 3.
- B. ALL ISOLATOR ROWS
  - B.1. REMOVE COVER FROM STRUCTURE AT UPSTREAM END OF ISOLATOR ROW
  - B.2. USING A FLASHLIGHT, INSPECT DOWN THE ISOLATOR ROW THROUGH OUTLET PIPE
    - i) MIRRORS ON POLES OR CAMERAS MAY BE USED TO AVOID A CONFINED SPACE ENTRY
    - ii) FOLLOW OSHA REGULATIONS FOR CONFINED SPACE ENTRY IF ENTERING MANHOLE
  - B.3. IF SEDIMENT IS AT, OR ABOVE, 3" (80 mm) PROCEED TO STEP 2. IF NOT, PROCEED TO STEP 3.

STEP 2) CLEAN OUT ISOLATOR ROW USING THE JETVAC PROCESS
- A. A FIXED CULVERT CLEANING NOZZLE WITH REAR FACING SPREAD OF 45" (1.1 m) OR MORE IS PREFERRED
- B. APPLY MULTIPLE PASSES OF JETVAC UNTIL BACKFLUSH WATER IS CLEAN
- C. VACUUM STRUCTURE SUMP AS REQUIRED

STEP 3) REPLACE ALL COVERS, GRATES, FILTERS, AND LIDS; RECORD OBSERVATIONS AND ACTIONS.

STEP 4) INSPECT AND CLEAN BASINS AND MANHOLES UPSTREAM OF THE STORMTECH SYSTEM.

NOTES

1. INSPECT EVERY 6 MONTHS DURING THE FIRST YEAR OF OPERATION. ADJUST THE INSPECTION INTERVAL BASED ON PREVIOUS OBSERVATIONS OF SEDIMENT ACCUMULATION AND HIGH WATER ELEVATIONS.
2. CONDUCT JETTING AND VACTORING ANNUALLY OR WHEN INSPECTION SHOWS THAT MAINTENANCE IS NECESSARY.

IMPORTANT - NOTES FOR THE BIDDING AND INSTALLATION OF THE DC-780 CHAMBER SYSTEM

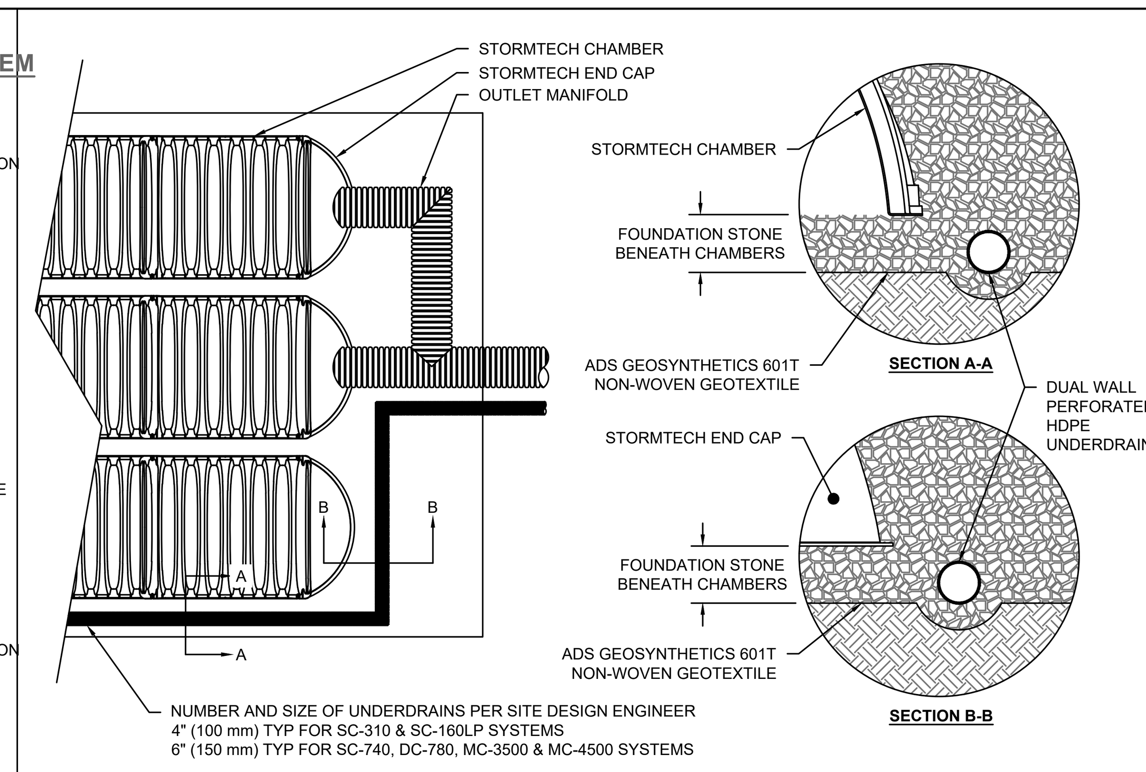
1. STORMTECH DC-780 CHAMBERS SHALL NOT BE INSTALLED UNTIL THE MANUFACTURER'S REPRESENTATIVE HAS COMPLETED A PRE-CONSTRUCTION MEETING WITH THE INSTALLERS.
2. STORMTECH DC-780 CHAMBERS SHALL BE INSTALLED IN ACCORDANCE WITH THE "STORMTECH SC-310/SC-740/DC-780 CONSTRUCTION GUIDE".
3. CHAMBERS ARE NOT TO BE BACKFILLED WITH A DOZER OR AN EXCAVATOR SITUATED OVER THE CHAMBERS. STORMTECH RECOMMENDS 3 BACKFILL METHODS:
   - STONESHOOTER LOCATED OFF THE CHAMBER BED.
   - BACKFILL AS ROWS ARE BUILT USING AN EXCAVATOR ON THE FOUNDATION STONE OR SUBGRADE.
   - BACKFILL FROM OUTSIDE THE EXCAVATION USING A LONG BOOM HOE OR EXCAVATOR.
4. THE FOUNDATION STONE SHALL BE LEVELED AND COMPACTED PRIOR TO PLACING CHAMBERS.
5. JOINTS BETWEEN CHAMBERS SHALL BE PROPERLY SEATED PRIOR TO PLACING STONE.
6. MAINTAIN MINIMUM - 6" (150 mm) SPACING BETWEEN THE CHAMBER ROWS.
7. EMBEDMENT STONE SURROUNDING CHAMBERS MUST BE A CLEAN, CRUSHED, ANGULAR STONE 3/4-2" (20-50 mm).
8. THE CONTRACTOR MUST REPORT ANY DISCREPANCIES WITH CHAMBER FOUNDATION MATERIALS BEARING CAPACITIES TO THE SITE DESIGN ENGINEER.
9. ADS RECOMMENDS THE USE OF "FLEXSTORM CATCH IT" INSERTS DURING CONSTRUCTION FOR ALL INLETS TO PROTECT THE SUBSURFACE STORMWATER MANAGEMENT SYSTEM FROM CONSTRUCTION SITE RUNOFF.

NOTES FOR CONSTRUCTION EQUIPMENT

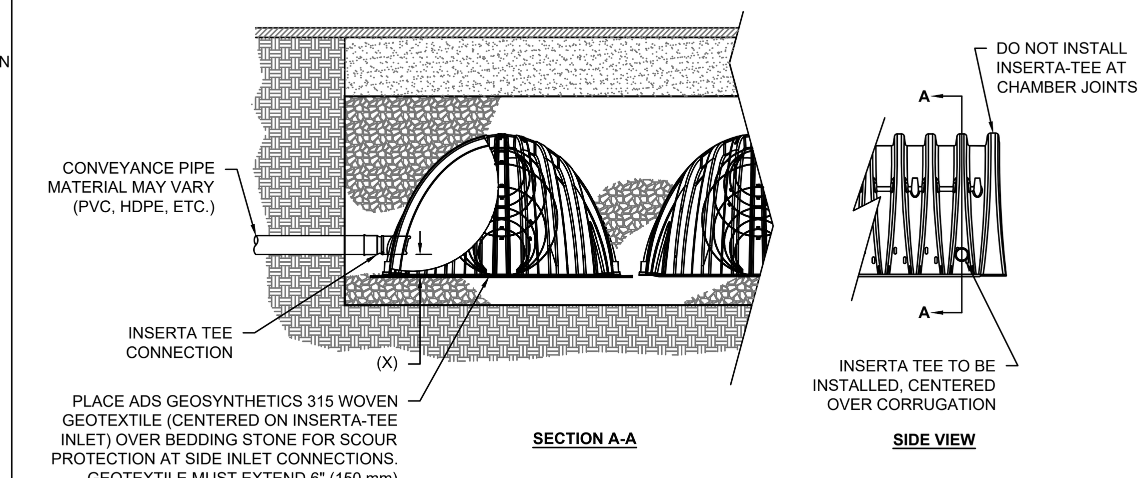
1. STORMTECH DC-780 CHAMBERS SHALL BE INSTALLED IN ACCORDANCE WITH THE "STORMTECH SC-310/SC-740/DC-780 CONSTRUCTION GUIDE".
2. THE USE OF CONSTRUCTION EQUIPMENT OVER DC-780 CHAMBERS IS LIMITED:
   - NO EQUIPMENT IS ALLOWED ON BARE CHAMBERS.
   - NO RUBBER TIRED LOADERS, DUMP TRUCKS, OR EXCAVATORS ARE ALLOWED UNTIL PROPER FILL DEPTHS ARE REACHED IN ACCORDANCE WITH THE "STORMTECH SC-310/SC-740/DC-780 CONSTRUCTION GUIDE".
   - WEIGHT LIMITS FOR CONSTRUCTION EQUIPMENT CAN BE FOUND IN THE "STORMTECH SC-310/SC-740/DC-780 CONSTRUCTION GUIDE".
3. FULL 36" (900 mm) OF STABILIZED COVER MATERIALS OVER THE CHAMBERS IS REQUIRED FOR DUMP TRUCK TRAVEL OR DUMPING.

USE OF A DOZER TO PUSH EMBEDMENT STONE BETWEEN THE ROWS OF CHAMBERS MAY CAUSE DAMAGE TO THE CHAMBERS AND IS NOT AN ACCEPTABLE BACKFILL METHOD. ANY CHAMBERS DAMAGED BY THE "DUMP AND PUSH" METHOD ARE NOT COVERED UNDER THE STORMTECH STANDARD WARRANTY.

CONTACT STORMTECH AT 1-888-892-2694 WITH ANY QUESTIONS ON INSTALLATION REQUIREMENTS OR WEIGHT LIMITS FOR CONSTRUCTION EQUIPMENT.



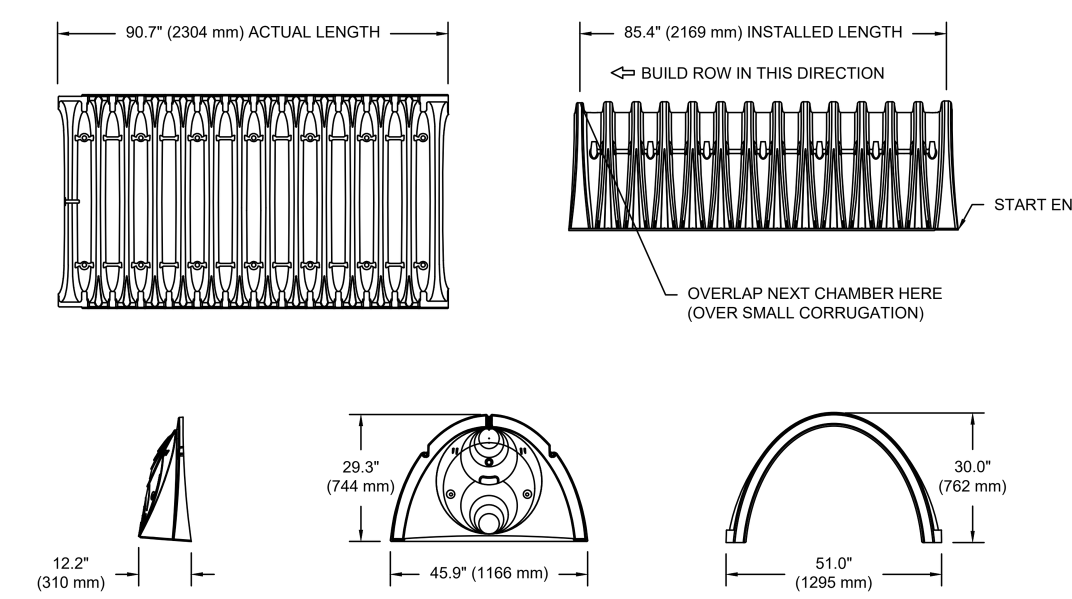
5 UNDERDRAIN DETAIL



CHAMBER	MAX DIAMETER OF INSERTA TEE	HEIGHT FROM BASE OF CHAMBER (X)
SC-310	6" (150 mm)	4" (100 mm)
SC-740	10" (250 mm)	4" (100 mm)
DC-780	10" (250 mm)	4" (100 mm)
MC-3500	12" (300 mm)	6" (150 mm)
MC-4500	12" (300 mm)	8" (200 mm)
INSERTA TEE FITTINGS AVAILABLE FOR SDR 26, SDR 35, SCH 40 IPS GASKETED & SOLVENT WELD, N-12, HP STORM, C-900 OR DUCTILE IRON		

NOTE:
PART NUMBERS WILL VARY BASED ON INLET PIPE MATERIALS. CONTACT STORMTECH FOR MORE INFORMATION.

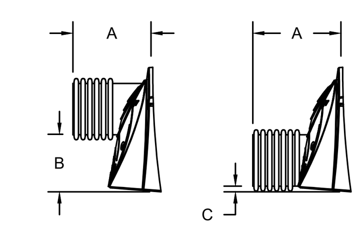
6 INSERTA-TEE SIDE INLET DETAIL



NOMINAL CHAMBER SPECIFICATIONS

SIZE (W X H X INSTALLED LENGTH)	51.0" X 30.0" X 85.4"	(1295 mm X 762 mm X 2169 mm)
CHAMBER STORAGE	46.2 CUBIC FEET	(1.30 m³)
MINIMUM INSTALLED STORAGE*	78.4 CUBIC FEET	(2.20 m³)
WEIGHT	75.0 lbs.	(33.6 kg)

*ASSUMES 6" (152 mm) STONE ABOVE, 9" (229 mm) BELOW, AND 6" (152 mm) BETWEEN CHAMBERS



STUBS AT BOTTOM OF END CAP FOR PART NUMBERS ENDING WITH "B"
STUBS AT TOP OF END CAP FOR PART NUMBERS ENDING WITH "T"

PART #	STUB	A	B	C
SC740EPE06T / SC740EPE06TPC	6" (150 mm)	10.9" (277 mm)	18.5" (470 mm)	---
SC740EPE06B / SC740EPE06BPC			---	0.5" (13 mm)
SC740EPE08T / SC740EPE08TPC	8" (200 mm)	12.2" (310 mm)	16.5" (419 mm)	---
SC740EPE08B / SC740EPE08BPC			---	0.6" (15 mm)
SC740EPE10T / SC740EPE10TPC	10" (250 mm)	13.4" (340 mm)	14.5" (368 mm)	---
SC740EPE10B / SC740EPE10BPC			---	0.7" (18 mm)
SC740EPE12T / SC740EPE12TPC	12" (300 mm)	14.7" (373 mm)	12.5" (318 mm)	---
SC740EPE12B / SC740EPE12BPC			---	1.2" (30 mm)
SC740EPE15T / SC740EPE15TPC	15" (375 mm)	18.4" (467 mm)	9.0" (229 mm)	---
SC740EPE15B / SC740EPE15BPC			---	1.3" (33 mm)
SC740EPE18T/ SC740EPE18TPC	18" (450 mm)	19.7" (500 mm)	5.0" (127 mm)	---
SC740EPE18B / SC740EPE18BPC			---	1.6" (41 mm)
SC740EPE24B*	24" (600 mm)	18.5" (470 mm)	---	0.1" (3 mm)

ALL STUBS, EXCEPT FOR THE SC740EPE24B ARE PLACED AT BOTTOM OF END CAP SUCH THAT THE OUTSIDE DIAMETER OF THE STUB IS FLUSH WITH THE BOTTOM OF THE END CAP. FOR ADDITIONAL INFORMATION CONTACT STORMTECH AT 1-888-892-2694.

* FOR THE SC740EPE24B THE 24" (600 mm) STUB LIES BELOW THE BOTTOM OF THE END CAP APPROXIMATELY 1.75" (44 mm). BACKFILL MATERIAL SHOULD BE REMOVED FROM BELOW THE N-12 STUB SO THAT THE FITTING SITS LEVEL.

NOTE: ALL DIMENSIONS ARE NOMINAL

2 DC-780 TECHNICAL SPECIFICATIONS

Vicinity Map - Not to Scale

Point Legend:

Symbol	Abbr	Description
	STMH	Storm Water Manhole
	CI	Curb Inlet
	DI	Drop Inlet

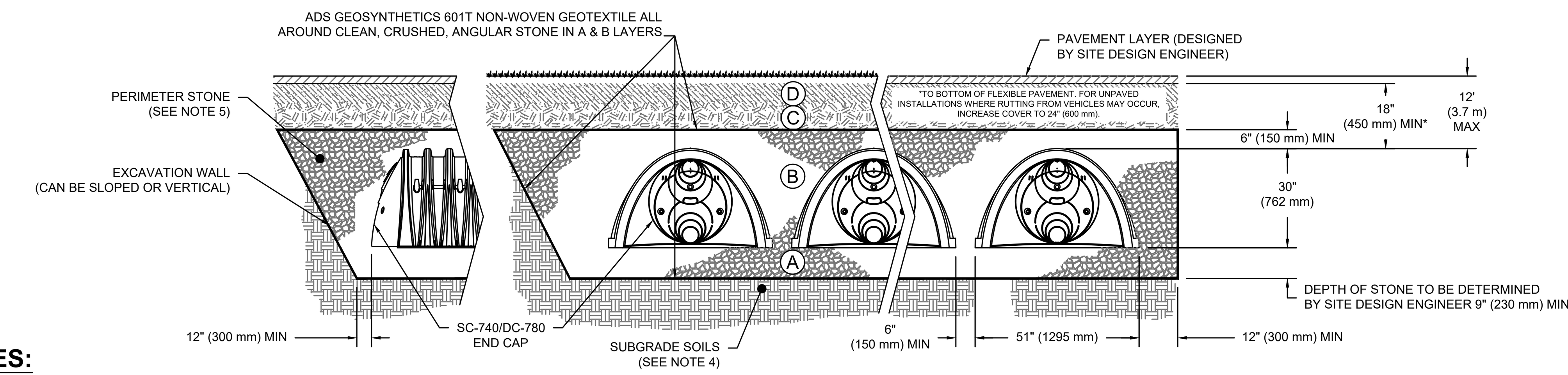
Line Legend:

Symbol	Description
	Road Centerline
	Storm Pipe

ACCEPTABLE FILL MATERIALS: STORMTECH DC-780 CHAMBER SYSTEMS

MATERIAL LOCATION		DESCRIPTION	AASHTO MATERIAL CLASSIFICATIONS	COMPACTION / DENSITY REQUIREMENT
D	**FINAL FILL:** FILL MATERIAL FOR LAYER 'D' STARTS FROM THE TOP OF THE 'C' LAYER TO THE BOTTOM OF FLEXIBLE PAVEMENT OR UNPAVED FINISHED GRADE ABOVE. NOTE THAT PAVEMENT SUBBASE MAY BE PART OF THE 'D' LAYER	ANY SOIL/ROCK MATERIALS, NATIVE SOILS, OR PER ENGINEER'S PLANS. CHECK PLANS FOR PAVEMENT SUBGRADE REQUIREMENTS.	N/A	PREPARE PER SITE DESIGN ENGINEER'S PLANS. PAVED INSTALLATIONS MAY HAVE STRINGENT MATERIAL AND PREPARATION REQUIREMENTS.
C	**INITIAL FILL:** FILL MATERIAL FOR LAYER 'C' STARTS FROM THE TOP OF THE EMBEDMENT STONE ('B' LAYER) TO 18" (450 mm) ABOVE THE TOP OF THE CHAMBER. NOTE THAT PAVEMENT SUBBASE MAY BE A PART OF THE 'C' LAYER.	GRANULAR WELL-GRADED SOIL/AGGREGATE MIXTURES, <35% FINES OR PROCESSED AGGREGATE. MOST PAVEMENT SUBBASE MATERIALS CAN BE USED IN LIEU OF THIS LAYER.	AASHTO M145[1] A-1, A-2-4, A-3 OR AASHTO M43[1] 3, 357, 4, 467, 5, 56, 57, 6, 67, 68, 7, 78, 8, 89, 9, 10	BEGIN COMPACTIONS AFTER 12" (300 mm) OF MATERIAL OVER THE CHAMBERS IS REACHED. COMPACT ADDITIONAL LAYERS IN 6" (150 mm) MAX LIFTS TO A MIN. 95% PROCTOR DENSITY FOR WELL GRADED MATERIAL AND 95% RELATIVE DENSITY FOR PROCESSED AGGREGATE MATERIALS. ROLLER GROSS VEHICLE WEIGHT NOT TO EXCEED 12,000 lbs (53 kN). DYNAMIC FORCE NOT TO EXCEED 20,000 lbs (89 kN).
B	**EMBEDMENT STONE:** FILL SURROUNDING THE CHAMBERS FROM THE FOUNDATION STONE ('A' LAYER) TO THE 'C' LAYER ABOVE.	CLEAN, CRUSHED, ANGULAR STONE	AASHTO M43[1] 3, 357, 4, 467, 5, 56, 57	NO COMPACTION REQUIRED.
A	**FOUNDATION STONE:** FILL BELOW CHAMBERS FROM THE SUBGRADE UP TO THE FOOT (BOTTOM) OF THE CHAMBER.	CLEAN, CRUSHED, ANGULAR STONE	AASHTO M43[1] 3, 357, 4, 467, 5, 56, 57	PLATE COMPACT OR ROLL TO ACHIEVE A FLAT SURFACE.[2,3]

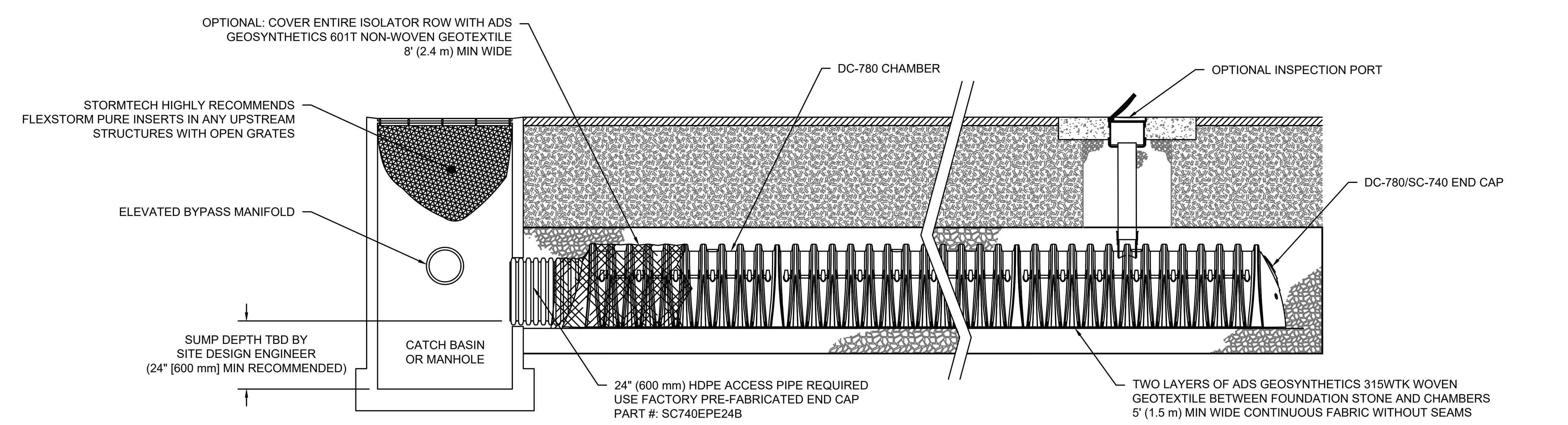
PLEASE NOTE:
1. THE LISTED AASHTO DESIGNATIONS ARE FOR GRADATIONS ONLY. THE STONE MUST ALSO BE CLEAN, CRUSHED, ANGULAR. FOR EXAMPLE, A SPECIFICATION FOR #4 STONE WOULD STATE: "CLEAN, CRUSHED, ANGULAR NO. 4 (AASHTO M43) STONE".
2. STORMTECH COMPACTION REQUIREMENTS ARE MET FOR 'A' LOCATION MATERIALS WHEN PLACED AND COMPACTED IN 6" (150 mm) (MAX) LIFTS USING TWO FULL COVERAGES WITH A VIBRATORY COMPACTOR.
3. WHERE INFILTRATION SURFACES MAY BE COMPROMISED BY COMPACTION, FOR STANDARD DESIGN LOAD CONDITIONS, A FLAT SURFACE MAY BE ACHIEVED BY RAKING OR DRAGGING WITHOUT COMPACTION EQUIPMENT. FOR SPECIAL LOAD DESIGNS, CONTACT STORMTECH FOR COMPACTION REQUIREMENTS.



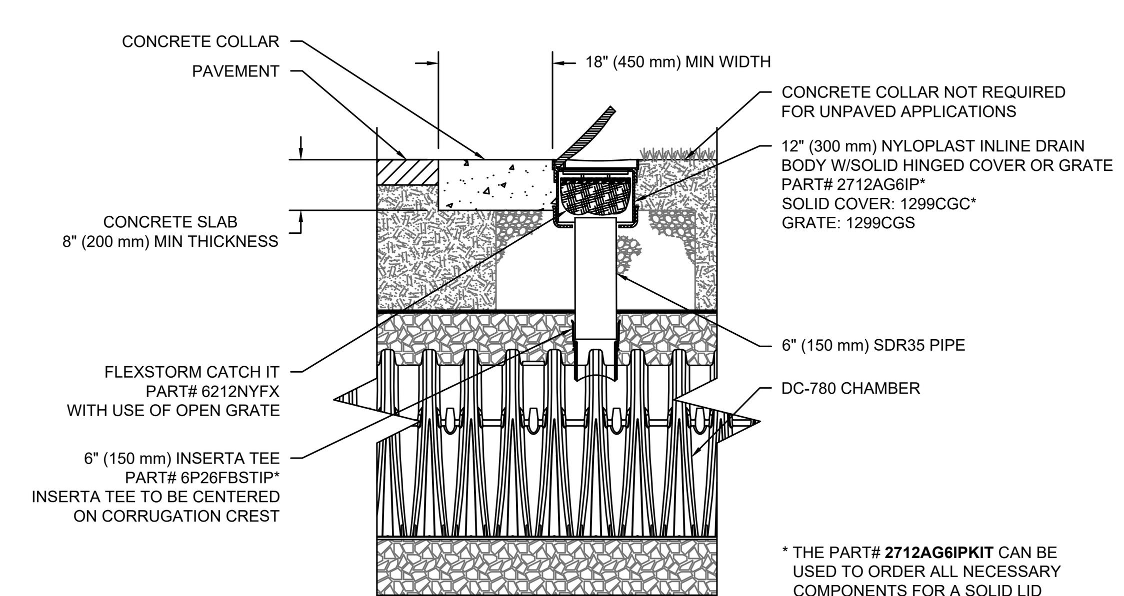
NOTES:

1. DC-780 CHAMBERS SHALL CONFORM TO THE REQUIREMENTS OF ASTM F2418 "STANDARD SPECIFICATION FOR POLYPROPYLENE (PP) CORRUGATED WALL STORMWATER COLLECTION CHAMBERS", OR ASTM F2922 "STANDARD SPECIFICATION FOR POLYETHYLENE (PE) CORRUGATED WALL STORMWATER COLLECTION CHAMBERS".
2. DC-780 CHAMBERS SHALL BE DESIGNED IN ACCORDANCE WITH ASTM F2787 "STANDARD PRACTICE FOR STRUCTURAL DESIGN OF THERMOPLASTIC CORRUGATED WALL STORMWATER COLLECTION CHAMBERS".
3. "ACCEPTABLE FILL MATERIALS" TABLE ABOVE PROVIDES MATERIAL LOCATIONS, DESCRIPTIONS, GRADATIONS, AND COMPACTION REQUIREMENTS FOR FOUNDATION, EMBEDMENT, AND FILL MATERIALS.
4. THE SITE DESIGN ENGINEER IS RESPONSIBLE FOR ASSESSING THE BEARING RESISTANCE (ALLOWABLE BEARING CAPACITY) OF THE SUBGRADE SOILS AND THE DEPTH OF FOUNDATION STONE WITH CONSIDERATION FOR THE RANGE OF EXPECTED SOIL MOISTURE CONDITIONS.
5. PERIMETER STONE MUST BE EXTENDED HORIZONTALLY TO THE EXCAVATION WALL FOR BOTH VERTICAL AND SLOPED EXCAVATION WALLS.
6. ONCE LAYER 'C' IS PLACED, ANY SOIL/MATERIAL CAN BE PLACED IN LAYER 'D' UP TO THE FINISHED GRADE. MOST PAVEMENT SUBBASE SOILS CAN BE USED TO REPLACE THE MATERIAL REQUIREMENTS OF LAYER 'C' OR 'D' AT THE SITE DESIGN ENGINEER'S DISCRETION.

1 DC-780 CROSS SECTION DETAIL



3 DC-780 ISOLATOR ROW DETAIL



* THE PART# **2712AG6IPKIT** CAN BE USED TO ORDER ALL NECESSARY COMPONENTS FOR A SOLID LID INSPECTION PORT INSTALLATION

4 DC-780 6" (150 mm) INSPECTION PORT DETAIL

NOT FOR CONSTRUCTION

ISSUED FOR: PRELIMINARY REVIEW

Clean Water Management Trust Fund [CWMTF]
Dune Infiltration Exhibit

prepared for:
Town of Kure Beach

No.	Revision	By	Date
1			##/##/##
2			
3			
4			

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Graphic Scale 40 20 0 40
Text Scale: 1"=40'

Flile: 4518040E-1.DWG	Plot Date: 2019-05-31
Project Number: 4518040	
Drawn By: JDH	
Reviewed By:	Sheet 7 of 7
Sealed By:	