2024

Stormwater Master Plan Report

TOWN OF HOLDEN BEACH, NORTH CAROLINA

Prepared by:

McGill Associates

mcgill Shaping Communities Together

McGill Associates, P.A.
712 Village Rd. Suite #103
Shallotte, North Carolina 28470
Firm License No.: C-0459

TOWN OF HOLDEN BEACH
BRUNSWICK COUNTY, NORTH CAROLINA
STORMWATER MASTER PLAN REPORT

MICHAEL HANSON, PE, LEED AP

712 Village Rd. Suite #103

Shallotte, North Carolina 28470

910.755.5872

JUNE 2024

PROJECT NO. 22.07132

Executive Summary
Town of Holden Beach Stormwater Master Plan

Introduction/Scope of Work

The Town of Holden Beach (Town) has retained McGill Associates (McGill) to prepare this Stormwater Master Plan (SWMP). The primary purposes of this project were to analyze the existing stormwater system at six known areas of concern, evaluate alternatives to remedy flooding at these locations, identify future opportunities for stormwater improvements, and create a financial model to determine viability of a Town Stormwater Utility (SWU). The aforementioned areas of concern are as follows:

Area 1 – 300 Block of Ocean Boulevard West
Area 2 – East End of Mullet Street & East End of Avenue A
Area 3 – West End Right-of-Way
Area 4 – 760 Block of Ocean Boulevard West
Area 5 – Carolina Avenue
Area 6 – Davis Street

A geographic information system (GIS)-based stormwater system inventory and limited closed circuit TV (CCTV) inspections were performed on the existing storm sewer system. Additionally, a detailed topographic survey of drainage features within identified areas of concern was performed.

This data was used to develop a hydrologic and hydraulic model of the island community. This model was used to assess the capacity of the existing stormwater system for the 2-year and 10-year storm events within the identified areas of concern and for the 2-year storm event and sunny day mean higher-high tide across all other portions of the system.

Two alternative solutions to alleviate flooding at each area of concern were evaluated along with estimating the cost of each alternative solution. A recommended alternative was provided for each area of concern while a heat map was developed for other areas to identify future opportunities for stormwater system improvements.

A financial model was developed to determine the revenue, expenses, and ultimate viability of a Town Stormwater Utility including two potential funding scenarios. Revenue was determined using a flat fee amount per month for each parcel. The financial model uses $7.20 per month per developed parcel for Scenario A assuming the projects are funded entirely by the Town. Scenario B assumes grant funding equal to 75% of the project cost with the remaining 25% of the cost funded by the Town. These rates compare favorably to the mean rate charged by four (4) stormwater utilities in coastal communities within approximately 30 miles that charge a flat fee (Oak Island, Kure Beach, Carolina Beach, and Wilmington) of $11.76.

A Stormwater Master Plan was prepared to summarize the results and provide recommendations.

Recommendations

After completing our requested scope of services, McGill is pleased to provide the following recommendations to the Town:

Stormwater Improvements

Area 1 – 300 Block of Ocean Boulevard West (OBW)

Issue: Flooding in public ROW and roads during 2-year storm event.

Public Benefit: Eliminate 2-year flooding along OBW and Brunswick Ave.

Recommended Solution: Install a system of High-Performance Polypropylene pipes (HPPP) along OBW and High Point St. that discharges into the existing Brunswick Ave. channel. Upsize the existing culvert under Mile Marker Fifty-Five Dr. and the outlet pipe along High Point St. Construct two (2) storage depressions in the ROW between OBW and Brunswick Ave. and connect to the proposed system. Lower the Brunswick Ave. channel to accommodate connection into the proposed system.

In the future, storage depressions may be converted to underground storage units in order to provide some additional public benefit such as parking or roadway.

Area 2 – East End of Mullet Street & East End of Avenue A

Issue: Flooding in public ROW and road during 2-year storm event.

Public Benefit: Eliminates 2-year flooding along Ocean Boulevard East (OBE) east of Mullet St. and 10-year roadway flooding between Avenue A. and Dunescape drive.

Recommended Solution: Drop inverts of existing pipes along OBE west of Mullet St. to create a positive outfall. Install 1-foot-deep swales along OBE between Dunescape Dr. and McCray St., connected to the existing system via HPPPs. Upsize existing pipes along OBE east of Mullet St. and along Mullet St. to the outfall. Install a tide gate on the final outlet pipe.

Area 3 – West End Right-of-Way

Issue: Flooding in public ROW and road during 2-year storm event.

Public Benefit: Reduces 2-year roadway flooding.

Recommended Solution: Install a system of HPPPs and Reinforced Concrete Pipes (RCP) at the low point of OBW to discharge through an easement into the Intracoastal Waterway.

Area 4 – 760 Block of Ocean Boulevard West

Issue: Flooding in public ROW and street during 2-year storm event.

Public Benefit: Eliminates 2-year flooding along OBW.

Recommended Solution: Install a system of RCPs along the ROW of OBW to discharge into the Intracoastal Waterway.

Area 5 – Carolina Avenue

Issue: Flooding in public ROW and street during 2-year storm event.

Public Benefit: Eliminates 2-year and 10-year flooding along Carolina Ave.

Recommended Solution: Install a system of 24" RCPs along Carolina Ave. and Halstead St. to discharge into the Intracoastal Waterway.

Area 6 – Davis Street

Issue: Surface runoff erosion from ROW into Intracoastal Waterway.

Public Benefit: Improved water quality within the Intracoastal Waterway.

Recommended Solution: Install a grassed blind swale with level spreader at the end of the road and adjust existing outfall pipes as needed for proper operation.

Town Stormwater Utility

Based on the project cost of capital stormwater projects and on-going and planned maintenance for the stormwater system we recommend proceeding with implementation of Scenario A (full Town funding), should the Town decide to implement a stormwater management utility. This scenario provides sufficient funds to cover the planned activities for the next ten years while maintaining a sufficient fund balance that suggests the utility will remain stable and fiscally healthy. If pursuit of grant funding is favorable, the utility can easily be converted to Scenario B in the future and rates reevaluated at that time.

Table of Contents

ATTACHMENTS

1.0 Introduction

The Town of Holden Beach (Town) is located in Brunswick County, North Carolina on a barrier island that sits between Oak Island to the east and Ocean Isle to the west. It is surrounded by the Intracoastal Waterway to the north and the Atlantic Ocean to the south (Figure 1.1).

The Town's stormwater infrastructure includes a combination of pipes, structures, and ditches which convey stormwater throughout the Town. The North Carolina Department of Transportation (NCDOT) also owns and maintains stormwater infrastructure within the Town limits associated with NCDOT roads.

The Town's stormwater infrastructure is frequently overburdened by rainfall events, as well as sunny day tidal flooding, resulting in erosion, road blockages, and damage to surrounding properties. The following six areas of concern have been identified by the Town for capital improvement projects, with Areas 1-5 facing regular flooding and Area 6 facing surface runoff erosion.

1. Area 1 – 300 Block of Ocean Boulevard West
2. Area 2 – East End of Mullet Street & East End of Avenue A
3. Area 3 – West End Right-of-Way
4. Area 4 – 760 Block of Ocean Boulevard West
5. Area 5 – Carolina Avenue
6. Area 6 – Davis Street

The Town retained McGill Associates, PA (McGill) to evaluate the Town's stormwater network with focus on these areas of concern. The goals of this evaluation were to:

1. Analyze the existing stormwater system and drainage conditions at each area of concern for the 2-year and 10-year rainfall events.
2. Identify deficiencies in the network at these locations and evaluate available alternatives to remedy flooding.
3. Develop an island-wide flooding heat map for the 2-year rainfall event and sunny day high tide to identify future opportunities for improvement.
4. Create a financial model to determine the revenue, expenses, and ultimate viability of a Town Stormwater Utility (SWU).

Figure 1.1 Location Map

2.0 Existing Stormwater System Mapping

Available data was acquired from reliable sources such as Town records, the North Carolina Floodplain Mapping Program (NCFMP), survey, and the NCDOT and collated to develop an understanding of major drainage patterns, outfalls, and area characteristics. McGill conducted a meeting and field reconnaissance trip with Town staff to confirm which drainage outfalls, pipes, and ditches were present in each area of concern and to identify any major data gaps needed to be filled to analyze the system.

A field mapping program was conducted by McGill to populate a Geographic Information System (GIS) database of the stormwater features and develop an initial inventory of the fragmented stormwater network (Attachment A). This consisted of Global Positioning System (GPS) grade mapping of all stormwater system drainage features including inlets, catch basins, pipes, and ditches where present as well as a topographic survey of key areas of concern along Ocean Boulevard. Closed Circuit Television (CCTV) inspections were attempted on two outfalls, however, there was material present which blocked half or more of both pipes and resisted initial removal efforts, preventing a complete inspection along the entire length of the pipes.

The datum reference for GPS and survey was North American Datum of 1983 (NAD 83) for horizontal position data and North American Vertical Datum of 1988 (NAVD 88) for vertical elevation data.

The stormwater network map included in Attachment A shows some of the data collected. The full extent of the data content is included in the GIS geodatabase provided as a digital submittal.

3.0 Hydrologic and Hydraulic Analysis

Computational Hydraulics International's (CHI) Personal Computer Storm Water Management Model (PCSWMM) version 7.6 was used to conduct hydrologic and hydraulic analyses for this study. Drainage basin boundaries (Attachment B) were delineated using QL2 LiDAR data from the North Carolina Spatial Data Download (NC SDD), survey data, aerial imagery, and site photos for each of the following areas of concern identified by the Town:

Area 1 – 300 Block of Ocean Boulevard West

This area of concern includes Ocean Boulevard West (OBW) and Brunswick Avenue West between High Point Street and Neptune Street. The existing stormwater network consists of ditches and culverts along the north side of Brunswick Ave. W. that continue down the east side of High Point St. before discharging into the Intracoastal Waterway. A few pipes that act as underground detention and discharge via infiltration into the soil are present on OBW. For the purposes of this analysis, these detention pipes were not included in the model.

Sub-basins in this area are assigned basin numbers with an A1-Dx prefix.

Area 2 – East End of Mullet Street Area & East End of Avenue A

This area of concern includes Ocean Boulevard East (OBE) between Mullet Street and Dunescape Drive, however, in order to model the full stormwater network in this area, the model also included the area of OBE between Mullet Street and Halstead Street. The existing stormwater network consists of ditches and pipes that run along the south side of OBE between Halstead Street and McCray Street and meet at Mullet Street where they run north to discharge into the Intracoastal Waterway.

Sub-basins in this area are assigned basin numbers with an A2-Dx prefix.

Area 3 – West End Right-of-Way

This area of concern includes Ocean Boulevard West between 1324 and 1308 OBW. The existing stormwater network consists of a few pipes that act as underground detention and discharge via infiltration into the soil. For the purposes of this analysis, these pipes were not included in the model.

Sub-basins in this area are assigned basin numbers with an A3-Dx prefix.

Area 4 – 760 Block of Ocean Boulevard West

This area of concern includes Ocean Boulevard West between 762 and 714 OBW. The existing stormwater network consists of a few pipes that act as underground detention and discharge via infiltration into the soil. For the purposes of this analysis, these pipes were not included in the model.

Sub-basins in this area are assigned basin numbers with an A4-Dx prefix.

Area 5 – Carolina Avenue

This area of concern includes Carolina Avenue between Halstead Street and the end of Carolina Avenue. The existing stormwater network consists of a few pipes that act as underground detention and discharge via infiltration into the soil. For the purposes of this analysis, these pipes were not included in the model.

Sub-basins in this area are assigned basin numbers with an A5-Dx prefix.

Area 6 – Davis Street

This area of concern includes Davis Street. The existing stormwater network consists of two short swale segments that discharge to the Intracoastal Waterway via two short High-Density Polyethylene (HDPE) pipes through the seawall at the end of the road, however these are not depicted on the survey.

Sub-basins in this area are assigned basin numbers with an A6-Dx prefix.

Curve numbers were determined by combining United States Geological Survey (USGS) soils data (Attachment C) with the 2021 National Land Cover Database (NLCD) land use data in ArcGIS Pro.

The time of concentration for the study basins was calculated by PCSWMM using the Soil Conservation Service (SCS) Curve Number method. The total precipitation depth data for the 2-year and 10-year 24-hour storms were obtained from the National Oceanic and Atmospheric Administration (NOAA) Atlas 14 (Attachment C). Seasonal high-water table (SHWT) and groundwater level data were available from other studies performed on the island by ECS Southeast LLC. From these sources the SHWT used for this project is estimated at elevation 2.5 with the groundwater level around elevation 2.

The computed hydrologic data (Table 3.1) was used to conduct hydrologic and hydraulic (H&H) modeling using PCSWMM. Runoff was computed using the SCS Curve Number method.

Table 3.1. Summary of Model Hydrologic Inputs

Area of Concern	Basin Name	Area (ac)	CN	Time of Concentration (min)
1	A1-D1	7.40	60	24
	A1-D2	4.49	60	14
	A1-D3	3.34	60	14
	A1-D4	5.22	59	24
	A1-D5	6.17	59	24
	A1-D6	3.25	58	22
2	A2-D1	9.05	61	30
	A2-D2	5.82	60	32
	A2-D3	8.41	59	28
	A2-D4	10.22	59	41
	A2-D5	0.99	61	10
	A2-D6	9.84	60	28
	A2-D7	23.88	66	29
	A2-D8	1.72	57	19
	A2-D9	2.86	53	24
	A2-D10	2.64	58	31
	A2-D11	1.75	54	18
3	A3-D1	3.78	60	17
4	A4-D1	7.52	61	35
	A4-D2	2.97	60	17
5	A5-D1	4.73	60	18
	A5-D2	2.57	61	19
6	A6-D1	3.05	59	25

The hydraulic parameters of the current stormwater system were input into the model based on the data collected during survey. Channel cross-sections were generally based on the topographic survey, supplemented with QL2 LiDAR as needed. Overland flow was modeled as overtopping weirs to simulate flow over the roads or connections between adjacent basins. Weir crest elevations and dimensions were approximated from the topography at each location.

Tidal data was obtained from two National Oceanic and Atmospheric Administration (NOAA) Tidal Datum Stations, Bowen Point - Shallotte Inlet on the west side of the island and Varnamtown - Lockwoods Folly River on the east side of the island. Mean tide levels and mean higher-high water (MHHW) levels were obtained from each station and averaged together to create one mean tide and one MHHW level for the whole island (Table 3.2 and Attachment C). Outfalls were set to a fixed elevation equivalent to the mean tide for the 2- and 10-year storm event runs and the MHHW level was used to simulate sunny day flooding conditions.

Table 3.2 - Tidal Station Data

	Mean Tide (ft.)	Mean Higher-High Water Level (ft.)
Station 8659665 Bowen Point – Shallotte Inlet	2.28	4.76
Station 8659414 Varnamtown – Lockwoods Folly River	2.08	4.27
Island-wide Average Used for Model	2.18	4.52

4.0 Existing Stormwater System Analysis

The existing system analysis identified stormwater system deficiencies within the areas of concern and validated known problems or deficiencies in the existing systems. The existing system was found to be undersized at several locations based on surcharges shown by the Hydraulic Grade Line (HGL) in the conveyance system (Table 4.1). The maps in Attachment D provide a visual representation of the undersized portions of the stormwater network and show the extent of flooding during the 2- and 10-year storm events.

Area 1 – 300 Block of Ocean Boulevard West

Several hundred feet of public right-of-way (ROW) along Ocean Boulevard West (OBW), in an area referred to as the 300 Block, experience significant floodwater retention following storm events due to a low point in the road which acts as a storage depression. This allows water to pond on the road up to a depth of ~1 foot before it can overflow down the road and into the canal west of High Point Street. A few small underground storage pipes that allow for infiltration are present here, however, their inverts sit below the measured seasonal high-water table (SHWT) elevation and likely do not contribute significantly to 2-year storm retention. The stormwater network along Brunswick Avenue W. is also undersized for the 2-year storm event.

During the sunny day (i.e. no rainfall) MHHW tide, the northern half of High Point St. experiences flooding however a tide gate prevents backflow into the Brunswick Avenue stormwater network.

Area 2 – East End of Mullet Street Area & East End of Avenue A

Public ROW along Ocean Boulevard East (OBE) on the east end of Holden Beach, between Ferry Road and Dunescape Drive, experiences frequent periods of standing water following rain events as runoff is transported through the existing stormwater network or infiltrates into the soil. Much of this existing network is undersized for the 2-year storm event with the entire system undersized for the 10-year storm event. This network also contains a large number of pipes with negative slopes (the pipe outlet is higher than the pipe inlet) which produces inefficient flow conditions and contributes to surcharging.

A lack of any stormwater infrastructure along OBE between McCray Street and Dunescape Drive contributes to the flooding in this area during the 10-year storm event though natural depressions in the existing topography appear to control the 2-year storm event.

This area does not experience sunny day flooding due to the MHHW tide.

Area 3 – West End Right-of-Way

The public ROW near 1338 Ocean Boulevard West experiences flooding following rain events due to a low point in the road which acts as a storage depression, allowing water

to pond to a depth of ~2 feet before it can overflow into the Intracoastal Waterway. The only stormwater network present in this area are a few small underground storage pipes that allow for infiltration; however, their inverts sit below the average groundwater level and likely do not contribute significantly to 2-year storm retention.

This area does not experience sunny day flooding due to the MHHW tide.

Area 4 – 760 Block of Ocean Boulevard West

The public ROW near 743 Ocean Boulevard West experiences flooding following rain events due to a low point in the road which acts as a storage depression, allowing water to pond to a depth of ~1 foot before it can overflow into the Intracoastal Waterway. The only stormwater network present in this area are two 12" underground storage pipes that allow for infiltration. As these pipes sit above the SHWT it is possible that they contribute to 2-year storm retention, however, due to their small size these pipes were not included in the model.

This area does not experience sunny day flooding due to the MHHW tide.

Area 5 – Carolina Avenue

The public ROW near 142 Carolina Avenue experiences flooding following rain events due to a low point in the road which acts as a storage depression, allowing water to pond to a depth of ~0.75 feet before it can overflow south to Ocean Boulevard East. The only stormwater network present in this area is a single 12" underground storage pipe that allows for infiltration. As this pipe sits above the SHWT it is possible that it contributes to 2-year storm retention, however, it was not included in the model due to its small size.

This area does not experience sunny day flooding due to the MHHW tide.

Area 6 – Davis Street

No flooding due to storm events was reported in this area as all runoff sheet flows south down the road and into the Intracoastal Waterway. However, the low elevations at the end of the road make the final 50 feet of Davis Street susceptible to sunny day flooding due to the MHHW tide.

The Town has also reported surface runoff erosion that may be impacting water quality.

Table 4.1 - Existing Condition Model Results

Problem Area	Location	Overtop Elev.	2-YR Storm		10-YR Storm	
			WSEL	Flood Depth (ft.)	WSEL	Flood Depth (ft.)
1	Ocean Boulevard West	4.50	5.61	1.11	5.97	1.47
	Brunswick Ave. (Start of Channel)	5.91	5.98	0.07	6.17	0.26
	Brunswick Ave. (Marker Fifty-Five Dr.)	5.30	5.13	-	5.26	-
	High Point St. at Outlet Pipe	5.05	5.06	0.01	5.14	0.09
2	Ocean Boulevard East (West of Mullet St.)	6.22	6.82	0.60	7.62	1.40
	Ocean Boulevard East (East of Mullet St.)	6.45	6.78	0.33	7.62	1.17
	Ocean Boulevard East (McCray St. - Dunescape Dr.)	7.00	6.63	-	7.64	0.64
3	Ocean Boulevard West	3.60	5.16	1.61	5.54	1.94
4	Ocean Boulevard West	5.50	6.61	1.10	6.70	1.20
5	Carolina Avenue	9.70	10.56	0.85	10.70	1.00

5.0 Evaluation of Alternatives

Two alternatives were evaluated for areas of concern 1 through 5 as identified in Chapter 4 to achieve the 2-year level of service and improve conditions during the 10-year storm. Where a 2-year level of service was not possible, alternatives sought to improve flood conditions as much as possible.

In general, improvements consisted of hydraulic improvements such as upsizing or adding pipes and swales within the improvement area. Below is a description of the evaluated alternatives for each area of concern. Water surface elevation comparisons for each alternative are shown separately for each area of concern. A concept-level Opinion of Probable Construction Cost is provided for each alternative and detailed in Attachment H.

A fact sheet was developed for each alternative that describes the existing problem, project benefits, solution, and costs of implementation. The fact sheets are included in this chapter, but each fact sheet is designed for standalone use for presentations or meetings with stakeholders. Full maps of each alternative are provided in Attachment E.

Area 1 – 300 Block of Ocean Boulevard West

The following alternatives for Area 1 are presented in two phases. Phase 1 seeks to provide immediate flood relief whereas Phase 2 seeks to maintain the level of service achieved by Phase 1 while allowing the Town to undertake future construction projects. Phase 2 is included in this analysis for informational purposes only and is not included in the recommendations found in Section 7.

Alternative 1

Phase 1

A dedicated right-of-way (ROW) at 317 Brunswick Avenue West, which connects Ocean Boulevard West (OBW) and Brunswick Ave., is currently used as an unofficial vehicle and pedestrian access. Phase 1 of this alternative would see this ROW converted to a 2.5-foot-deep storage depression to hold runoff from both OBW and Brunswick Ave.

Catch basins will be installed along the north side of OBW, including at the low point of the road, and at the intersection of High Point Street and Brunswick Ave. As the catch basin at the low point of the road will be located within the ROW of OBW and not on the road itself, its rim elevation will sit above the lowest elevation of the road. For this reason, it is recommended that the road be raised to elevation 4.85' to encourage positive flow to the inlet and to avoid further road ponding.

Catch basins will be connected by 15" High Performance Polypropylene pipes (HPPP), producing two different directions of flow: one, from the low point of the road, through the storage depression, and discharging at the outset of the Brunswick Ave. channel, and

the other from the low point of the road, down OBW and High Point Street, and discharging into the channel near the intersection of High Point St. and Brunswick Ave.

In order to maintain a positive outfall within the proposed stormwater network, the Brunswick Ave. channel will be dropped approximately 1.5 feet between its outset and the inlet of the existing outlet pipe. The channel will be regraded as needed while maintaining minimum side slopes of 3:1.

The existing culvert under Marker Fifty-Five Drive and the existing outlet pipe running along the east side of High Point St. will both be upsized to 18" Reinforced Concrete Pipes (RCPs). The tide gate on the existing outlet pipe will be replaced.

Alternative 1 Phase 1 eliminates flooding from the 2-year storm event along Brunswick Ave. and reduces flooding from the 2-year storm event along OBW. to ~0.1 feet. This alternative also reduces the flood depth of the 10-year storm to ~ 0.1 feet along Brunswick Ave. and ~1.0 foot along OBW.

The estimated construction cost of Alternative 1 Phase 1 is $450k - $675k.

Phase 2

This ROW area may also be suitable for use as a roadway or parking area. Should the Town wish to pave this area for such uses, the storage depression from Phase 1 could be converted to an underground storage/ infiltration system. This underground detention system was modeled after the ADS StormTech SC-310 system (Attachment F). All other improvements from Phase 1 would remain in place.

Alternative 1 Phase 2 produces comparable results to Phase 1.

The estimated construction cost of Alternative 1 Phase 2 is $731k - $1.1 million.

<u>Alternative 2</u>

Phase 1

Alternative 2 Phase 1 includes all improvements proposed in Alternative 1 Phase 1 with the addition of a second 1.5-foot-deep storage depression at 339 Brunswick Ave., another dedicated ROW. This storage depression will be connected to the proposed stormwater network on OBW and discharge north into the Brunswick Ave. channel just before the Marker Fifty-Five Dr. culvert.

Alternative 2 Phase 1 solves flooding on Brunswick Ave. during both the 2-year and 10-year storm events and on OBW during the 2-year storm event. 10-year flood depths on OBW are reduced to ~1.0 foot.

The estimated construction cost of Alternative 2 Phase 1 is $498k - $747k.

Phase 2

Alternative 2 Phase 2 includes all improvements proposed in Alternative 1 Phase 2 with the second storage depression being similarly converted into an underground storage/ infiltration system in order to accommodate a drive and/or parking. This additional underground detention system was modeled after the ADS StormTech SC-160LP system (Attachment F).

Alternative 2 Phase 2 solves flooding on both Brunswick Ave. and OBW during the 2-year storm event. 10-year flood depths are ~1.0 foot on OBW and ~0.1 feet on Brunswick Ave.

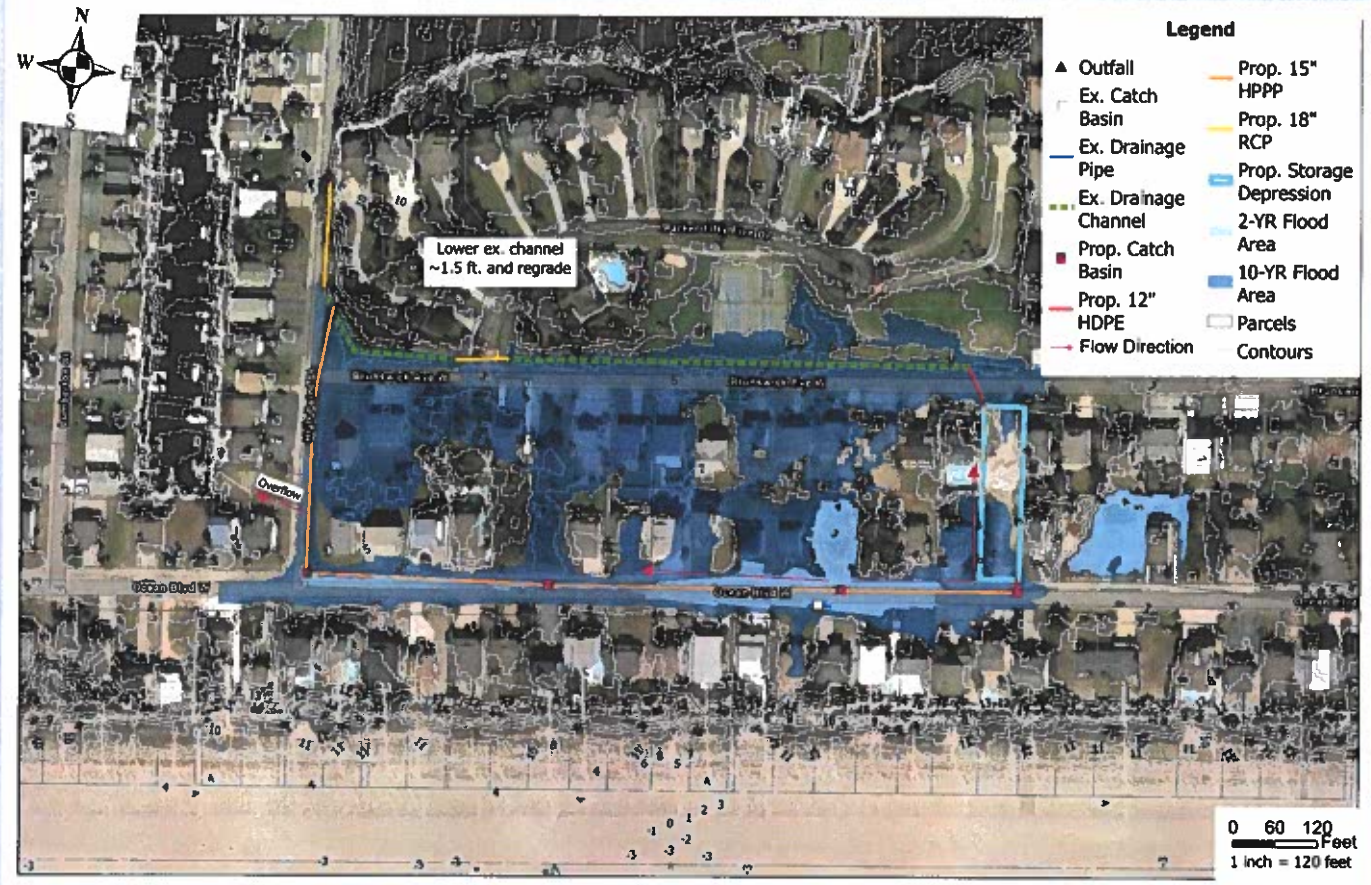
The estimated construction cost of Alternative 2 Phase 2 is $1.55 - $2.33 million.

Table 5.1 - Area 1 Results Comparison

Location	Overtop Elev.	Alternative 1		Alternative 2	
		WSEL	Flood Depth (ft.)	WSEL	Flood Depth (ft.)
2-YEAR STORM					
Ocean Boulevard West	4.85	5.00	0.15	4.68	-
Brunswick Ave. (Start of Channel)	5.91	4.74	-	4.69	-
Brunswick Ave. (Marker Fifty-Five Dr.)	5.30	4.55	-	4.48	-
High Point St. at Outlet Pipe	5.05	4.50	-	4.43	-
10-YEAR STORM					
Ocean Boulevard West	4.85	5.87	1.02	5.85	1.00
Brunswick Ave. (Start of Channel)	5.91	6.09	0.18	6.06	0.15
Brunswick Ave. (Marker Fifty-Five Dr.)	5.30	5.25	-	5.22	-
High Point St. at Outlet Pipe	5.05	5.16	0.11	5.15	0.1

Note that for both Table 5.1 above and the maps in Attachment E, only results for Phase 2 are shown as this is the anticipated final condition. Were Phase 1 to be pursued without Phase 2, results would be slightly lower, however the addition of parking in Phase 2 and the subsequent switch from above ground to underground storage, decreases the amount of storage possible.

Area 1 – Alternative 1 Phase 1	300 Block of Ocean Boulevard West



PROBLEM

Existing road topography along the 300 Block of OBW leads to road flooding during storm events including the 2-year storm. An existing stormwater system along Brunswick Ave., just north of this area, is similarly undersized for the 2-year storm.

SOLUTION

- Construct a 2.5-ft deep storage depression in the ROW at 317 Brunswick Ave. that discharges into the existing Brunswick Ave. channel
- Install system of 15" HPPPs along OBW and High Point St. that discharges into the existing Brunswick Ave. channel
- Lower Brunswick Ave. channel by ~1.5 feet
- Upsize existing Mile Marker Fifty-Five Dr. culvert and outlet pipe along High Point St. to 18" RCPs

PROJECT BENEFITS

This alternative eliminates flooding on Brunswick Ave. and significantly reduces flooding on OBW during the 2-year storm. Flood depths on both Brunswick Ave. and OBW are reduced during the 10-year storm.

PROJECT CHALLENGES

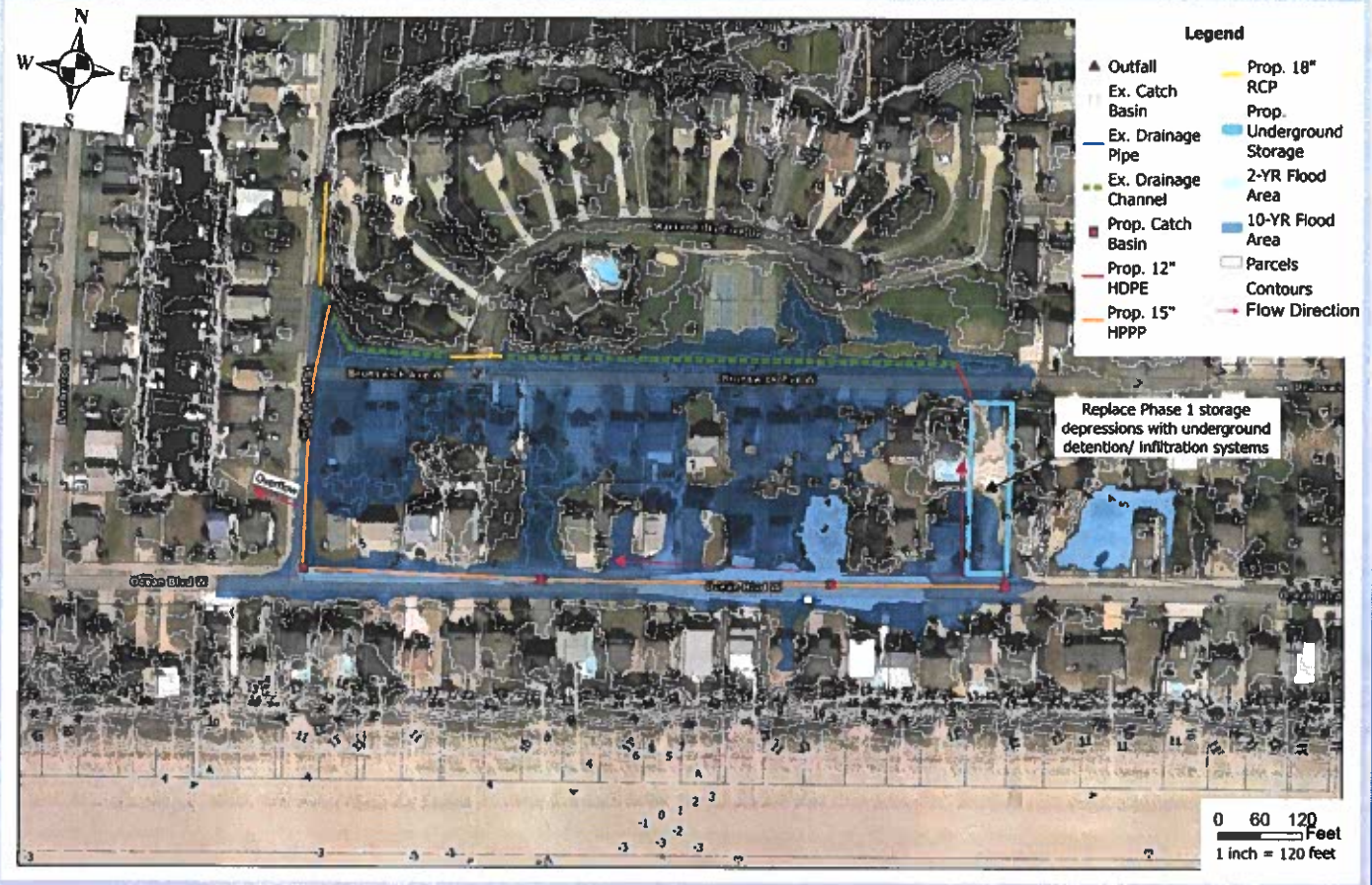
- Disruption of traffic during construction
- Low road surface elevations limit pipe size and material options along OBW
- Small difference between surface elevations and SHWT limits available storage volume

COST

Estimated Construction Cost Range

$450,000 to $675,000

Area 1 – Alternative 1 Phase 2	300 Block of Ocean Boulevard West



PROBLEM

The solution presented in Phase 1 limits the usage of the ROW at 317 Brunswick Ave. which may be suitable for use as roadway or beach access parking.

SOLUTION

- Replace the storage depression at 317 Brunswick Ave. with an underground storage/ infiltration system (StormTech SC-310 or similar) that discharges into the existing Brunswick Ave. channel

PROJECT BENEFITS

This alternative allows for flood reduction comparable to that in Phase 1 while allowing all or part of the ROW to be paved.

PROJECT CHALLENGES

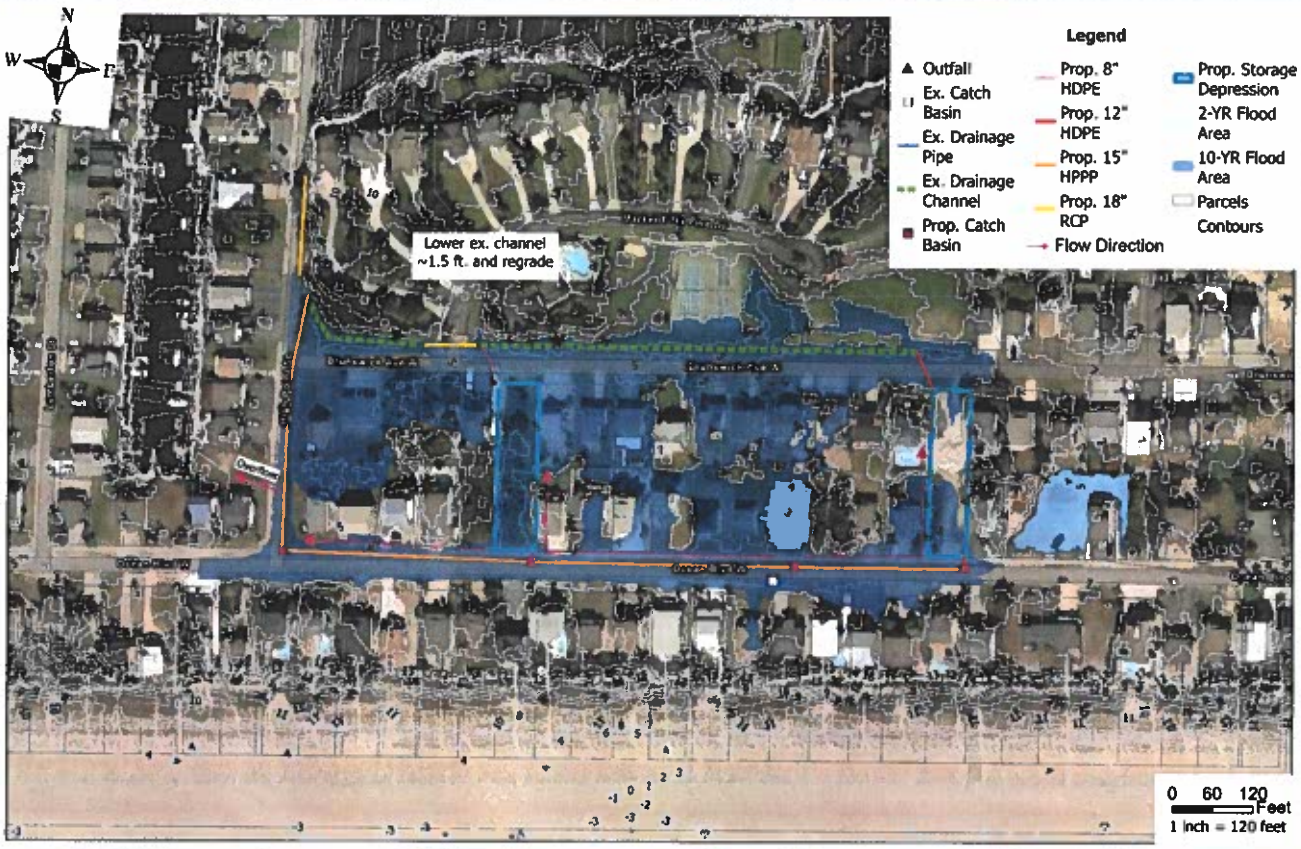
- Small difference between surface elevations and SHWT limits size of underground storage
- High cost

COST

Estimated Construction Cost Range

$731,000 to $1,096,500

Area 1 – Alternative 2 Phase 1	300 Block of Ocean Boulevard West



PROBLEM

Existing road topography along the 300 Block of OBW leads to road flooding during storm events including the 2-year storm. An existing stormwater system along Brunswick Ave., just north of this area, is similarly undersized for the 2-year storm.

SOLUTION

- Construct storage depressions on the ROWs at 317 Brunswick Ave. (2.5-ft-deep) and 339 Brunswick Ave. (1.5-ft-deep) that discharge into the existing Brunswick Ave. channel
- Install a system of 15" HPPPs along OBW and High Point St. that discharges into the existing Brunswick Ave. channel
- Lower Brunswick Ave. channel by ~1.5 feet
- Upsize existing Mile Marker Fifty-Five Dr. culvert and outlet pipe along High Point St. to 18" RCPs

PROJECT BENEFITS

This alternative eliminates flooding on OBW during the 2-year storm and on Brunswick Ave. during both the 2-year and 10-year storms. Flood depths on OBW are reduced during the 10-year storm.

PROJECT CHALLENGES

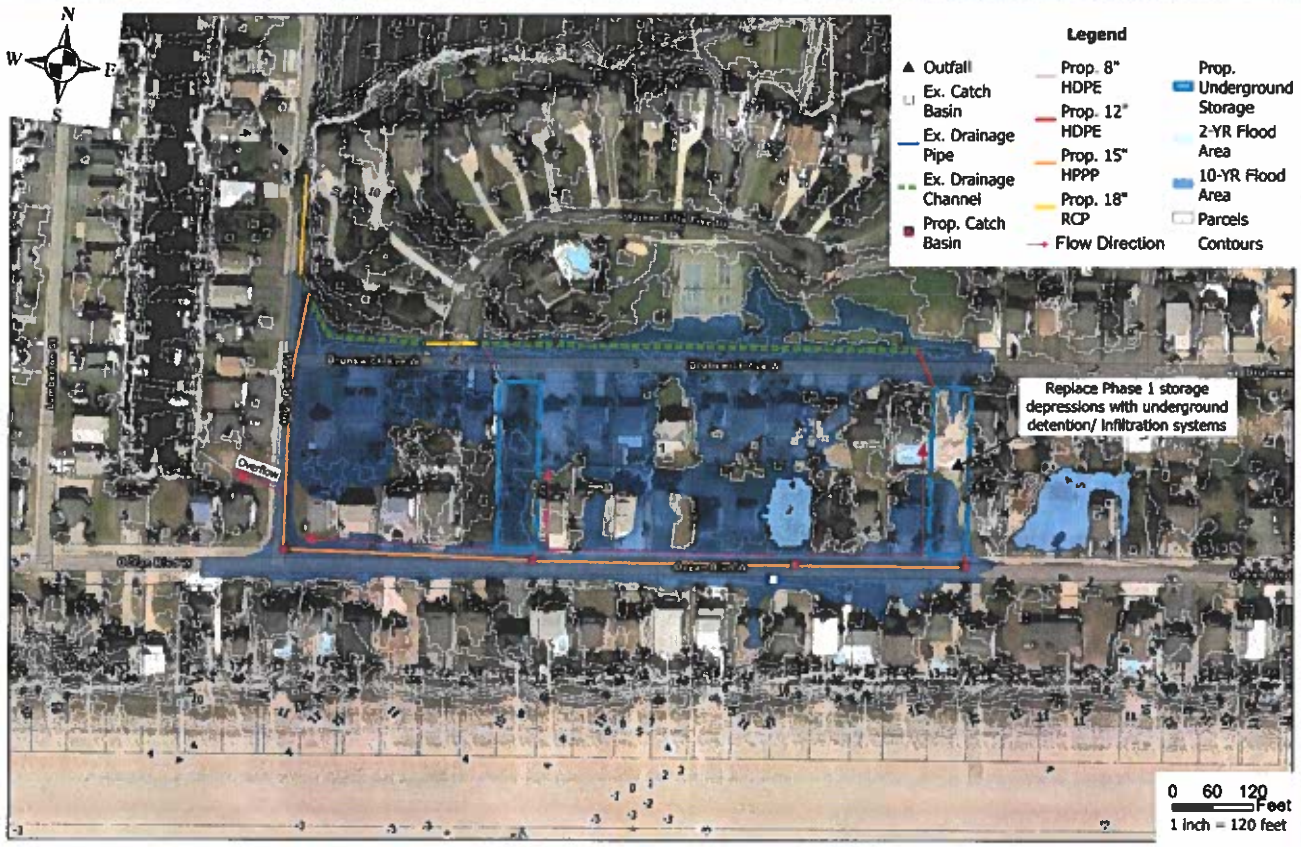
- Disruption of traffic during construction
- Low road surface elevations limit pipe size and material options along OBW
- Small difference between surface elevations and SHWT limits available storage volume

COST

Estimated Construction Cost Range

$498,000 to $747,000

Area 1 – Alternative 2 Phase 2	300 Block of Ocean Boulevard West



PROBLEM

The solution presented in Phase 1 limits the usage of the ROWs at 317 and 339 Brunswick Ave. which may be suitable for use as roadway or beach access parking.

SOLUTION

- Replace the storage depressions with underground storage/ infiltration systems at 317 (StormTech SC-310 or similar) and 339 Brunswick Ave. (StormTech SC-160LP or similar) that discharge into the existing Brunswick Ave. channel

PROJECT BENEFITS

This alternative allows for flood reduction comparable to that in Phase 1 while allowing all or part of the ROW to be paved.

PROJECT CHALLENGES

- Small difference between surface elevations and SHWT limits size of underground storage
- High cost

COST

Estimated Construction Cost Range

$1,550,000 to $2,325,000

Area 2 – East End of Mullet Street Area & East End of Avenue A

Alternative 1

The existing stormwater network along Ocean Boulevard East (OBE) west of Mullet Street will remain with individual pipe inverts dropped as needed to create positive drainage within the system. Existing pipes along OBE east of Mullet St. will be upsized to 24" RCPs with the final of these pipes upsized to a 30" RCP. In order to accommodate the burial of the new 24" RCP, the existing channel at the upstream end of this pipe system will be dropped by ~0.5 feet and regraded as needed while maintaining a minimum side slope of 3:1.

Similarly, the existing pipe under Blockade Runner Drive will be upsized to an 18" RCP with its downstream pipe that runs under OBE upsized to a 24" RCP. All pipes along Mullet St. will be upsized to 30" RCPs and a tide gate will be installed on the final outlet pipe. These are the largest pipe sizes that can reasonably fit underneath the road while maintaining necessary clearance.

Alternative 1 solves flooding from the 2-year storm east of Mullet St. and reduces the 2-year flood depth west of Mullet St. to ~0.5 feet. This alternative also reduces the flood depth of the 10-year storm to ~0.7 foot between Halstead St. and McCray St. and to ~0.25 feet between Avenue A and Dunescape Dr.

The estimated construction cost of Alternative 1 is $650k - $975k.

Alternative 2

Alternative 2 includes all improvements from Alternative 1. Additionally, three (3) 1-foot-deep swales with 4:1 side slopes will be installed along the northern ROW of OBE between McCray Street and Dunescape Drive. 12" HPPP culverts will be installed under roadways to connect the swales and tie them to the existing system.

Alternative 2 produces similar results to Alternative 1, slightly increasing the 10-year flood depth on OBE but providing additional storage capacity along OBE between McCray St. and Dunescape Dr. that is not currently available and eliminating road flooding during the 10-year storm in the same aforementioned area.

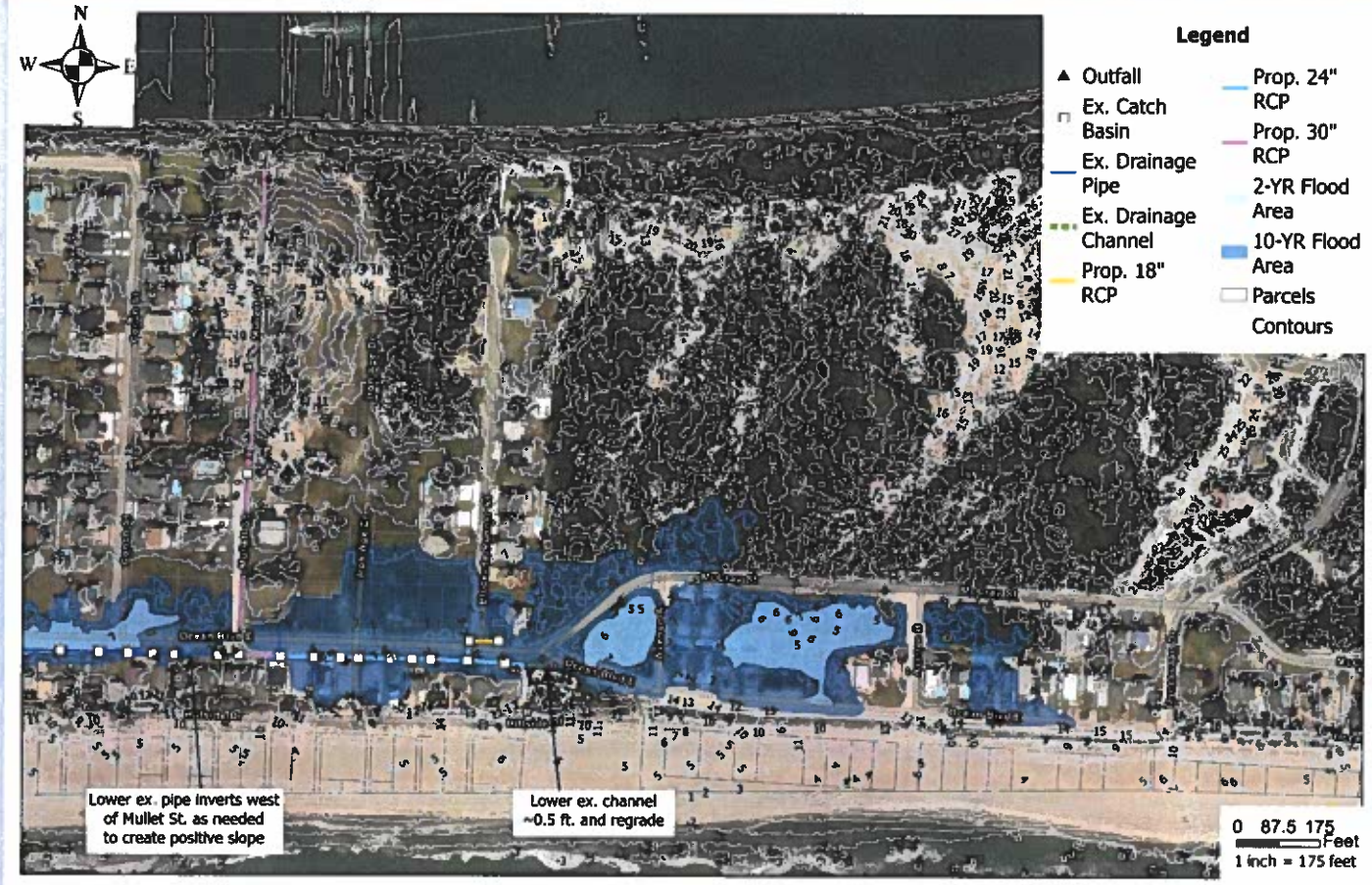
The estimated construction cost of Alternative 2 is $808k - $1.21 million.

Due to the Coastal Area Management Act (CAMA), improvement options in this area are limited.

Table 5.2 – Area 2 Results Comparison

Location	Overtop Elev.	Alternative 1		Alternative 2	
		WSEL	Flood Depth (ft.)	WSEL	Flood Depth (ft.)
2-YEAR STORM					
Ocean Boulevard East (West of Mullet St.)	6.22	6.68	0.46	6.68	0.46
Ocean Boulevard East (East of Mullet St.)	6.45	5.33	-	5.33	-
Ocean Boulevard East (McCray St. - Dunescape Dr.)	7.00	6.63	-	6.63	-
10-YEAR STORM					
Ocean Boulevard East (West of Mullet St.)	6.22	7.26	1.04	7.33	1.11
Ocean Boulevard East (East of Mullet St.)	6.45	7.25	0.80	7.33	0.88
Ocean Boulevard East (McCray St. - Dunescape Dr.)	7.00	7.26	0.26	7.25	0.25

Area 2 – Alternative 1	East End of Mullet Street & East End of Avenue A



PROBLEM

Portions of the existing stormwater network along Ocean Boulevard East (OBE) are undersized for the 2-year storm with the entire system undersized for the 10-year storm. Some pipes within the existing network were installed at a negative slope, leading to water retention and surcharging. A lack of stormwater infrastructure along OBE between McCray St. and Dunescape Dr. leads to roadway flooding in this area during the 10-year storm.

SOLUTION

- Drop inverts of existing pipes along OBE west of Mullet St. as needed to create a positive outfall
- Upsize existing pipes along OBE east of Mullet St. to 24" RCPs
- Drop existing channel on east side of system by ~0.5 feet and regrade
- Upsize pipes at Blockade Runner Dr. to an 18" RCP (upstream-most) and 24" RCP
- Upsize existing pipes on Mullet St. to 30" RCPs
- Install a tide gate on the final outlet pipe

PROJECT BENEFITS

This alternative eliminates flooding on OBE east of Mullet St. during the 2-year storm and reduces flooding west of Mullet St. Flood depths during the 10-year storm are similarly reduced across the entire problem area.

PROJECT CHALLENGES

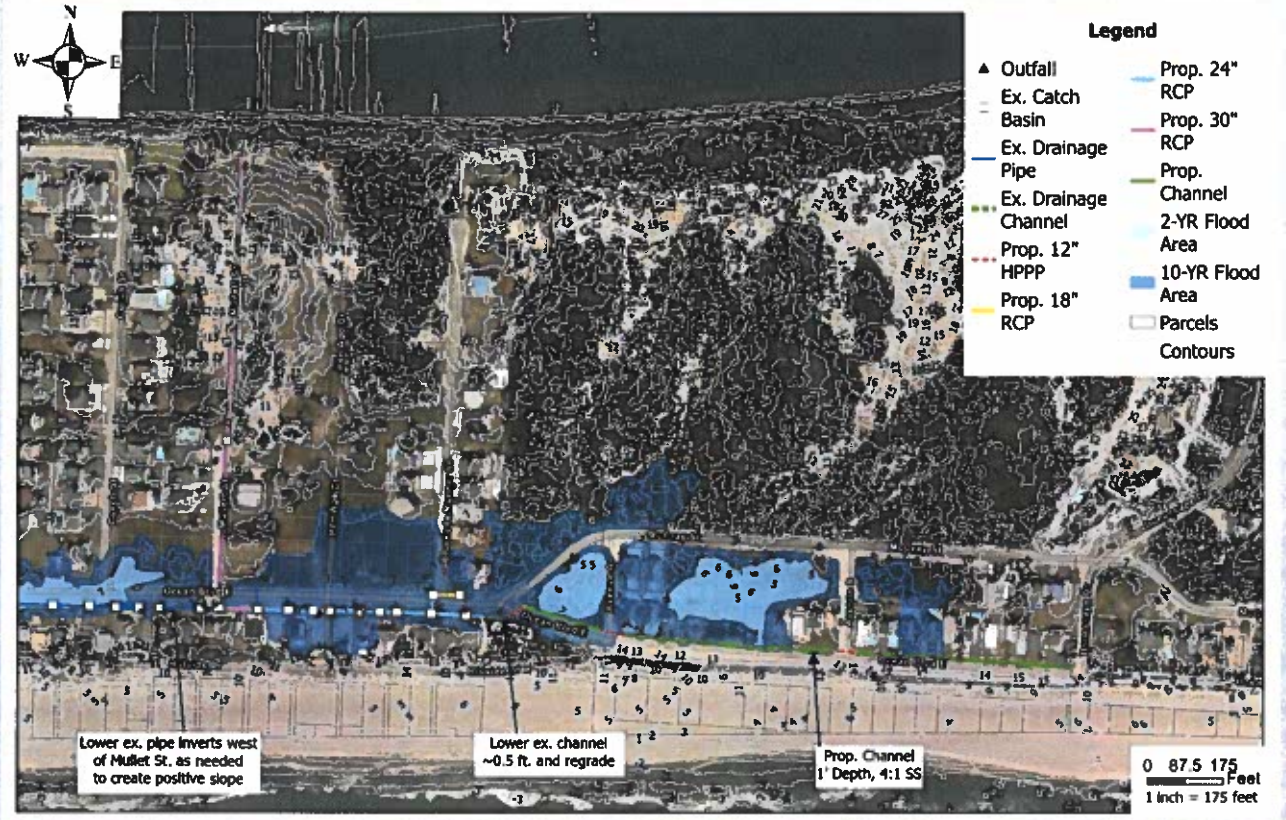
- Disruption of traffic during construction
- Low road surface elevations limit pipe size options along OBE

COST

Estimated Construction Cost Range

$650,000 to $975,000

Area 2 – Alternative 2	East End of Mullet Street & East End of Avenue A



PROBLEM

Portions of the existing stormwater network along Ocean Boulevard East (OBE) are undersized for the 2-year storm with the entire system undersized for the 10-year storm. Some pipes within the existing network were installed at a negative slope, leading to water retention and surcharging. A lack of stormwater infrastructure along OBE between McCray St. and Dunescape Dr. leads to roadway flooding in this area during the 10-year storm.

SOLUTION

- Drop inverts of existing pipes along OBE west of Mullet St. as needed to create a positive outfall
- Install 1-foot-deep swales along OBE between McCray St. and Dunescape Dr., connected to the existing system by 12" HPPPs
- Upsize existing pipes along OBE east of Mullet St. to 24" RCPs
- Drop existing channel on east side of system by ~0.5 feet and regrade
- Upsize pipes at Blockade Runner Dr. to an 18" RCP (upstream-most) and 24" RCP
- Upsize existing pipes on Mullet St. to 30" RCPs
- Install a tide gate on the final outlet pipe

PROJECT BENEFITS

This alternative eliminates flooding on OBE east of Mullet St. during the 2-year storm and reduces flooding west of Mullet St. Flood depths during the 10-year storm are similarly reduced across the entire problem area and roadway flooding between Avenue A and Dunescape Dr. is eliminated.

PROJECT CHALLENGES

- Disruption of traffic during construction
- Low road surface elevations limit pipe size options along OBE
- New stormwater system options are limited without a CAMA permit

COST

Estimated Construction Cost Range

$808,000 to $1,212,000

Area 3 – West End Right-of-Way

Alternative 1

Inlets will be installed on the north side of Ocean Boulevard West (OBW) with at least one (1) at the low point of the road. Inlets will be connected by 12" HPPPs. A 12" RCP will discharge this system through a public utility easement acquisition, adequate public ROW location, or other secured point of outfall, into the Intracoastal Waterway. Catch basins will have open bottoms to allow for infiltration.

Alternative 1 reduces flooding during the 2-year storm event to ~0.4 feet and during the 10-year storm event to ~1.2 feet. These results are approximate and may change depending on the outfall location chosen.

The estimated construction cost of Alternative 1 is $120k - $241k.

Alternative 2

Inlets will be installed on the north side of Ocean Boulevard West (OBW) with at least one (1) at the low point of the road and one inside the ROW in front of 1330 OBW. These inlets will be connected by 12" HPPPs. An 18" RCP outlet pipe will discharge this system through a public utility easement acquisition, adequate public ROW location, or other secured point of outfall, into the Intracoastal Waterway. Catch basins will have open bottoms to allow for infiltration.

Alternative 2 reduces flooding during the 2-year storm event to ~0.8 feet and during the 10-year storm event to ~1.5 feet.

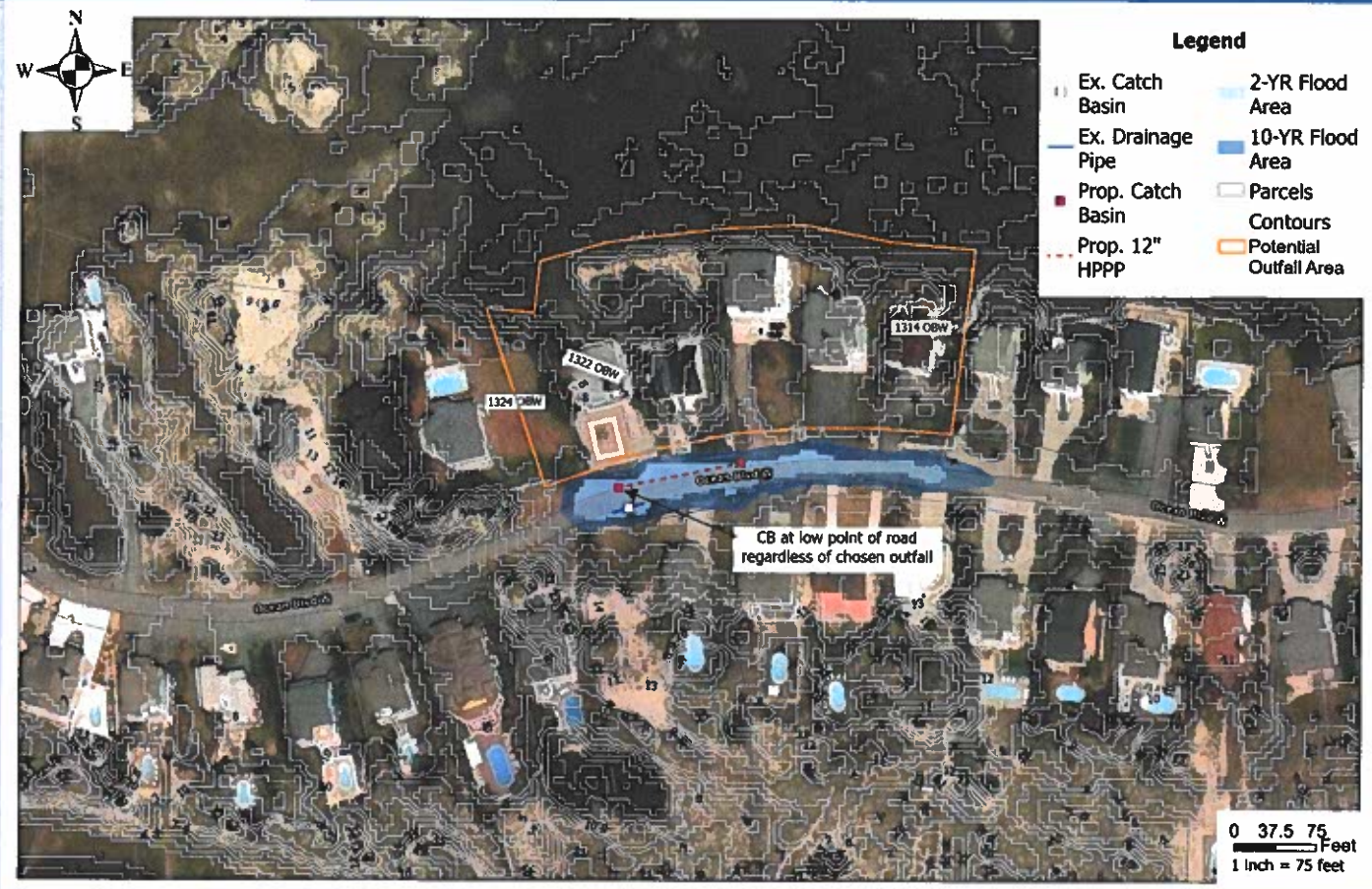
The estimated construction cost of Alternative 2 is $212k - $378k.

Due to the low elevation of the road (elevation 3.6'), options for pipe size and material are limited for both alternatives. A 12" HPPP is the largest pipe that allows for both a positive pipe slope to the outfall and sufficient pipe clearance under the road. Both alternatives will require acquisition of a CAMA permit in order to create a new outfall. New outfalls are feasible as a CAMA major permit. These are evaluated on a case-by-case basis and may require some form of water quality treatment.

Table 5.3 - Area 3 Results Comparison

Location	Storm	Overtop Elev.	Alternative 1		Alternative 2	
			WSEL	Flood Depth (ft.)	WSEL	Flood Depth (ft.)
Ocean Boulevard West	2-year	3.60	3.97	0.37	4.42	0.82
	10-year		4.76	1.16	5.13	1.53

Area 3 – Alternative 1 | **West End ROW**



PROBLEM

Existing road topography of OBW near 1338 OBW leads to road flooding during storm events including the 2-year storm. The current infiltration system is unable to handle these storms and there is no way to drain the road in case of an emergency.

SOLUTION

- Install catch basins within ROW of OBW, including at the low point of the road
- Install 12" HPPPs to connect catch basins
- Install 12" RCP to discharge through easement - location to be chosen by Town

PROJECT BENEFITS

This alternative better reduces flooding along OBW during both the 2-year and 10-year storms.

PROJECT CHALLENGES

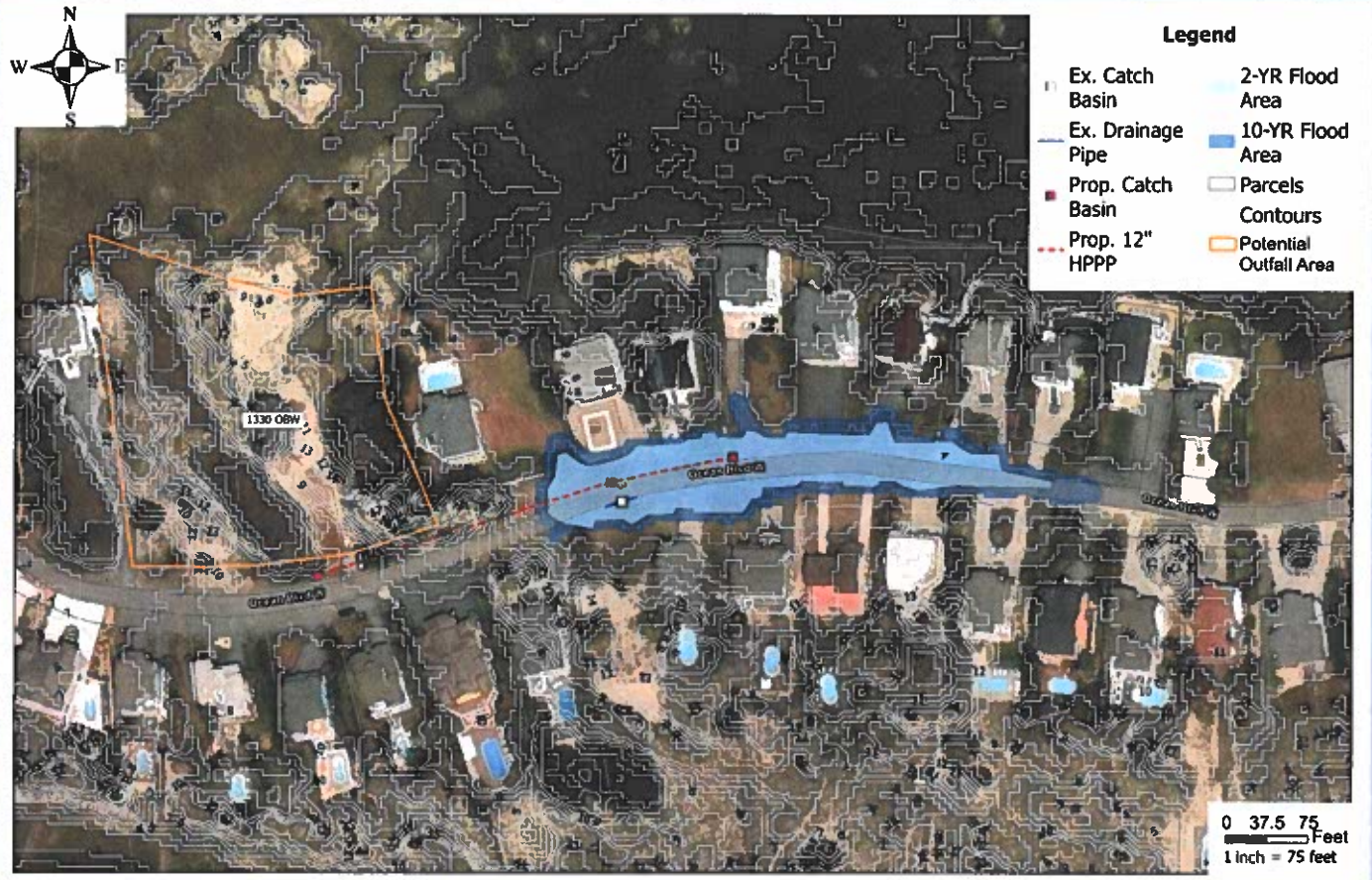
- Disruption of traffic during construction
- Low road surface elevations limit pipe size and material options along OBW
- New stormwater outfalls require a CAMA permit
- May require easement acquisition

COST

Estimated Construction Cost Range

$120,500 to $240,750

Area 3 – Alternative 2	West End ROW



PROBLEM

Existing road topography of OBW near 1338 OBW leads to road flooding during storm events including the 2-year storm. The current infiltration system is unable to handle these storms and there is no way to drain the road in case of an emergency.

SOLUTION

- Install catch basins within ROW of OBW, including at the low point of the road and in front of 1330 OBW
- Install 12" HPPPs to connect catch basins
- Install 18" RCP to discharge through easement – location to be chosen by Town

PROJECT BENEFITS

This alternative somewhat reduces flooding along OBW during both the 2-year and 10-year storms.

PROJECT CHALLENGES

- Disruption of traffic during construction
- Low road surface elevations limit pipe size and material options along OBW
- New stormwater outfalls require a CAMA permit
- May require easement acquisition
- Outfall is within a storage depression that allows backflow into system

COST

Estimated Construction Cost Range

$212,000 to $378,000

Area 4 – 760 Block of Ocean Boulevard West

Alternative 1

Inlets will be installed along the northern edge of Ocean Boulevard West (OBW) with at least one (1) at the low point of the road which will connect to the existing catch basin on the south side of OBW via a 15" RCP. Proposed inlets will be connected via 24" RCPs. A 24" RCP will discharge this system through a public utility easement acquisition, adequate public ROW location, or other secured point of outfall, into the Intracoastal Waterway.

Alternative 1 solves flooding from the 2-year storm event and reduces flood depths from the 10-year storm event to ~0.7 feet.

These results are approximate and may change depending on the outfall location chosen.

The estimated construction cost of Alternative 1 is $149k - $473k.

Alternative 2

Four inlets will be installed along the northern edge of Ocean Blvd. at ~200-foot intervals, starting at the low point of the road and running just past 762 OBW. A 15" RCP will be installed to connect this system to the existing catch basin on the south side of OBW. A 24" RCP will connect the remaining inlets and turn northwest to discharge into the Intracoastal Waterway.

Alternative 2 also solves flooding from the 2-year storm event and reduces flood depths from the 10-year storm event to ~1.3 feet.

This alternative would avoid either easement or property acquisition but would not provide as much reduction in flood depths from the 10-year storm.

The estimated construction cost of Alternative 2 is $273k - $409k.

Both alternatives will require acquisition of a CAMA permit in order to create a new outfall. New outfalls are feasible as a CAMA major permit. These are evaluated on a case-by-case basis and may require some form of water quality treatment.

Table 5.4 - Area 4 Results Comparison

Location	Storm	Overtop Elev.	Alternative 1		Alternative 2	
			WSEL	Flood Depth (ft.)	WSEL	Flood Depth (ft.)
Ocean Boulevard West	2-year	5.09	4.39	-	4.89	-
	10-year		5.81	0.72	6.35	1.26

Area 4 – Alternative 1	760 Block of Ocean Boulevard West

PROBLEM

Existing road topography in the 760 block of OBW leads to road flooding during storm events including the 2-year storm. The current infiltration system is unable to handle these storms and there is no way to drain the road in case of an emergency.

SOLUTION

- Install catch basins within ROW of OBW, including at the low point of the road
- Install 15" RCP to connect existing catch basin to proposed system
- Install 24" RCPs to connect proposed catch basins and discharge through easement or property – location to be chosen by Town

PROJECT BENEFITS

This alternative eliminates flooding along OBW during the 2-year storm and better reduces flooding during the 10-year storm.

PROJECT CHALLENGES

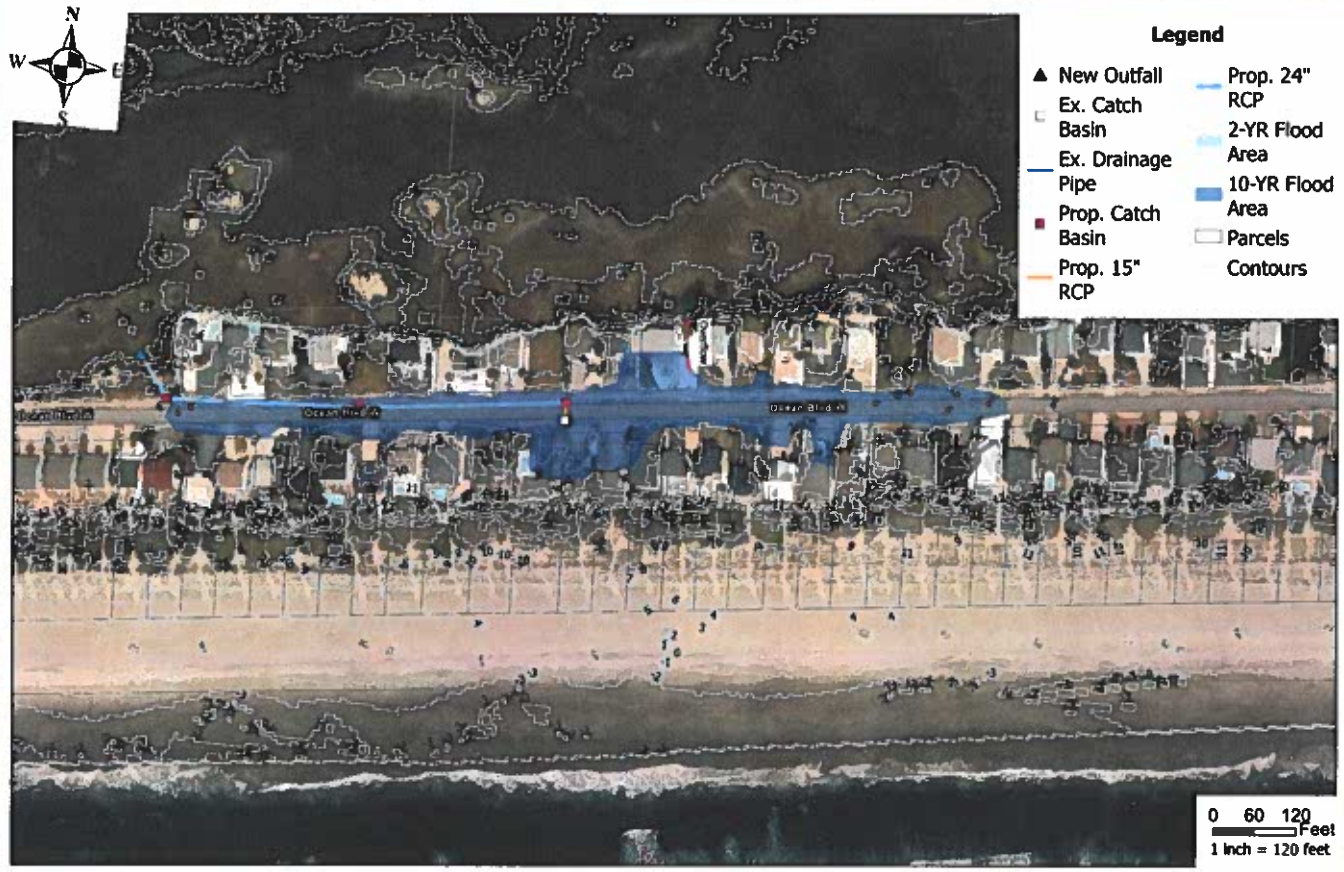
- Disruption of traffic during construction
- New stormwater outfalls require a CAMA permit
- May require easement or property acquisition

COST

Estimated Construction Cost Range

$148,500 to $472,750

Area 4 – Alternative 2	760 Block of Ocean Boulevard West



PROBLEM

Existing road topography in the 760 block of OBW leads to road flooding during storm events including the 2-year storm. The current infiltration system is unable to handle these storms and there is no way to drain the road in case of an emergency.

SOLUTION

- Install catch basins within ROW of OBW from low point of the road to 762 OBW
- Install 15" RCP to connect existing catch basin to proposed system
- Install 24" RCPs to connect catch basins and discharge into Intracoastal Waterway

PROJECT BENEFITS

This alternative eliminates flooding along OBW during the 2-year storm and somewhat reduces flooding during the 10-year storm. It does not require easement or property acquisition.

PROJECT CHALLENGES

- Disruption of traffic during construction
- New stormwater outfalls require a CAMA permit

COST

Estimated Construction Cost Range

$272,500 to $408,750

Area 5 – Carolina Avenue

Alternative 1

Two inlets will be installed, one on the north side of Carolina Avenue at the low point of the road and another in the parking lot of Halstead Park. These inlets will be connected via 30" RCPs with junction boxes at the intersections of Carolina Ave. & Halstead St. and Halstead St. & Southshore Dr. to facilitate pipe elevation and direction changes. A 30" RCP will also connect the first proposed inlet to the existing catch basin on the south side of Carolina Ave.

The inlet in the parking lot of Halstead Park will also act as the outflow, with water leaving the system by bubbling up out of the inlet and sheet flowing over the parking lot and into the Intracoastal Waterway.

This alternative solves flooding from both the 2-year and 10-year storm events without requiring a CAMA permit.

The estimated construction cost of Alternative 1 is $207k - $310k.

Alternative 2

This alternative utilizes the same pipe and structure layout as Alternative 1 but using a 24" RCP instead of a 30" RCP and installing an outlet pipe from the final inlet that discharges into the Intracoastal Waterway. While this alternative is more hydraulically efficient, providing a higher level of service and eliminating discharge within a parking area as depicted in Alternative 1, it will create a new stormwater outlet and thus require a CAMA permit. New outfalls are feasible as a CAMA major permit. These are evaluated on a case-by-case basis and may require some form of water quality treatment.

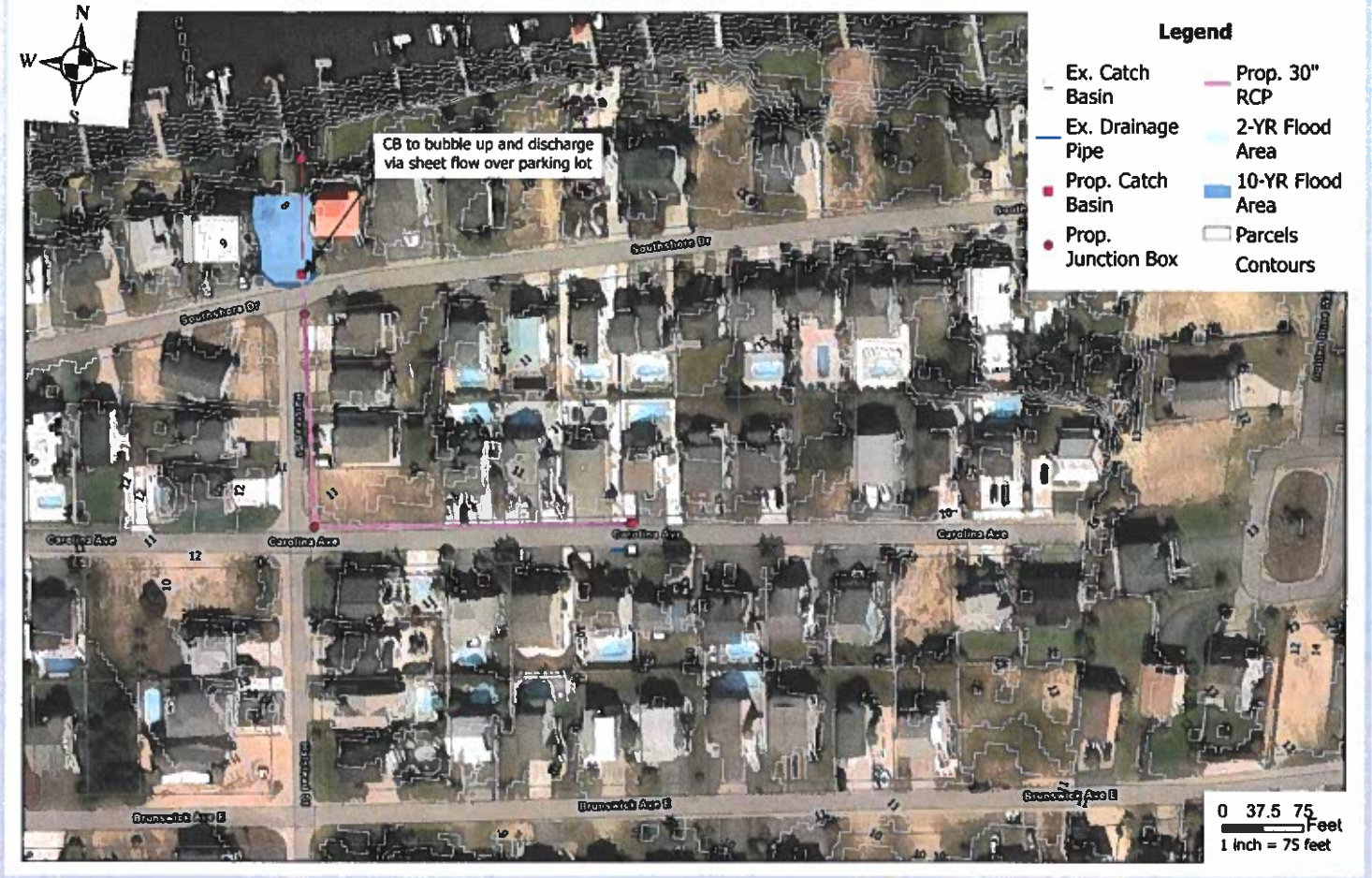
This alternative solves flooding from both the 2-year and 10-year storm events.

The estimated construction cost of Alternative 1 is $205k - $327k.

Table 5.5 - Area 5 Results Comparison

Location	Storm	Overtop Elev.	Alternative 1		Alternative 2	
			WSEL	Flood Depth (ft.)	WSEL	Flood Depth (ft.)
Carolina Avenue	2-year	9.70	8.71	-	7.48	-
	10-year		9.43	-	8.40	-

Area 5 – Alternative 1	Carolina Avenue



PROBLEM

Existing road topography along Carolina Ave. east of Halstead St. leads to road flooding during storm events including the 2-year storm. The current infiltration system is unable to handle these storms.

SOLUTION

- Install catch basins and junction boxes within ROW of Carolina Ave. and Halstead St.
- Install 30" RCPs to connect existing and proposed structures

PROJECT BENEFITS

This alternative eliminates flooding along Carolina Ave. during the 2-year and 10-year storms without the need for a CAMA permit.

PROJECT CHALLENGES

- Disruption of traffic during construction
- Creates flooding across Southshore Dr. during the 10-year storm and through the Halstead Park parking lot during both the 2-year and 10-year storms.

COST

Estimated Construction Cost Range

$206,500 to $309,750

Area 5 – Alternative 2 | **Carolina Avenue**

PROBLEM

Existing road topography along Carolina Ave. east of Halstead St. leads to road flooding during storm events including the 2-year storm. The current infiltration system is unable to handle these storms.

SOLUTION

- Install catch basins and junction boxes within ROW of Carolina Ave. and Halstead St.
- Install 24" RCPs to connect existing and proposed structures and discharge into the Intracoastal Waterway

PROJECT BENEFITS

This alternative eliminates flooding along Carolina Ave. during both the 2-year and 10-year storms.

PROJECT CHALLENGES

- Disruption of traffic during construction
- New stormwater outfalls require a CAMA permit

COST

Estimated Construction Cost Range

$204,500 to $327,200

6.0 Stormwater Project Recommendations

The following is a summary of the recommended alternative for each area of concern based on the extent of improvements, implementation cost, ease of implementation, and overall net benefit, followed by a tabulation of the estimated cost for each (Table 6.1).

The recommended solutions are not interdependent, therefore the Town could implement any of the recommended solutions at any time, depending on funding availability, easement and/or property acquisition, and coordination with stakeholders (e.g. NCDOT).

Area 1 – 300 Block of OBW

Several hundred feet of public ROW along Ocean Boulevard West (OBW), in an area referred to as the 300 Block, and Brunswick Avenue to the north, experience significant floodwater retention following storm events. As previously mentioned in Section 5, only Phase 1 of these alternatives is recommended in this report.

Alternative 1 Phase 1 would eliminate 2-year flooding along Brunswick Ave. while reducing 2-year flood depths on Brunswick Ave. and 10-year flood depths across the entire area. Alternative 2 Phase 1 would eliminate 2-year flooding across the entire area and 10-year flooding on Brunswick Ave. while reducing 10-year flooding on OBW.

As the only difference between the alternatives is the addition of a second storage depression in Alternative 2 which does not significantly increase expected construction costs, Alternative 2 Phase 1 is recommended in order to achieve a 2-year level of service across the entire area and a 10-year level of service along Brunswick Ave.

Area 2 – East End of Mullet Street & East End of Avenue A

Public ROW along Ocean Boulevard East (OBE) on the east end of Holden Beach, between Ferry Road and Dunescape Drive, experiences frequent periods of standing water following rain events as runoff is transported through the existing stormwater network or infiltrates into the soil. Both alternatives involve upsizing the existing stormwater system such that a 2-year level of service is achieved in the section of OBE east of Mullet St. and the entire area sees a reduction in flood depths due to both 2-year and 10-year storms. Alternative 2 further reduces flooding from the 10-year storm by eliminating roadway flooding along OBE between Avenue A and Dunescape Dr.

Despite its slightly higher cost, Alternative 2 is therefore recommended for its higher level of improvement.

Area 3 – West End ROW

The public ROW near 1338 Ocean Boulevard West experiences flooding following storm events. Both alternatives would improve flood conditions during both the 2- and 10-year storms.

Alternative 1 produces a better chance of successful flood drawdown as it allows for less piping, and therefore a steeper slope and higher pipe capacity, to reach an outfall in the Intracoastal Waterway. As it is also the lower cost option, Alternative 1 is recommended, with future survey needed to identify an appropriate outfall location.

Area 4 – 760 Block of Ocean Boulevard West

The public ROW near 743 Ocean Boulevard West experiences flooding following storm events. Both alternatives will solve flooding from the 2-year storm with Alternative 1 being more effective at draining the 10-year storm due to its steeper pipe slope. However, the cost of property acquisition is likely not worth the small improvement in system efficiency. Therefore, Alternative 2 is recommended, with future survey needed to identify an appropriate outfall location.

Area 5 – Carolina Avenue

The public ROW near 142 Carolina Avenue experiences flooding following storm events. Both alternatives would eliminate flooding from both 2-year and 10-year storms.

Alternative 2 is the more hydraulically efficient option, providing a higher level of service without requiring localized flooding, therefore it is recommended despite higher costs due to permitting.

Area 6 – Davis Street

While no flooding was reported in this area, the Town has reported surface runoff erosion that may be impacting water quality. In order to catch sediment before it reaches the nearby Intracoastal Waterway, the installation of a grassed blind swale/detention area and possible level spreader at the end of Davis St. is recommended, with existing outfall piping retrofits suitable for proper operation.

Table 6.1. Summary of Selected Alternatives

Project Area	Project Description	Selected Alternative	Cost Estimate
1	300 Block OBW	2	$498k - $747k
2	East End Mullet St. & East End Avenue A	2	$808k - $1.21 million
3	West End ROW	1	$121k - $241k
4	760 Block OBW	2	$273k - $409k
5	Carolina Ave	2	$204k - $327k
6	Davis St	-	$17.5k - $26.25k

7.0 Other Problem Areas

A heat map of the entire island was developed to indicate areas where roadway or structure flooding is likely to occur (Attachment G). QL2 LiDAR was supplemented with survey data where available. Low areas on roads or near structures that might hold water were identified and these areas were analyzed as storage devices in PCSWMM to determine if significant flooding would occur during the 2-year storm. The extents of the MHHW tide are also shown to indicate which areas are most likely to be impacted by sunny day tidal flooding.

Table 7.1 below lists each area not previously covered in this report that is susceptible to flooding during the 2-year storm event, MHHW tide, or both. Areas are listed in order of location, from west to east. Each row number corresponds to the area labeled on the maps in Attachment G.

Table 7.1 - Potential Additional Areas of Concern

Area No.	Location	Flood Event	Length of Road Flooded (ft.)	Avg. Depth of Road Flooding (ft.)	Max. Flood Depth Before Relief (ft.)	Existing Stormwater System
1	OBW – Saltation Ct. & Loggerhead Dr.	2-year MHHW Tide	610 100	0.56 0.5	0.75 -	Single infiltration pipe
2	Saltation Dr.	MHHW Tide	110	0.5	-	None
3	OBW & Shell Dr.	2-year	700	0.4	0.5	System of infiltration pipes
4	Sea Gull Dr.	MHHW Tide	225	0.5	-	None
5	Pointe West Dr.	2-year	65	0.3	0.5	System of 15" RCP culverts
6	Sailfish St.	MHHW Tide	1,250	1.5	-	None

Area No.	Location	Flood Event	Length of Road Flooded (ft.)	Avg. Depth of Road Flooding (ft.)	Max. Flood Depth Before Relief (ft.)	Existing Stormwater System
7	Tarpon Dr.	MHHW Tide	1,150	0.5	-	System of 12" CPPs
8	Marlin Dr.	MHHW Tide	750	0.5	-	System of 6" & 12" CPPs
9	Tuna Dr.	2-year MHHW Tide	400 940	0.5 1.5	0.75 -	None
10	Dolphin St.	MHHW Tide	620	1.0	-	None
11	Swordfish Dr.	MHHW Tide	730	1.0	-	None
12	Sand Dollar St.	MHHW Tide	1,250	1.5	-	None
13	Scotch Bonnet Dr.	MHHW Tide	1,360	1.5	-	None
14	Greensboro St.	MHHW Tide	1,050	1.0	-	None
15	Charlotte St.	MHHW Tide	440	0.5	-	None
16	Sanford St.	MHHW Tide	400	0.5	-	None
17	Raleigh St.	MHHW Tide	140	0.5	-	None
18	Fayetteville St.	MHHW Tide	120	0.5	-	None
19	Lumberton St.	MHHW Tide	75	0.5	-	None
20	High Point St.	MHHW Tide	600	0.5	-	None

Area No.	Location	Flood Event	Length of Road Flooded (ft.)	Avg. Depth of Road Flooding (ft.)	Max. Flood Depth Before Relief (ft.)	Existing Stormwater System
21	OBW & Yacht Watch Dr.	2-year	650	1.2	1.75	System of 12" & 18" RCPs
22	Brunswick Ave. W.	2-year	190	0.2	0.75	None
23	Davis St.	MHHW Tide	60	0.5	-	None
24	OBE – Halstead St. to Mullet St.	2-year	1,230	0.4	2.0	System of 15" & 18" RCPs
25	Serenity Ln.	2-year	400	0.7	0.75	None

8.0 Stormwater Utility Feasibility Assessment

A financial model specific to the proposed Holden Beach Storm Water Utility (SWU) was developed using expected expenses for administration, operation, maintenance, and capital projects provided by the Town. Costs associated with each of these functions were used to determine the overall revenue requirements of the utility. User charges required to meet these revenue needs were developed on a monthly per parcel basis. Revenue and expenses were then projected for a period of 10 years based on customer growth rate, inflation, etc., to get a sense of the utility's potential viability.

8.1 Revenue

Revenue is determined using a flat fee amount per month for each parcel, which is a typical methodology for a number of Stormwater Utilities in North Carolina. The financial model uses $7.20 per developed parcel. This compares to four (4) stormwater utilities in coastal communities within approximately 30 miles that charge a flat fee. The median value of these utilities (Oak Island, Kure Beach, Carolina Beach, and Wilmington) charged for residential properties based on a building lot with approximately 3,000 square feet of impervious surface is $11.76.

Table 8.1 - Coastal Communities with Stormwater Utilities using Flat Rates

Jurisdiction	Flat Fee
Oak Island	$7.04
Kure Beach	$15.00
Carolina Beach	$17.00
Willmington	$8.51
Median	$11.76

Revenue transferred from the Town's General Fund required for startup of the proposed stormwater utility is anticipated in the amount of $300,000. This amount is repaid to the General Fund at year 10-year of the planning period (FY34).

The model allows revenue generation to be adjusted based on changes to input and assumption entries to create various scenarios for evaluation. The values used for alternate scenarios are listed with the description of each model scenario.

The Town requested an alternate scenario (Scenario B) that assumes USACE Federal 5113 funding is secured and therefore reduces the cost of each capital improvement project by 75%. All other assumptions and inputs remain constant in Scenario B.

8.2 Expenses

Expenses include ongoing costs for personnel, operations, maintenance, capital investment, debt service, transfers, and contingency as applicable. Repayment of the startup funding contribution is anticipated to begin in FY26, and transfers will continue to complete full

repayment in FY34. The costs for personnel, operations, maintenance, and capital investment have all been developed in collaboration with Holden Beach management staff.

Capital Improvements are funded using available stormwater utility resources including available Fund Balance, Sinking Fund, debt issues as necessary, and/or external sources (grants, legislative appropriation, etc.). Fund Balance is managed to maintain a minimum of 90 days of Cash on Hand. Transfers to the Sinking Fund are determined by the funding amount(s) required for specific future capital investments, i.e. construction projects, specialized equipment, etc., and/or available net income generated by utility user fees.

The model allows expense forecasts to be adjusted based on changes to input and assumption entries to create various scenarios for evaluation. The values used for these inputs are listed in Table 8.2.

8.3 Utility Scenarios

Two stormwater utility scenarios were created for the Town's consideration using the inputs and assumptions shown in Tables 8.2 and 8.3.

Scenario A assumes 100% of the projected capital investment needs are funded by user fees generated by the stormwater utility.

Scenario B assumes 75% of the projected capital investment needs are funded using US Army Corps of Engineers (USACE) Environmental Infrastructure Assistance.

The model allows for adjustments to be made to each input and assumption to see the effect of each potential change and quantifies the resulting outcomes for evaluation of the utility's viability and sustainability.

Table 8.2 – Summary of Financial Model Scenario Inputs & Assumptions

Model Parameters		Scenario A	Scenario B
Inputs	Developed Parcels	3,617	3,617
	Initial Monthly Fee: Per Parcel Basis	$7.20	$5.30
	Developed Parcel growth rate (annual)	0.2%	0.2%
Assumptions	Inflation: Personnel / Labor	4.5%	4.5%
	Inflation: Other operating expenses	2.5%	2.5%
	Capital Improvements Funding Source(s)	User Fees 100%	USACE 75% User Fees 25%
	Debt Issues: Bank Loan Terms	20-Years 4.25% Interest	5-Years 5.25% Interest
	Sinking Fund Target per 5-year cycle	$200,000	$400,000
	Fund Balance Target: Min. Days Cash on Hand	90	90

Table 8.3 - Financial Model Scenario Output Summary Tables: 5-Year Snapshot

Scenario A - Model Outputs and Tracking

Parameter	Year 1	Year 2	Year 3	Year 4	Year 5
Per-Parcel Monthly Fee	$7.20	$7.40	$7.60	$7.80	$7.90
Sinking Fund Balance	$ 62,000	$ 124,000	$ 154,000	$ 214,000	$ 269,000
Fund Balance	$ 458,000	$ 540,000	$ 567,000	$ 494,000	$ 362,000
Days Cash on Hand	1,076	821	678	435	276

Scenario B - Model Outputs and Tracking

Parameter	Year 1	Year 2	Year 3	Year 4	Year 5
Per-Parcel Monthly Fee	$5.30	$5.40	$5.60	$5.70	$5.90
Sinking Fund Balance	$ 62,000	$ 124,000	$ 154,000	$ 224,000	$ 299,000
Fund Balance	$ 375,000	$ 366,000	$ 382,000	$ 312,000	$ 199,000
Days Cash on Hand	882	546	613	356	195

*See Attachment I for 10-Year Expanded Table

8.4 Model Outcomes

Model outcomes are presented in a series of data tables (Attachment I) including a summary chart showing a 10-year projection of revenue, expenses, user fee adjustments, financial outcomes (net income), effect on user fees, financial indicator (benchmark) and capital improvements plan (CIP). Definitions of each of the model outcome parameters are as follows:

Revenue and Expenses

Revenue data is presented in the following three (3) general categories:
1. Operating Revenue Base User Fee: Represents revenue generated by initial stormwater utility user fees and increases by the addition of parcels over time.
2. New Revenue – Fee Adjustments: Revenue generated by projected user fee increases that are based on a 2.5% annual rate of inflation.
3. Total Projected Revenue: The sum of the former revenue categories.

Expenses are presented in the following four (4) general categories:
1. Cash Financed Capital Improvements Plan (CIP): Capital projects that are funded using available utility fund equity (cash).
2. Projected Debt Service: Projected principal and interest payments on debt incurred to fund capital improvements.
3. Existing Debt Service: Principal and interest payments on debt incurred in years prior to the financial model.
4. Operating Expenses: The remaining costs to operate and maintain the stormwater utility.

Percent Increase Applied

Tracks overall revenue percentage adjustments needed to keep pace with inflation (assumed at 2.5%).

Financial Outcomes

Tracks total annual revenue less expenses and the difference or shortage (positive or net income) for each year.

Effect on User Fees

Tracks the net monthly fee for each customer class (residential and commercial) and dollar-amount adjustments as they occur.

Financial Indicators

Track the general sufficiency of revenue over expenses. Fund Balance Tracker reports available cash for the beginning of each fiscal year and is an indication of the general stability of the utility. Days Cash on Hand shows number of days that fund balance (cash) would cover expenses in the absence of operating revenue (user fees). Values consistently above the target of 90 days indicate effective overall management of the utility.

Summary Chart

Graphic display of the data described above, showing the relationships between various types of revenue and expenses, and providing a general indication of anticipated revenue and expense trending over time.

Capital Investment

Summarizes the cost and timing of capital projects over the 10-year planning period.

8.5 Recommendations

Based on the project cost of capital stormwater projects and on-going and planned maintenance for the stormwater system we recommend proceeding with implementation of Scenario A. This scenario provides sufficient funds to cover the planned activities for the next ten years while maintaining a sufficient fund balance that suggests the utility will remain stable and fiscally healthy. If pursuit of grant funding is favorable, the utility can easily be converted to Scenario B in the future and rates reevaluated at that time.

REFERENCES

2023-24 UNC School of Government, Environmental Finance Center NC Residential Stormwater Utility Fee Dashboard https://efc.sog.unc.edu/nc-stormwater-dashboard/

ECS Southeast LLC, *Report of Seasonal High Water Table Estimation and Infiltration Testing: Ocean Boulevard Driveway*, ESC Project No. 49.22774, April 5, 2024

NC Spatial Data Download https://sdd.nc.gov/

NOAA's National Weather Service Precipitation Frequency Data Server https://hdsc.nws.noaa.gov/hdsc/pfds/pfds_map_cont.html?bkmrk=nc

NOAA's Tides & Currents Tidal Datums https://tidesandcurrents.noaa.gov/stations.html?type=Datums

United States Department of Agriculture, Natural Resources Conservation Service, Web Soil Survey https://websoilsurvey.sc.egov.usda.gov/App/WebSoilSurvey.aspx

USGS, National Land Cover Database https://www.usgs.gov/centers/eros/science/national-land-cover-database?qt-science_center_objects=0#qt-science_center_objects

Urban Hydrology for Small Watersheds, Technical Release 55, United States Department of Agriculture, June 1986

Appendix A

As-Built Survey & Stormwater Network Map

TOPOGRAPHIC & STORMSEWER ASBUILT SURVEY FOR:

TOWN OF HOLDEN BEACH

FEBRUARY 2024

PREPARED FOR:

mcgill Shaping Communities Together

SURVEYOR'S CERTIFICATE

I CERTIFY THAT THIS GROUND SURVEY WAS PERFORMED AT THE 95 PERCENT CONFIDENCE LEVEL TO MEET FEDERAL GEOGRAPHIC DATA COMMITTEE STANDARDS; THAT THIS SURVEY WAS PERFORMED TO MEET THE REQUIREMENTS FOR A TOPOGRAPHIC SURVEY TO THE ACCURACY OF CLASS A AND VERTICAL ACCURACY WHEN APPLICABLE TO THE CLASS C STANDARD, AND THAT THE ORIGINAL DATA WAS OBTAINED ON 09-23-2023; THAT THE SURVEY WAS COMPLETED ON 02-05-2024; THAT CONTOURS SHOWN AS [BROKEN LINES] MAY NOT MEET THE STATED STANDARD; AND ALL COORDINATES ARE BASED ON N.A.D. 83 (2011 ADJUSTMENT) AND ALL ELEVATIONS ARE BASED ON N.A.V.D. 88; THAT THE GRID TIE TO PROJECT CONTROL SHOWN WAS PERFORMED UNDER MY SUPERVISION FROM AN ACTUAL GPS SURVEY MADE UNDER MY SUPERVISION AND THE FOLLOWING INFORMATION WAS USED TO PERFORM THIS SURVEY:

CLASS OF SURVEY:	AA
POSITIONAL ACCURACY:	0.008 METERS
TYPE OF GPS FIELD PROCEDURE:	RTN
DATES OF SURVEY:	10-26-2023
DATUM/EPOCH:	NAD 83-2011
PUBLISHED /FIXED CONTROL:	RTN
GEOID MODEL:	18B
COMBINED GRID FACTOR:	1.00014710
UNITS:	US FEET

THAT THE RATIO OF PRECISION IS 1:10,000; AND THAT THIS SURVEY IS OF AN EXISTING PARCEL OF LAND; AND THAT THIS MAP MEETS THE REQUIREMENTS OF THE STANDARDS OF PRACTICE FOR LAND SURVEYING IN NORTH CAROLINA (21 NCAC 56. 1600). THIS 5TH DAY OF FEBRUARY, 2024.

PRELIMINARY DRAWING
NOT CERTIFIED FOR RECORDING.
SALES OR CONVEYANCE WITHOUT ORIGINAL SEAL & SIGNATURE

PROFESSIONAL LAND SURVEYOR — NC L-3387

PROJECT CONTROL POINTS (NAD 83/2011)

DESCRIPTION	POINT NUMBER	NORTHING (US FT.)	EASTING (US FT.)	ELEVATION (US FT.)
HB 005 MONUMENT	10004	60874.23	2226046.10	7.46
NCGS - FERRY	10001	60842.10	2224472.25	9.13
MNF-JORDAN BLVD	2114	61029.42	2222242.48	14.17
MNF - OBW & DELANNE	11501	60342.61	2220390.53	6.33
CSPK - OBW & HIGHPOINT	10612	59861.31	2219541.89	4.80
CSPK - OBW & CHARLLOTTE	12222	59356.89	2218206.91	5.78
MNF - OBW & GREENSBORO	12221	59510.59	2212443.08	5.29
CSPK - OBW & SHELL	3802	57251.49	2195108.01	6.71
MNF - 1321 OBW	2820	56385.49	2190567.76	3.68

PROJECT LEGEND

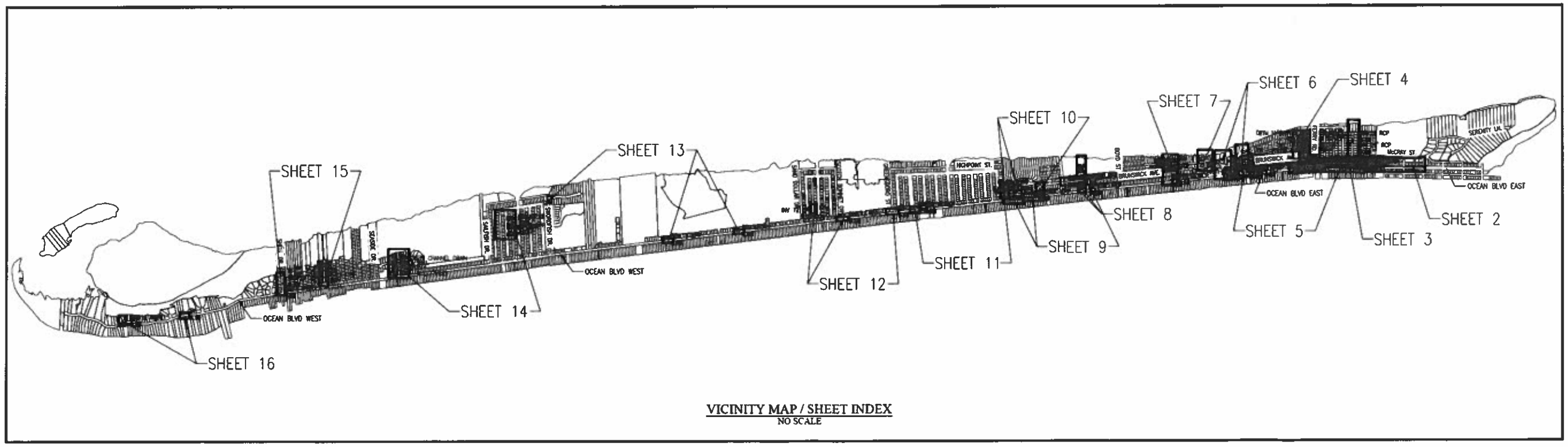
LABEL	SYM.	DESCRIPTION
IPF/IRF		IRON PIPE /ROD FOUND
MNF		MAG NAIL FOUND
CMF		CONC. MON. FOUND
NCGS		GEODETIC MONUMENT
CSPK		COTTON SPIKE
CATV		CABLE TV PEDESTAL
TPED		TELEPHONE PEDESTAL
TMH		TELEPHONE MANHOLE
FOP		FIBER OPTIC POST
FOB	FOB	FIBER OPTIC BOX
IRV		IRRIGATION VALVE
EB		ELECTRIC BOX
SMH		SEWER MANHOLE
SCO		SEWER CLEANOUT
SV		SEWER VALVE
RPZ		REDUCED PRESSURE ZONE
FH		FIRE HYDRANT
WM		WATER METER
SWMH		STORMWATER MANHOLE
GS	+25.1	SPOT ELEVATION
CB		CATCH BASIN
INV.		INVERT OF PIPE
CPP		CORRUGATED PLASTIC PIPE
RCP		REINFORCED CONCRETE PIPE
CMP		CORRUGATED METAL PIPE
HDPE		HIGH DENSITY POLYETHYLENE PIPE
R/W		RIGHT OF WAY

GENERAL NOTES:

1. ADJOINING DEED REFERENCES BASED ON CURRENT INFORMATION FOUND IN THE BRUNSWICK COUNTY TAX OFFICE.
2. THIS PROPERTY IS SUBJECT TO ANY AND ALL EASEMENTS, COVENANTS, RESTRICTIONS, RIGHT-OF-WAYS OF RECORD, GOVERNMENTAL ORDINANCES AND/OR REQUIREMENTS WHICH MAY LIMIT THE USE OF THIS PROPERTY; WHETHER SHOWN OR NOT SHOWN ON THIS SURVEY MAP.
3. THIS SURVEY PERFORMED AND MAP PREPARED WITHOUT THE BENEFIT OF A TITLE REPORT AND IS THEREBY SUBJECT TO ANY FACTS WHICH MAY BE DISCLOSED BY A FULL AND ACCURATE TITLE SEARCH. USERS OF THIS PLAT SHOULD OBTAIN AN ACCURATE LEGAL OPINION AS TO OWNERSHIP WITHIN THE BOUNDARIES OF THIS PLAT.
4. ALL BEARINGS ARE BASED ON NC GRID NORTH (NAD83-NSRS 2011); ALL DISTANCES ARE HORIZONTAL GROUND DISTANCES.
5. ALL RIGHT OF WAY AND PROPERTY LINES ARE BASED ON BRUNSWICK COUNTY GIS AND WERE NOT SURVEYED BY ME AT THIS TIME.
6. ELEVATIONS WERE OBTAINED FROM NORTH CAROLINA REAL TIME NETWORK AND ARE BASED ON NAVD 88.
7. ONE FOOT CONTOUR INTERVALS.
8. AREA BY COORDINATE METHOD.
9. US SURVEY FEET.

SUB-SURFACE UTILITY DISCLAIMER:

THERE HAS BEEN NO ATTEMPT BY THE CERTIFYING SURVEYOR TO LOCATE, MARK OR IDENTIFY ANY SUB-SURFACE UTILITY LINES ON THE PROPERTIES SHOWN ON THIS MAP. THE EXISTENCE OF SUB-SURFACE UTILITIES, IF ANY, MAY AFFECT THE USE OF THESE PROPERTIES BEYOND THE CONTROL OF THE SURVEYOR. USERS OF THIS MAP, AND THEIR ASSIGNS, ARE HEREBY NOTIFIED AND ACKNOWLEDGE THAT ANY DAMAGE RESULTING FROM ANY UTILITY SHOWN OR NOT SHOWN ON THIS MAP IS NOT THE RESPONSIBILITY OF THE SURVEYOR OR COASTAL GEOMATICS, PLLC.



VICINITY MAP / SHEET INDEX
NO SCALE

Revisions

COASTALGEOMATICS
LAND SURVEYING · MAPPING · PLANNING
Physical Address: 5041-3 Main Street, Shallotte, NC 28470
Mailing Address: Post Office Box 1560, Shallotte, NC 28459
Telephone: 910-256-1800 ~ www.coastalgeomatics.com
Firm License # P-2248

TOPOGRAPHIC & STORMSWER ASBUILT SURVEY FOR:
TOWN OF HOLDEN BEACH
HOLDEN BEACH, NORTH CAROLINA

PRELIMINARY DRAWING
NOT CERTIFIED FOR RECORDING.
SALES OR CONVEYANCE WITHOUT ORIGINAL SEAL & SIGNATURE

SHEET 1 OF 16

PROJECT NO. 4900.84

MATCH LINE "A" SEE BELOW

MATCH LINE "B" SEE SHEET 3 OF 16

MATCH LINE "A" SEE ABOVE

SR 1116-OCEAN BLVD EAST

BLOCKADE RUNNER

AVENUE A

AVENUE B

DUNESCAPE DRIVE

NC GRID
NAD 83/2011

SCALE 1"=30'
0 15 30 60 90

PRELIMINARY DRAWING
NOT CERTIFIED FOR RECORDING, SALES OR CONVEYANCE WITHOUT ORIGINAL SEAL & SIGNATURE

SHEET 2 OF 16

PROJECT NO. 49008.64

TOWNSHIP: LOCKWOOD FOLLY
COUNTY: BRUNSWICK
STATE: NC
CREW: CT/RM
FB/PG: FILE

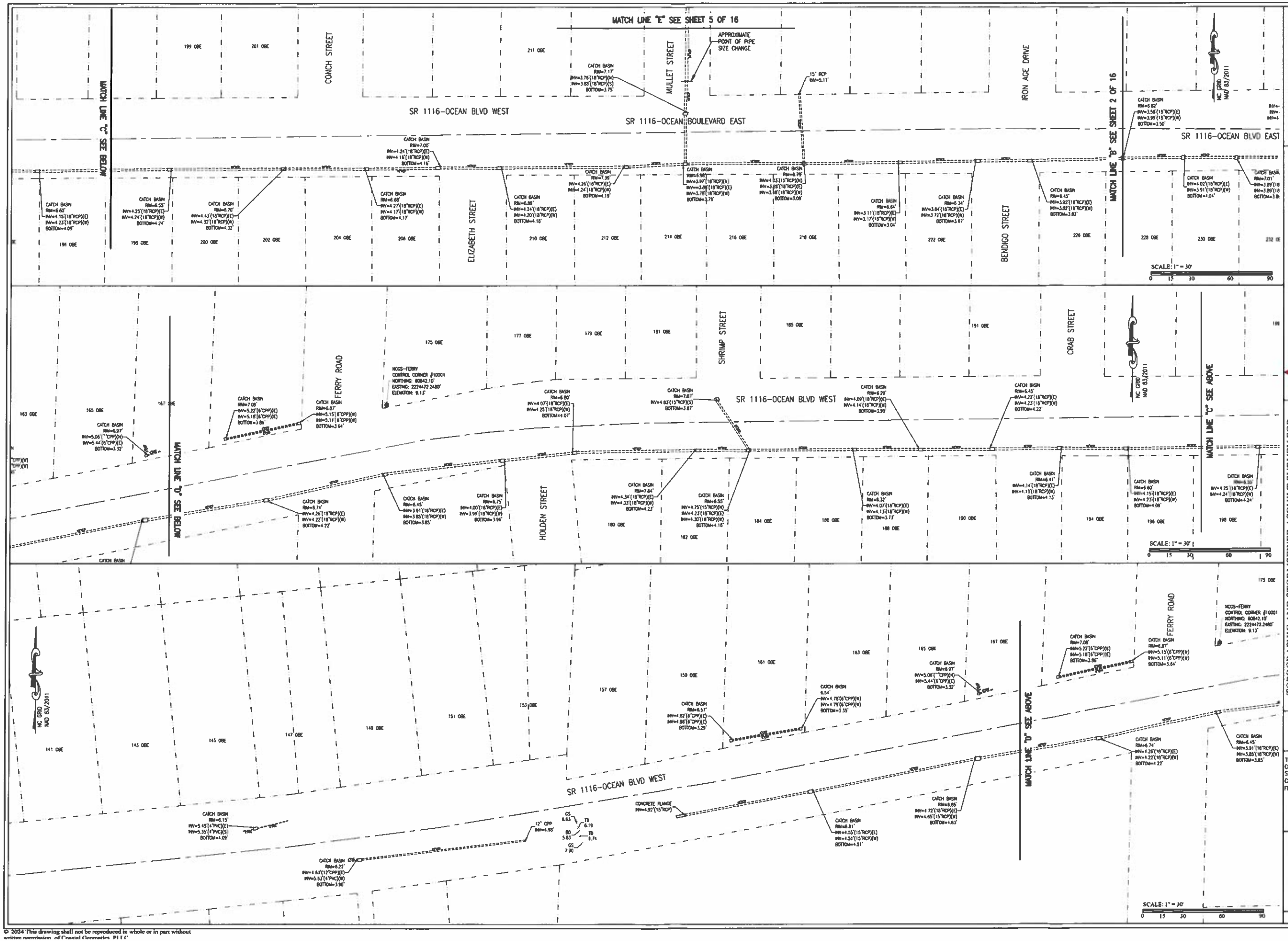
Date: 03.05.2024
Scale: AS SHOWN
Drawn By: CT
Checked By: CDS

TOPOGRAPHIC AND STORMSEWER ASBUILT SURVEY FOR:

TOWN OF HOLDEN BEACH

COASTALGEOMATICS
LAND SURVEYING · MAPPING · PLANNING
Firm License # P-2248
Physical Address: 5041-3 Main Street, Shallotte, NC 28470
Mailing Address: Post Office Box 1560, Shallotte, NC 28459
Telephone: 910-356-1800 ~ www.coastalgeomatics.com

Revisions



Revisions

COASTALGEOMATICS
LAND SURVEYING • MAPPING • PLANNING

Physical Address: 5041-3 Main Street, Shallotte, NC 28470
Mailing Address: Post Office Box 1560, Shallotte, NC 28459
Telephone: 910-350-1800 -- www.coastalgeomatics.com
Firm License # P-2248

TOPOGRAPHIC AND STORMSEWER ASBUILT SURVEY FOR:

TOWN OF HOLDEN BEACH

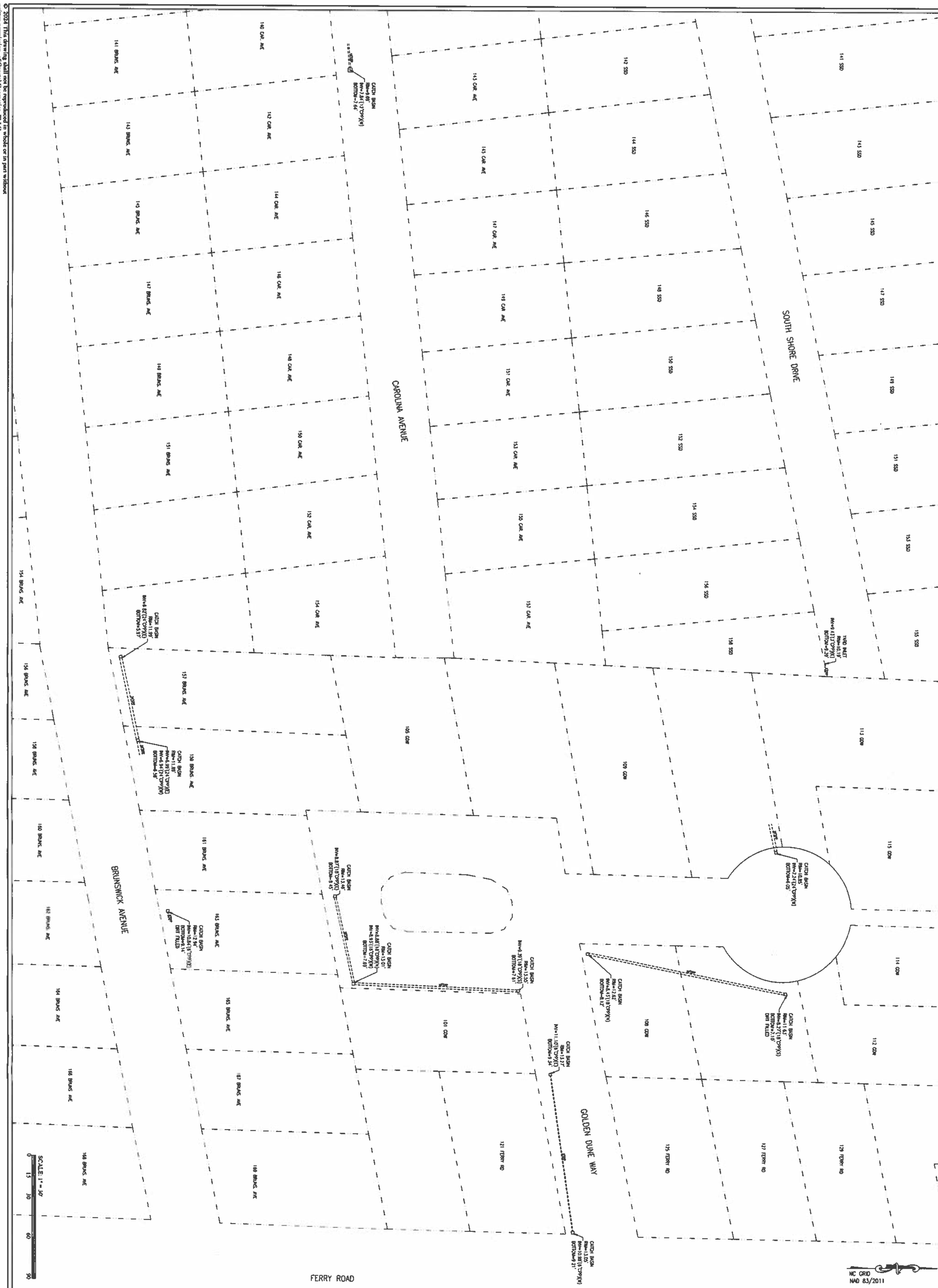
Date: 02-05-2024
Scale: AS SHOWN
Drawn By: CT
Checked By: CDS

TOWNSHIP: LOCKWOOD FOLLY
COUNTY: BRUNSWICK
STATE: NC
CREW: CT/RM
FB/PG: FILE

PRELIMINARY DRAWING
NOT CERTIFIED FOR RECORDING, SALES OR CONVEYANCE WITHOUT ORIGINAL SEAL & SIGNATURE

SHEET 3 OF 16

PROJECT NO. 4900.64



TOPOGRAPHIC AND STORMSEWER ASBUILT SURVEY FOR:

TOWN OF HOLDEN BEACH

COASTALGEOMATICS
LAND SURVEYING • MAPPING • PLANNING

Physical Address: 5041-3 Main Street, Shallotte, NC 28470
Mailing Address: Post Office Box 1560, Shallotte, NC 28459
Telephone: 910-356-1800 ~ www.coastalgeomatics.com

Firm License # P-2248

Revisions

Date 02-06-2024
Scale AS SHOWN
Drawn By CT
Checked By CDS

TOWNSHIP: LOCKWOOD FOLLY
COUNTY: BRUNSWICK
STATE: NC
CREW: CT/RM
FB/PG: FILE

PRELIMINARY DRAWING
NOT CERTIFIED FOR RECORDING, SALES OR CONVEYANCE WITHOUT ORIGINAL SEAL & SIGNATURE

SHEET 4 OF 16

PROJECT NO. 4900.64

MATCH LINE "E" SEE SHEET 3 OF 16

SR 1116-OCEAN BOULEVARD EAST

MULLET STREET

107 MULLET ST

109 MULLET ST

111 MULLET ST

110 MULLET ST

CATCH BASIN
RIM=7.13'
INV=3.76'(18"RCP)(N)
INV=3.66'(18"RCP)(S)
BOTTOM=3.75'

CATCH BASIN
RIM=7.39'
INV=4.26'(18"RCP)(E)
INV=4.24'(18"RCP)(W)
BOTTOM=4.19'

CATCH BASIN
RIM=6.98'
INV=3.97'(18"RCP)(N)
INV=3.80'(18"RCP)(E)
INV=3.78'(18"RCP)(W)
BOTTOM=3.78'

CATCH BASIN
RIM=6.78'
INV=4.03'(15"RCP)(N)
INV=3.26'(18"RCP)(E)
INV=3.48'(18"RCP)(W)
BOTTOM=3.08'

15" RCP
INV=5.11'

APPROXIMATE POINT OF PIPE SIZE CHANGE

CATCH BASIN
RIM=9.80'
INV=3.41'(24"RCP)(N)
INV=3.54'(24"RCP)(S)
BOTTOM=3.35'

MATCH LINE "F" SEE BELOW

CATCH BASIN
RIM=9.61'
INV=3.77'(24"RCP)(N)
INV=3.59'(18"RCP)(S)
BOTTOM=3.58'

NC GRID
NAD 83/2011

SCALE: 1" = 30'
0 15 30 60 90

MATCH LINE "F" SEE ABOVE

MULLET STREET

24" RCP
INV=0.09'

CATCH BASIN
RIM=9.80'
INV=3.41'(24"RCP)(N)
INV=3.54'(24"RCP)(S)
BOTTOM=3.35'

MATCH LINE "G" SEE SHEET 6 OF 16

JORDAN BLVD

112 OBW

102 OBE

109 OBE

CATCH BASIN
RIM=8.89'
INV=5.32'(18"RCP)(E)
INV=5.30'(18"RCP)(S)
BOTTOM=5.52'

CATCH BASIN
RIM=7.70'
INV=5.23'(18"RCP)(N)
INV=5.31'(18"RCP)(S)
INV=5.11'(18"RCP)(W)
BOTTOM=5.15'

CATCH BASIN
RIM=8.65'
INV=4.76'(18"RCP)(N)
INV=4.76'(18"RCP)(S)
BOTTOM=4.72'

CATCH BASIN
RIM=8.51'
INV=3.70'(18"RCP)(N)
INV=3.76'(18"RCP)(E)
BOTTOM=3.45'

CATCH BASIN
RIM=7.24'
INV=3.41'(18"RCP)(S)
INV=3.47'(18"RCP)(W)
BOTTOM=3.33'

CATCH BASIN
RIM=7.24'
INV=4.72'(18"RCP)(N)
BOTTOM=4.63'

CATCH BASIN
RIM=8.48'
INV=5.69'(15"RCP)(W)
BOTTOM=5.69'

SR 1116-OCEAN BLVD WEST

SR 1116-OCEAN BLVD EAST

CATCH BASIN
RIM=9.04'
INV=4.35'(18"RCP)(N)
INV=4.39'(18"RCP)(E)
INV=4.34'(18"RCP)(W)
BOTTOM=4.14'

NC GRID
NAD 83/2011

SCALE: 1" = 30'
0 15 30 60 90

Revisions

COASTALGEOMATICS
LAND SURVEYING · MAPPING · PLANNING
Physical Address: 5041-3 Main Street, Shallotte, NC 28470
Mailing Address: Post Office Box 1560, Shallotte, NC 28459
Telephone: 910-386-1800 ~ www.coastalgeomatics.com
Firm License # P-2248

TOPOGRAPHIC AND STORMSEWER ASBUILT SURVEY FOR:

TOWN OF HOLDEN BEACH

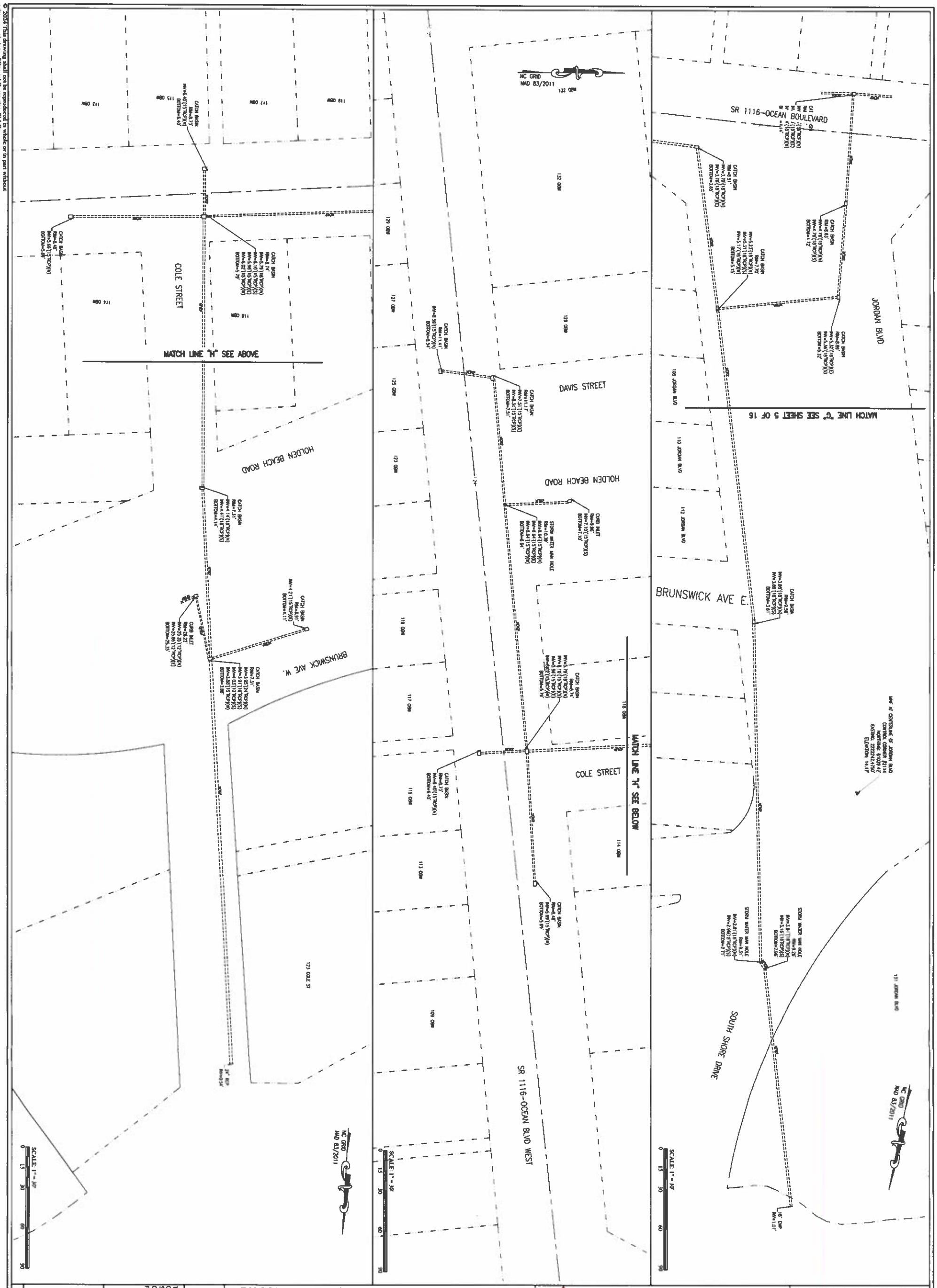
Date 02-05-2024
Scale AS SHOWN
Drawn By: CT
Checked By: CDS

TOWNSHIP: LOCKWOOD FOLLY
COUNTY: BRUNSWICK
STATE: NC
CREW: CT/RM
FB/PG: FILE

PRELIMINARY DRAWING
NOT CERTIFIED FOR RECORDING, SALES OR CONVEYANCE WITHOUT ORIGINAL SEAL & SIGNATURE

SHEET 5 OF 16

PROJECT NO. 4900.64



PRELIMINARY DRAWING
NOT CERTIFIED FOR RECORDING, SALES OR CONVEYANCE WITHOUT ORIGINAL SEAL & SIGNATURE

SHEET 6 OF 16

PROJECT NO. 4900.84

TOWNSHIP: LOCKWOOD FOLLY
COUNTY: BRUNSWICK
STATE: NC
DRWN: CT/RM
FB/PG: FILE

Date: 10-05-2024
Scale: AS SHOWN
Drawn By: CT
Checked By: CDS

TOPOGRAPHIC AND STORMSEWER ASBUILT SURVEY FOR:

TOWN OF HOLDEN BEACH

COASTALGEOMATICS
LAND SURVEYING · MAPPING · PLANNING
Firm License # P-2248
Physical Address: 5041-3 Main Street, Shallotte, NC 28470
Mailing Address: Post Office Box 1560, Shallotte, NC 28459
Telephone: 910-356-1800 ~ www.coastalgeomatics.com

Revisions

Revisions

COASTALGEOMATICS
LAND SURVEYING · MAPPING · PLANNING

Physical Address: 5041-3 Main Street, Shallotte, NC 28470
Mailing Address: Post Office Box 1560, Shallotte, NC 28459
Telephone: 910-356-1800 ~ www.coastalgeomatics.com

Firm License # P-2248

TOPOGRAPHIC AND STORMSEWER ASBUILT SURVEY FOR:

TOWN OF HOLDEN BEACH

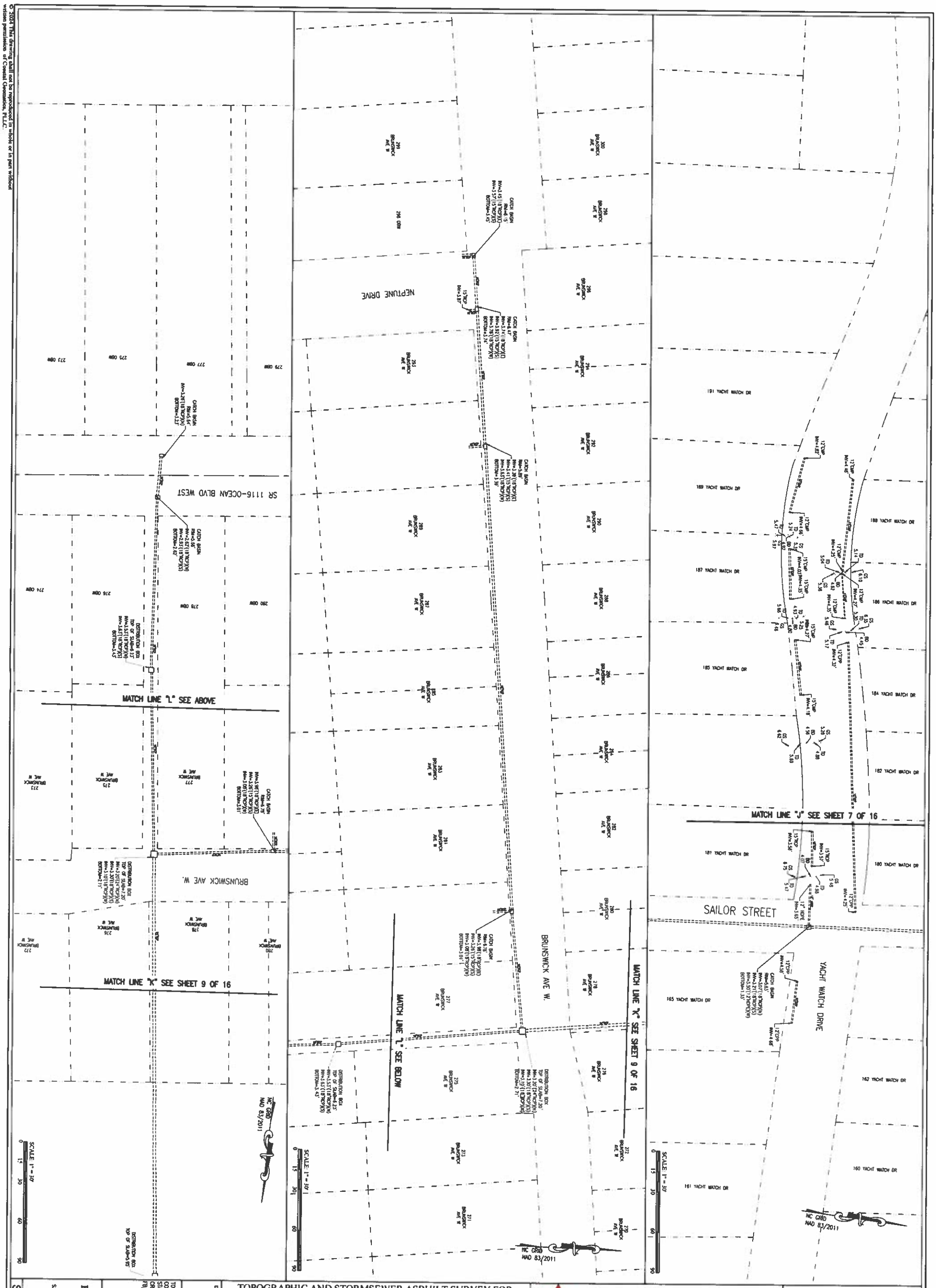
Date: 02-05-2024
Scale: AS SHOWN
Drawn By: CT
Checked By: CDS

TOWNSHIP: LOCKWOOD FOLLY
COUNTY: BRUNSWICK
STATE: NC
CREW: CT/RM
FB/PG: FILE

PRELIMINARY DRAWING
NOT CERTIFIED FOR RECORDING, SALES OR CONVEYANCE WITHOUT ORIGINAL SEAL & SIGNATURE

SHEET 7 OF 16

PROJECT NO. 4900 84



PRELIMINARY DRAWING
NOT CERTIFIED FOR RECORDING, SALES OR CONVEYANCE WITHOUT ORIGINAL SEAL & SIGNATURE

SHEET 8 OF 16

TOWNSHIP: LOCKWOOD FOLLY
COUNTY: BRUNSWICK
STATE: NC
CREW: CT/RM
FB/PG: FILE

Date: AS-BUILTS
Scale: AS SHOWN
Drawn By: CT
Checked By: CDS

TOPOGRAPHIC AND STORMSEWER ASBUILT SURVEY FOR:

TOWN OF HOLDEN BEACH

COASTALGEOMATICS
LAND SURVEYING • MAPPING • PLANNING
Firm License # P-2248
Physical Address: 5041-3 Main Street, Shallotte, NC 28470
Mailing Address: Post Office Box 1560, Shallotte, NC 28459
Telephone: 910-356-1800 ~ www.coastalgeomatics.com

Revisions

PROJECT NO. 4900.64

CHARLLOTTE STREET

466 OBW

464 OBW

460 OBW

456 OBW

454 OBW

450 OBW

448 OBW

446 OBW

444 OBW

109 HIGHPOINT ST

111 HIGHPOINT ST

113 HIGHPOINT ST

HIGHPOINT STREET

349 BRUNSWICK AVE W

341 BRUNSWICK AVENUE W

337 BRUNSWICK AVENUE W

SR 1116-OCEAN BLVD WEST

DURHAM STREET

BRUNSWICK AVE W

EDGE OF PAVEMENT

MATCH LINE "P" SEE SHEET 10 OF 16

MATCH LINE "Q" SEE SHEET 10 OF 16

107 HIGHPOINT ST

109 HIGHPOINT ST

111 HIGHPOINT ST

113 HIGHPOINT ST

115 HIGHPOINT ST

137 HIGHPOINT ST

SCALE: 1" = 20'

NC GRID NAD 83/2011

PRELIMINARY DRAWING
NOT CERTIFIED FOR RECORDING, SALES OR CONVEYANCE WITHOUT ORIGINAL SEAL & SIGNATURE

SHEET 11 OF 16

PROJECT NO. 45000.04

TOWNSHIP: LOCKWOOD FOLLY
COUNTY: BRUNSWICK
STATE: NC
CREW: CT/RM
FB/PG: FILE

Date: 07-05-2024
Scale: AS SHOWN
Drawn By: CT
Checked By: CBS

TOPOGRAPHIC AND STORMSEWER ASBUILT SURVEY FOR:

TOWN OF HOLDEN BEACH

COASTALGEOMATICS
LAND SURVEYING • MAPPING • PLANNING

Firm License # P-2248

Physical Address: 5041-3 Main Street, Shallotte, NC 28470
Mailing Address: Post Office Box 1560, Shallotte, NC 28459
Telephone: 910-356-1800 ~ www.coastalgeomatics.com

Revisions

494 OBW
492 OBW
480 OBW
478 OBW
476 OBW
474 OBW
472 OBW
GREENSBORO STREET
STORMWATER MAN HOLE
RIM=6.01'
INV=1.41'(18"RCP)(N)
INV=1.56'(18"RCP)(S)
BOTTOM=0.26'
48" RCP
36" RCP
STORM WATER MAN HOLE
RIM=6.42'
INV=2.42'(18"RCP)(E)
INV=2.22'(18"RCP)(E)
BOTTOM=1.34'
STORM WATER MAN HOLE
RIM=6.00'
INV=2.20'(15"RCP)(S)
INV=2.00'(18"RCP)(W)
BOTTOM=1.04'
MNF-OBW & GREENSBORO
CONTROL CORNER #17221
NORTHING: 585510.98'
EASTING: 221244.3.0750'
ELEVATION: 5.29'
15" RCP
CATCH BASIN
RIM=5.52'
INV=3.68'(15"RCP)(N)
BOTTOM=3.48'
SR 1116-OCEAN BLVD WEST
NC GRID
NAD 83/2011
495 OBW
493 OBW
491 OBW
489 OBW
487 OBW
485 OBW
483 OBW
481 OBW
479 OBW
477 OBW
475 OBW
473 OBW
SCALE: 1" = 20'
0 10 20 40 60

550 OBW
548 OBW
546 OBW
SCOTCH BONNET DRIVE
CATCH BASIN
RIM=5.56'
INV=3.50'(12"HDPE)(E)
INV=3.51'(12"HDPE)(W)
BOTTOM=3.22'
12" HDPE
SR 1116-OCEAN BLVD WEST
NC GRID
NAD 83/2011
549 OBW
547 OBW
545 OBW
543 OBW
541 OBW
539 OBW
537 OBW
535 OBW
533 OBW
531 OBW
529 OBW
527 OBW
SCALE: 1" = 20'
0 10 20 40 60

105 STARFISH DR
107 STARFISH DR
111 STARFISH DR
STARFISH DRIVE
12" CPP
CATCH BASIN
RIM=5.04'
INV=3.08'(12"CPP)(N)
INV=3.91'(12"CPP)(S)
BOTTOM=1.08'
SR 1116-OCEAN BLVD WEST
106 STARFISH DR
110 STARFISH DR
NC GRID
NAD 83/2011
SCALE: 1" = 20'
10 20 40 60

Revisions

COASTALGEOMATICS
LAND SURVEYING • MAPPING • PLANNING
Physical Address: 5041-3 Main Street, Shallotte, NC 28470
Mailing Address: Post Office Box 1560, Shallotte, NC 28459
Telephone: 910-754-1800 - www.coastalgeomatics.com
Firm License # P-2248

TOPOGRAPHIC AND STORMSEWER ASBUILT SURVEY FOR:

TOWN OF HOLDEN BEACH

Date: 02-05-2024
Scale: AS SHOWN
Drawn By: CT
Checked By: CDS

TOWNSHIP: LOCKWOOD FOLLY
COUNTY: BRUNSWICK
STATE: NC
CREW: CT/RM
FB/PG: FILE

PRELIMINARY DRAWING
NOT CERTIFIED FOR RECORDING, SALES OR CONVEYANCE WITHOUT ORIGINAL SEAL & SIGNATURE

SHEET 12 OF 16

PROJECT NO. 4900.64

668 OBW
664 OBW
662 OBW
660 OBW
658 OBW
SR 1116-OCEAN BLVD WEST
CATCH BASIN
RIM=6.74'
INV=4.66' (18"RCP)(N)
INV=4.75' (9"CPP)(W)
BOTTOM=4.66'
9" CPP
671 OBW
669 OBW
667 OBW
665 OBW
663 OBW
661 OBW
659 OBW
662 OBW
657 OBW
655 OBW
653 OBW
651 OBW
NC GRID NAD 83/2011
SCALE: 1" = 20'
0 10 20 40 60
752 OBW
748 OBW
746 OBW
744 OBW
CATCH BASIN
RIM=5.09'
INV=2.96' (12"CPP)(E)
INV=2.84' (12"CPP)(W)
BOTTOM=0.38'
12" CPP
12" CPP
SR 1116-OCEAN BLVD WEST
753 OBW
751 OBW
749 OBW
745 OBW
743 OBW
741 OBW
739 OBW
737 OBW
735 OBW
733 OBW
731 OBW
SCALE: 1" = 20'
0 10 20 40 60
153 SWORDFISH DR
157 SWORDFISH DR
159 SWORDFISH DR
SWORDFISH DRIVE
18"RCP
INV=2.98'
6" SPC
18"RCP
INV=3.40'
873 HLW
HERON LANDING WYND
SCALE 1" = 30'
0 15 30 60 90

Revisions

COASTALGEOMATICS
LAND SURVEYING · MAPPING · PLANNING
Physical Address: 5041-3 Main Street, Shallotte, NC 28470
Mailing Address: Post Office Box 1560, Shallotte, NC 28459
Telephone: 910-338-1800 ~ www.coastalgeomatics.com
Firm License # P-2249

TOPOGRAPHIC AND STORMSEWER ASBUILT SURVEY FOR:

TOWN OF HOLDEN BEACH

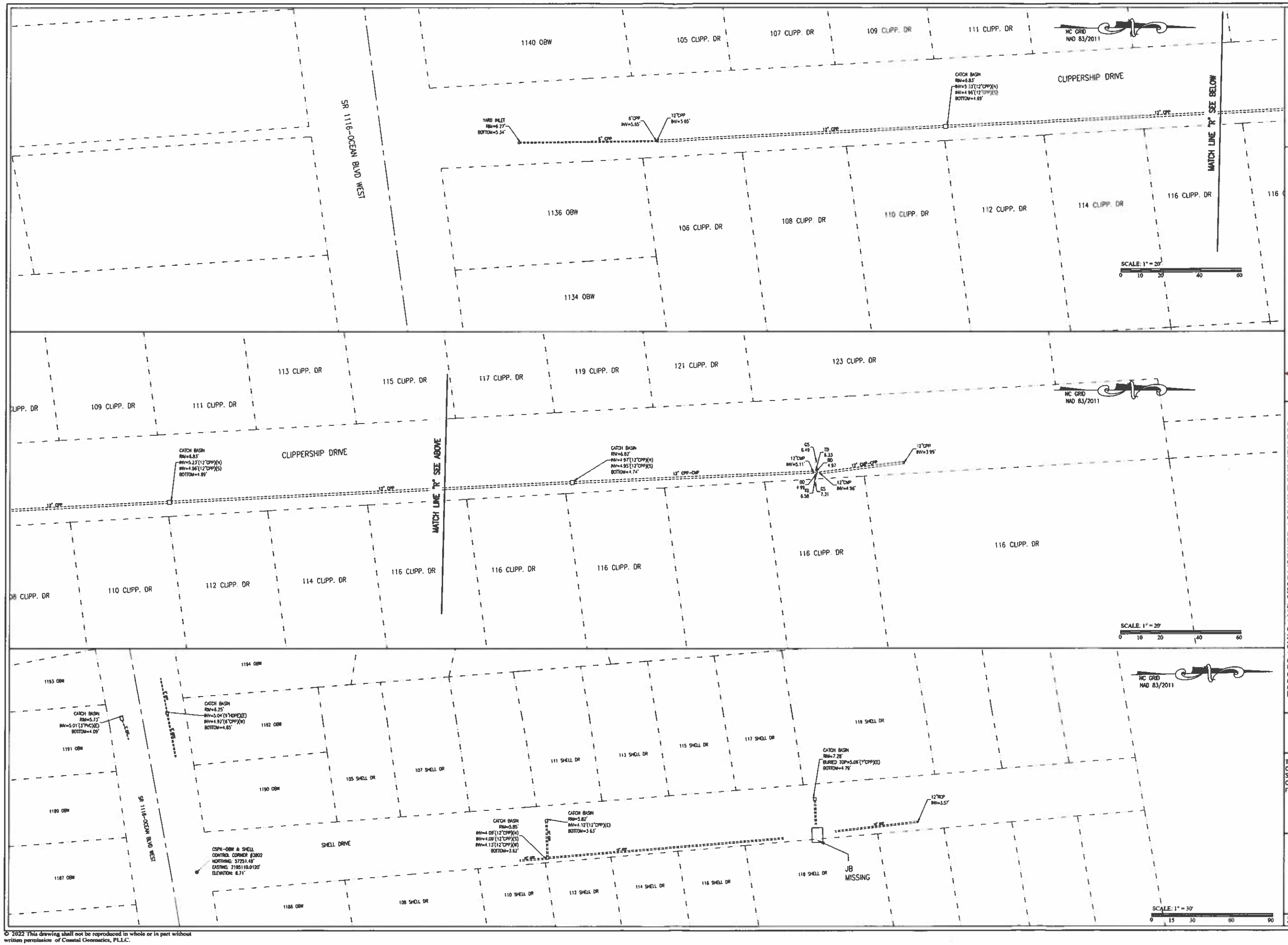
Date: 02-05-2024
Scale: AS SHOWN
Drawn By: CT
Checked By: CDS

TOWNSHIP: LOCKWOOD FOLLY
COUNTY: BRUNSWICK
STATE: NC
CREW: CT/RM
FB/PG: FILE

PRELIMINARY DRAWING
NOT CERTIFIED FOR RECORDING, SALES OR CONVEYANCE WITHOUT ORIGINAL SEAL & SIGNATURE

SHEET 13 OF 16

PROJECT NO. 4900.64



Revisions

COASTALGEOMATICS
LAND SURVEYING - MAPPING - PLANNING
Physical Address: 5041-3 Main Street, Shallotte, NC 28470
Mailing Address: Post Office Box 1560, Shallotte, NC 28459
Telephone: 910-386-1800 ~ www.coastalgeomatics.com
Firm License # P-2240

TOPOGRAPHIC AND STORMSEWER ASBUILT SURVEY FOR:

TOWN OF HOLDEN BEACH

Date: 02-05-2024
Scale: AS SHOWN
Drawn By: CT
Checked By: CDS

TOWNSHIP: LOCKWOOD FOLLY
COUNTY: BRUNSWICK
STATE: NC
CREW: CT/RM
FB/PG: FILE

PRELIMINARY DRAWING
NOT CERTIFIED FOR RECORDING, SALES OR CONVEYANCE WITHOUT ORIGINAL SEAL & SIGNATURE

SHEET 15 OF 16

PROJECT NO. 4900.64

Revisions

COASTALGEOMATICS
LAND SURVEYING • MAPPING • PLANNING
Physical Address: 5041-3 Main Street, Shallotte, NC 28470
Mailing Address: Post Office Box 1560, Shallotte, NC 28459
Telephone: 910-356-1800 ~ www.coastalgeomatics.com
Firm License # P-2248

TOPOGRAPHIC AND STORMSEWER ASBUILT SURVEY FOR:

TOWN OF HOLDEN BEACH

Date: 02-05-2024
Scale: AS SHOWN
Drawn By: CT
Checked By: CDS

TOWNSHIP: LOCKWOOD FOLLY
COUNTY: BRUNSWICK
STATE: NC
CREW: CT/RM
FB/PG: FILE

PRELIMINARY DRAWING
NOT CERTIFIED FOR RECORDING, SALES OR CONVEYANCE WITHOUT ORIGINAL SEAL & SIGNATURE

SHEET 16 OF 16

PROJECT NO. 4900.64

Appendix B

Drainage Basin Maps

Holden Beach Stormwater Improvements

Attachment B.1 Drainage Basins Problem Area 1 300 Block OBW

MAP PROJECTION:
NORTH CAROLINA STATE PLANE (FEET)

DATUM:
NAD 1983 (HORIZONTAL)
NAVD 1988 (VERTICAL)

DESIGNER: CA
REVIEWER: MH
DATE: April 2024

N
W E
S

Legend

- Outfall
- Drainage Point
- Ex. Catch Basin
- Ex. Drainage Pipe
- Ex. Channel
- Longest Flow Path
- Drainage Basin
- Contours
- Parcels

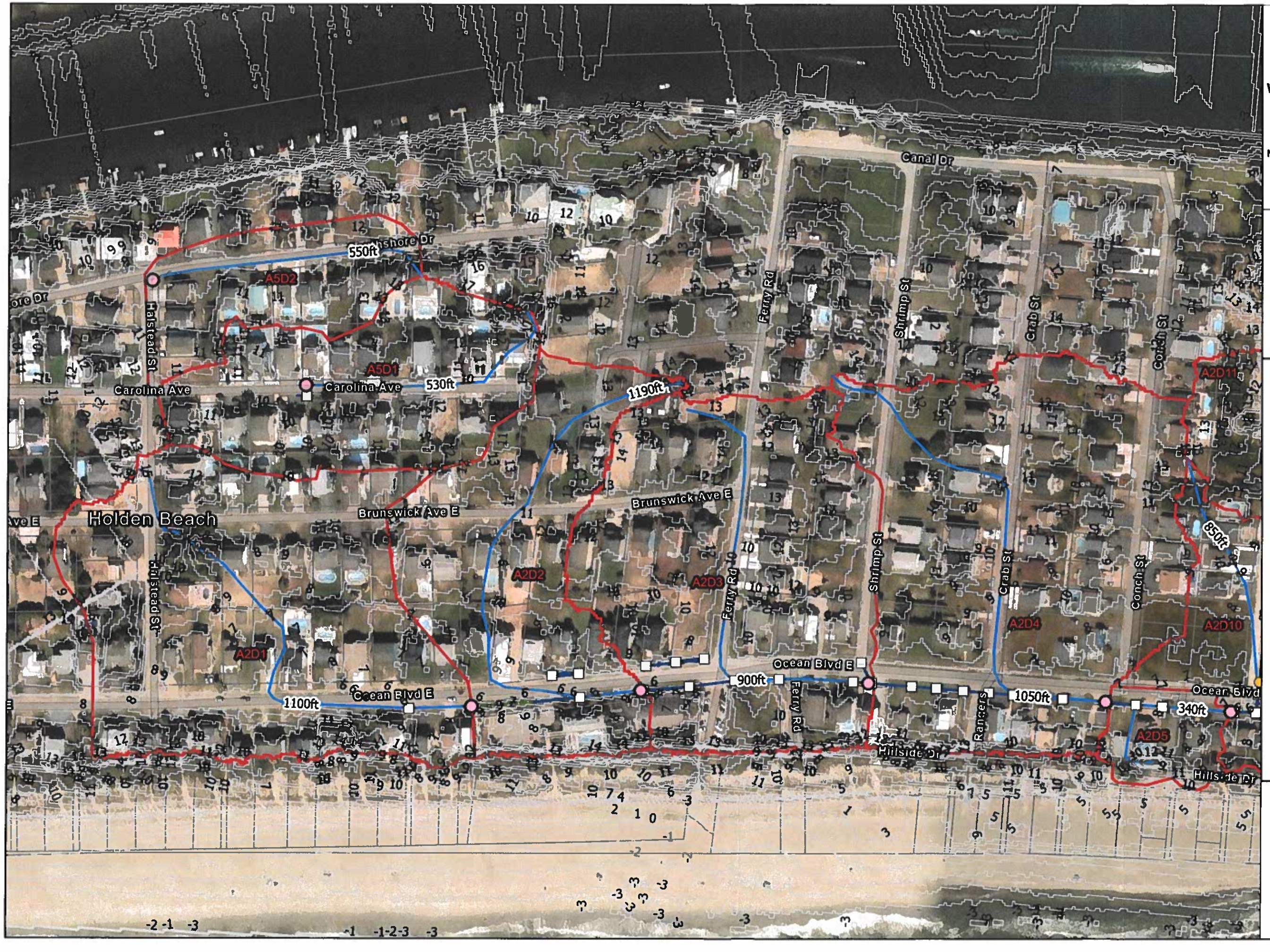
0 87.5 175 Feet

1 inch = 175 feet

mcgill

712 Village Rd. Suite #103
Shallotte, NC 28470
910.755.5872

NC Firm License # C-0459



Holden Beach
Stormwater Improvements

Attachment B.2
Drainage Basins
West Problem Area 2 - East End Mullet St. & East End Ave. A
Problem Area 5 - Carolina Ave.

MAP PROJECTION:
NORTH CAROLINA STATE PLANE (FEET)

DATUM:
NAD 1983 (HORIZONTAL)
NAVD 1988 (VERTICAL)

DESIGNER: CA
REVIEWER: MH
DATE: April 2024

N
W E
S

Legend

- Drainage Point
- Ex. Catch Basin
- Ex. Junction Box
- Ex. Drainage Pipe
- Ex. Channel
- Longest Flow Path
- Drainage Basin
- Contours
- Parcels

0 87.5 175 Feet

1 inch = 175 feet

mcgill

712 Village Rd. Suite #103
Shallotte, NC 28470
910.755.5872

NC Firm License # C-0459

Holden Beach Stormwater Improvements

Attachment B.3 Drainage Basins East Problem Area 2 East End Mullet St. & East End Ave. A

MAP PROJECTION:
NORTH CAROLINA STATE PLANE (FEET)

DATUM:
NAD 1983 (HORIZONTAL)
NAVD 1988 (VERTICAL)

DESIGNER: CA
REVIEWER: MH
DATE: April 2024

N
W E
S

Legend

- Outfall
- Drainage Point
- Ex. Catch Basin
- Ex. Junction Box
- Ex. Drainage Pipe
- Ex. Channel
- Longest Flow Path
- Drainage Basin
- Contours
- Parcels

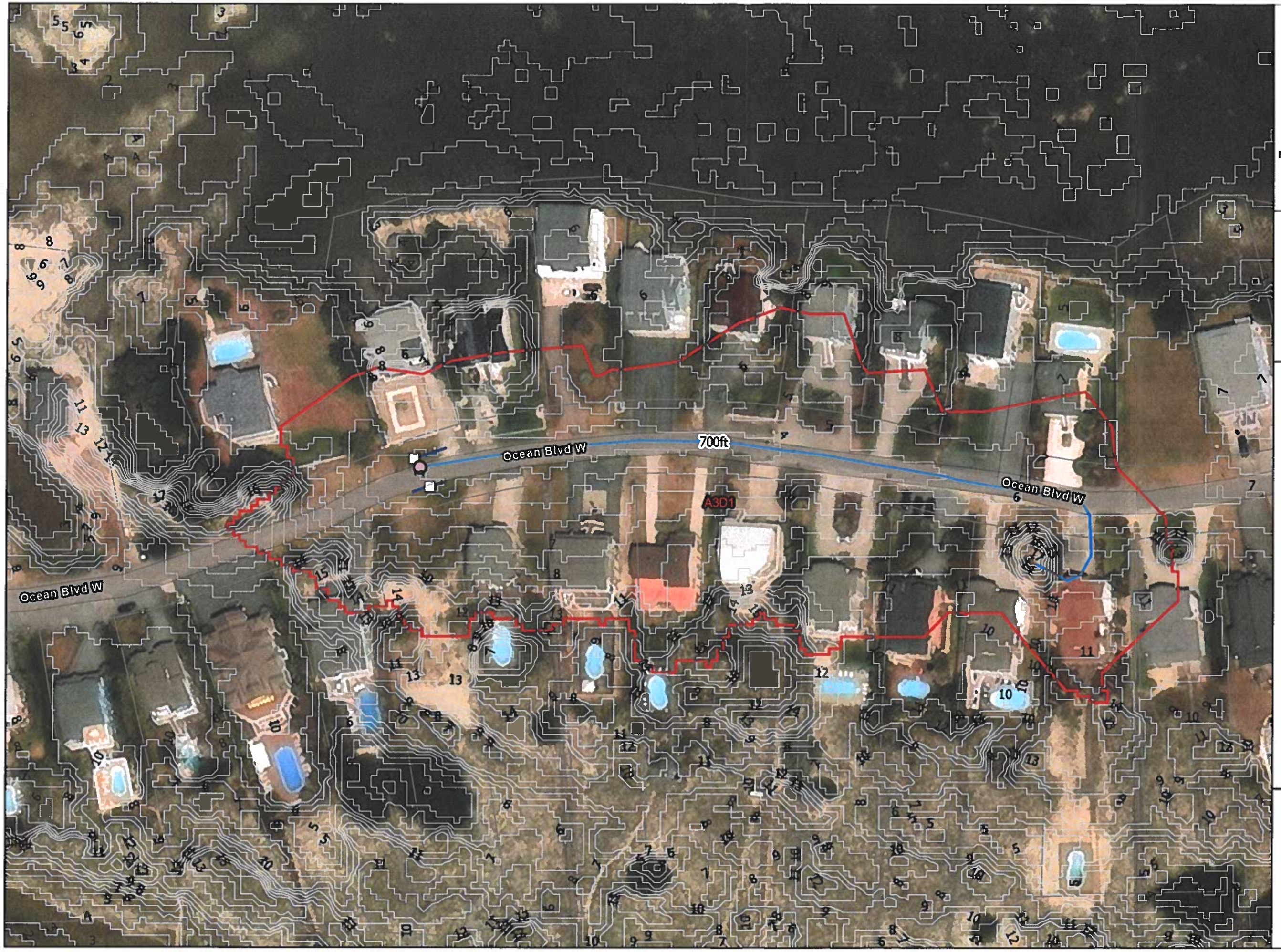
0 87.5 175 Feet

1 inch = 175 feet

mcgill

712 Village Rd. Suite #103
Shallotte, NC 28470
910 755 5872

NC Firm License # C-0459



Holden Beach Stormwater Improvements

Attachment B.4 Drainage Basins Problem Area 3 West End ROW

MAP PROJECTION:
NORTH CAROLINA STATE PLANE (FEET)

DATUM:
NAD 1983 (HORIZONTAL)
NAVD 1988 (VERTICAL)

DESIGNER: CA
REVIEWER: MH
DATE: April 2024

N
W E
S

Legend

- Drainage Point
- Ex. Catch Basin
- Ex. Drainage Pipe
- Longest Flow Path
- Drainage Basin
- Contours
- Parcels

0 37.5 75 Feet

1 inch = 75 feet

mcgill

712 Village Rd. Suite #103
Shallotte, NC 28470
910.755.5872

NC Firm License # C-0459

Holden Beach Stormwater Improvements

Attachment B.5 Drainage Basins Problem Area 4 760 Block OBW

MAP PROJECTION:
NORTH CAROLINA STATE PLANE (FEET)

DATUM:
NAD 1983 (HORIZONTAL)
NAVD 1988 (VERTICAL)

DESIGNER: CA
REVIEWER: MH
DATE: April 2024

N
W E
S

Legend

- Drainage Point
- Ex. Catch Basin
- Ex. Drainage Pipe
- Longest Flow Path
- Drainage Basin
- Contours
- Parcels

0 87.5 175 Feet

1 inch = 175 feet

mcgill

712 Village Rd. Suite #103
Shallotte, NC 28470
910.755.5872

NC Firm License # C-0459

Holden Beach Stormwater Improvements

Attachment B.6
Drainage Basins
Problem Area 6
Davis St.

MAP PROJECTION:
NORTH CAROLINA STATE PLANE (FEET)

DATUM:
NAD 1983 (HORIZONTAL)
NAVD 1988 (VERTICAL)

DESIGNER: CA
REVIEWER: MH
DATE: April 2024

N
W E
S

Legend

- Drainage Point
- Ex. Drainage Pipe
- Ex. Channel
- Longest Flow Path
- Drainage Basin
- Contours
- Parcels

0 37.5 75 Feet

1 inch = 75 feet

mcgill

712 Village Rd. Suite #103
Shallotte, NC 28470
910.755.5872

NC Firm License # C-0459

Appendix C

Hydrologic Data & Calculations

Holden Beach Stormwater System Improvements - Curve Number Calculation

Project Area	Basin Name	Soil Group	Residential (0.1 ha)		Open Space (Fair)		Brush (Fair)		Woody Wetlands		Weighted
			% of Area	CN	% of Area	CN	% of Area	CN	% of Area	CN	CN
1	D1	A	91%	61	9%	49	0%	35	0%	75	60
	D2	A	92%	61	8%	49	0%	35	0%	75	60
	D3	A	80%	61	20%	49	0%	35	0%	75	59
	D4	A	87%	61	13%	49	0%	35	0%	75	59
	D5	A	76%	61	24%	49	0%	35	0%	75	58
2	D1	A	97%	61	3%	49	0%	35	0%	75	61
	D2	A	95%	61	5%	49	0%	35	0%	75	60
	D3	A	85%	61	15%	49	0%	35	0%	75	59
	D4	A	83%	61	17%	49	0%	35	0%	75	59
	D5	A	100%	61	0%	49	0%	35	0%	75	61
	D6	A	61%	61	26%	49	0%	35	13%	75	60
	D7	A	15%	61	4%	49	14%	35	66%	75	66
	D8	A	68%	61	32%	49	0%	35	0%	75	57
	D9	A	36%	61	64%	49	0%	35	0%	75	53
	D10	A	73%	61	27%	49	0%	35	0%	75	58
	D11	A	45%	61	55%	49	0%	35	0%	75	54
	D12	A	25%	61	75%	49	0%	35	0%	75	52
3	D1	A	94%	61	6%	49	0%	35	0%	75	60
	D2	A	38%	61	0%	49	62%	35	0%	75	45
	D3	A	91%	61	0%	49	9%	35	0%	75	59
4	D1	A	100%	61	0%	49	0%	35	0%	75	61
	D2	A	96%	61	4%	49	0%	35	0%	75	60
5	D1	A	92%	61	8%	49	0%	35	0%	75	60
	D2	A	97%	61	3%	49	0%	35	0%	75	61
6	D1	A	86%	61	14%	49	0%	35	0%	75	59

United States Department of Agriculture

NRCS

Natural Resources Conservation Service

A product of the National Cooperative Soil Survey, a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local participants

Custom Soil Resource Report for Brunswick County, North Carolina

Holden Beach SW Management RFQ

March 26, 2024

Preface

Soil surveys contain information that affects land use planning in survey areas. They highlight soil limitations that affect various land uses and provide information about the properties of the soils in the survey areas. Soil surveys are designed for many different users, including farmers, ranchers, foresters, agronomists, urban planners, community officials, engineers, developers, builders, and home buyers. Also, conservationists, teachers, students, and specialists in recreation, waste disposal, and pollution control can use the surveys to help them understand, protect, or enhance the environment.

Various land use regulations of Federal, State, and local governments may impose special restrictions on land use or land treatment. Soil surveys identify soil properties that are used in making various land use or land treatment decisions. The information is intended to help the land users identify and reduce the effects of soil limitations on various land uses. The landowner or user is responsible for identifying and complying with existing laws and regulations.

Although soil survey information can be used for general farm, local, and wider area planning, onsite investigation is needed to supplement this information in some cases. Examples include soil quality assessments (http://www.nrcs.usda.gov/wps/portal/nrcs/main/soils/health/) and certain conservation and engineering applications. For more detailed information, contact your local USDA Service Center (https://offices.sc.egov.usda.gov/locator/app?agency=nrcs) or your NRCS State Soil Scientist (http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/contactus/?cid=nrcs142p2_053951).

Great differences in soil properties can occur within short distances. Some soils are seasonally wet or subject to flooding. Some are too unstable to be used as a foundation for buildings or roads. Clayey or wet soils are poorly suited to use as septic tank absorption fields. A high water table makes a soil poorly suited to basements or underground installations.

The National Cooperative Soil Survey is a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local agencies. The Natural Resources Conservation Service (NRCS) has leadership for the Federal part of the National Cooperative Soil Survey.

Information about soils is updated periodically. Updated information is available through the NRCS Web Soil Survey, the site for official soil survey information.

The U.S. Department of Agriculture (USDA) prohibits discrimination in all its programs and activities on the basis of race, color, national origin, age, disability, and where applicable, sex, marital status, familial status, parental status, religion, sexual orientation, genetic information, political beliefs, reprisal, or because all or a part of an individual's income is derived from any public assistance program. (Not all prohibited bases apply to all programs.) Persons with disabilities who require

alternative means for communication of program information (Braille, large print, audiotape, etc.) should contact USDA's TARGET Center at (202) 720-2600 (voice and TDD). To file a complaint of discrimination, write to USDA, Director, Office of Civil Rights, 1400 Independence Avenue, S.W., Washington, D.C. 20250-9410 or call (800) 795-3272 (voice) or (202) 720-6382 (TDD). USDA is an equal opportunity provider and employer.

Contents

How Soil Surveys Are Made

Soil surveys are made to provide information about the soils and miscellaneous areas in a specific area. They include a description of the soils and miscellaneous areas and their location on the landscape and tables that show soil properties and limitations affecting various uses. Soil scientists observed the steepness, length, and shape of the slopes; the general pattern of drainage; the kinds of crops and native plants; and the kinds of bedrock. They observed and described many soil profiles. A soil profile is the sequence of natural layers, or horizons, in a soil. The profile extends from the surface down into the unconsolidated material in which the soil formed or from the surface down to bedrock. The unconsolidated material is devoid of roots and other living organisms and has not been changed by other biological activity.

Currently, soils are mapped according to the boundaries of major land resource areas (MLRAs). MLRAs are geographically associated land resource units that share common characteristics related to physiography, geology, climate, water resources, soils, biological resources, and land uses (USDA, 2006). Soil survey areas typically consist of parts of one or more MLRA.

The soils and miscellaneous areas in a survey area occur in an orderly pattern that is related to the geology, landforms, relief, climate, and natural vegetation of the area. Each kind of soil and miscellaneous area is associated with a particular kind of landform or with a segment of the landform. By observing the soils and miscellaneous areas in the survey area and relating their position to specific segments of the landform, a soil scientist develops a concept, or model, of how they were formed. Thus, during mapping, this model enables the soil scientist to predict with a considerable degree of accuracy the kind of soil or miscellaneous area at a specific location on the landscape.

Commonly, individual soils on the landscape merge into one another as their characteristics gradually change. To construct an accurate soil map, however, soil scientists must determine the boundaries between the soils. They can observe only a limited number of soil profiles. Nevertheless, these observations, supplemented by an understanding of the soil-vegetation-landscape relationship, are sufficient to verify predictions of the kinds of soil in an area and to determine the boundaries.

Soil scientists recorded the characteristics of the soil profiles that they studied. They noted soil color, texture, size and shape of soil aggregates, kind and amount of rock fragments, distribution of plant roots, reaction, and other features that enable them to identify soils. After describing the soils in the survey area and determining their properties, the soil scientists assigned the soils to taxonomic classes (units). Taxonomic classes are concepts. Each taxonomic class has a set of soil characteristics with precisely defined limits. The classes are used as a basis for comparison to classify soils systematically. Soil taxonomy, the system of taxonomic classification used in the United States, is based mainly on the kind and character of soil properties and the arrangement of horizons within the profile. After the soil

scientists classified and named the soils in the survey area, they compared the individual soils with similar soils in the same taxonomic class in other areas so that they could confirm data and assemble additional data based on experience and research.

The objective of soil mapping is not to delineate pure map unit components; the objective is to separate the landscape into landforms or landform segments that have similar use and management requirements. Each map unit is defined by a unique combination of soil components and/or miscellaneous areas in predictable proportions. Some components may be highly contrasting to the other components of the map unit. The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The delineation of such landforms and landform segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, onsite investigation is needed to define and locate the soils and miscellaneous areas.

Soil scientists make many field observations in the process of producing a soil map. The frequency of observation is dependent upon several factors, including scale of mapping, intensity of mapping, design of map units, complexity of the landscape, and experience of the soil scientist. Observations are made to test and refine the soil-landscape model and predictions and to verify the classification of the soils at specific locations. Once the soil-landscape model is refined, a significantly smaller number of measurements of individual soil properties are made and recorded. These measurements may include field measurements, such as those for color, depth to bedrock, and texture, and laboratory measurements, such as those for content of sand, silt, clay, salt, and other components. Properties of each soil typically vary from one point to another across the landscape.

Observations for map unit components are aggregated to develop ranges of characteristics for the components. The aggregated values are presented. Direct measurements do not exist for every property presented for every map unit component. Values for some properties are estimated from combinations of other properties.

While a soil survey is in progress, samples of some of the soils in the area generally are collected for laboratory analyses and for engineering tests. Soil scientists interpret the data from these analyses and tests as well as the field-observed characteristics and the soil properties to determine the expected behavior of the soils under different uses. Interpretations for all of the soils are field tested through observation of the soils in different uses and under different levels of management. Some interpretations are modified to fit local conditions, and some new interpretations are developed to meet local needs. Data are assembled from other sources, such as research information, production records, and field experience of specialists. For example, data on crop yields under defined levels of management are assembled from farm records and from field or plot experiments on the same kinds of soil.

Predictions about soil behavior are based not only on soil properties but also on such variables as climate and biological activity. Soil conditions are predictable over long periods of time, but they are not predictable from year to year. For example, soil scientists can predict with a fairly high degree of accuracy that a given soil will have a high water table within certain depths in most years, but they cannot predict that a high water table will always be at a specific level in the soil on a specific date.

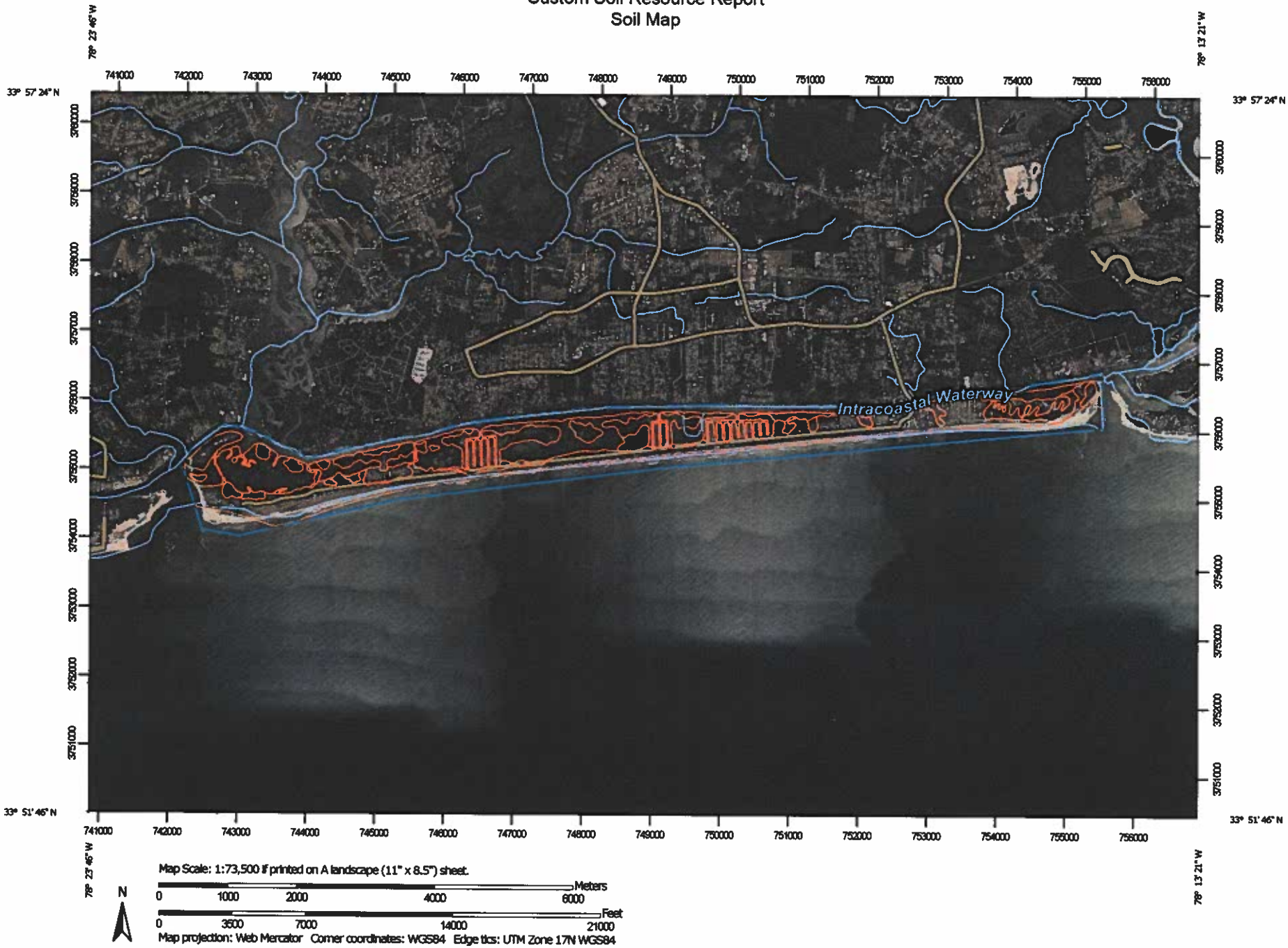
After soil scientists located and identified the significant natural bodies of soil in the survey area, they drew the boundaries of these bodies on aerial photographs and

identified each as a specific map unit. Aerial photographs show trees, buildings, fields, roads, and rivers, all of which help in locating boundaries accurately.

Soil Map

The soil map section includes the soil map for the defined area of interest, a list of soil map units on the map and extent of each map unit, and cartographic symbols displayed on the map. Also presented are various metadata about data used to produce the map, and a description of each soil map unit.

Custom Soil Resource Report
Soil Map



MAP LEGEND

Area of Interest (AOI)
- Area of Interest (AOI)

Soils
- Soil Map Unit Polygons
- Soil Map Unit Lines
- Soil Map Unit Points

Special Point Features
- Blowout
- Borrow Pit
- Clay Spot
- Closed Depression
- Gravel Pit
- Gravelly Spot
- Landfill
- Lava Flow
- Marsh or swamp
- Mine or Quarry
- Miscellaneous Water
- Perennial Water
- Rock Outcrop
- Saline Spot
- Sandy Spot
- Severely Eroded Spot
- Sinkhole
- Slide or Slip
- Sodic Spot
- Spoil Area
- Stony Spot
- Very Stony Spot
- Wet Spot
- Other
- Special Line Features

Water Features
- Streams and Canals

Transportation
- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background
- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:24,000.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Brunswick County, North Carolina
Survey Area Data: Version 28, Sep 13, 2023

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Dec 31, 2009—May 15, 2022

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Map Unit Legend

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
BO	Bohicket silty clay loam	10.1	0.3%
CA	Carteret loamy fine sand	542.8	18.5%
Co	Corolla fine sand	169.8	5.8%
Du	Duckston fine sand	24.7	0.8%
NeE	Newhan fine sand, 2 to 30 percent slopes	793.5	27.0%
NhE	Newhan fine sand, dredged, 2 to 30 percent slopes	419.9	14.3%
W	Water	405.7	13.8%
Totals for Area of Interest		**2,934.9**	**100.0%**

Map Unit Descriptions

The map units delineated on the detailed soil maps in a soil survey represent the soils or miscellaneous areas in the survey area. The map unit descriptions, along with the maps, can be used to determine the composition and properties of a unit.

A map unit delineation on a soil map represents an area dominated by one or more major kinds of soil or miscellaneous areas. A map unit is identified and named according to the taxonomic classification of the dominant soils. Within a taxonomic class there are precisely defined limits for the properties of the soils. On the landscape, however, the soils are natural phenomena, and they have the characteristic variability of all natural phenomena. Thus, the range of some observed properties may extend beyond the limits defined for a taxonomic class. Areas of soils of a single taxonomic class rarely, if ever, can be mapped without including areas of other taxonomic classes. Consequently, every map unit is made up of the soils or miscellaneous areas for which it is named and some minor components that belong to taxonomic classes other than those of the major soils.

Most minor soils have properties similar to those of the dominant soil or soils in the map unit, and thus they do not affect use and management. These are called noncontrasting, or similar, components. They may or may not be mentioned in a particular map unit description. Other minor components, however, have properties and behavioral characteristics divergent enough to affect use or to require different management. These are called contrasting, or dissimilar, components. They generally are in small areas and could not be mapped separately because of the scale used. Some small areas of strongly contrasting soils or miscellaneous areas are identified by a special symbol on the maps. If included in the database for a given area, the contrasting minor components are identified in the map unit descriptions along with some characteristics of each. A few areas of minor components may not have been observed, and consequently they are not mentioned in the descriptions, especially where the pattern was so complex that it

was impractical to make enough observations to identify all the soils and miscellaneous areas on the landscape.

The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The objective of mapping is not to delineate pure taxonomic classes but rather to separate the landscape into landforms or landform segments that have similar use and management requirements. The delineation of such segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, however, onsite investigation is needed to define and locate the soils and miscellaneous areas.

An identifying symbol precedes the map unit name in the map unit descriptions. Each description includes general facts about the unit and gives important soil properties and qualities.

Soils that have profiles that are almost alike make up a *soil series.* Except for differences in texture of the surface layer, all the soils of a series have major horizons that are similar in composition, thickness, and arrangement.

Soils of one series can differ in texture of the surface layer, slope, stoniness, salinity, degree of erosion, and other characteristics that affect their use. On the basis of such differences, a soil series is divided into *soil phases.* Most of the areas shown on the detailed soil maps are phases of soil series. The name of a soil phase commonly indicates a feature that affects use or management. For example, Alpha silt loam, 0 to 2 percent slopes, is a phase of the Alpha series.

Some map units are made up of two or more major soils or miscellaneous areas. These map units are complexes, associations, or undifferentiated groups.

A *complex* consists of two or more soils or miscellaneous areas in such an intricate pattern or in such small areas that they cannot be shown separately on the maps. The pattern and proportion of the soils or miscellaneous areas are somewhat similar in all areas. Alpha-Beta complex, 0 to 6 percent slopes, is an example.

An *association* is made up of two or more geographically associated soils or miscellaneous areas that are shown as one unit on the maps. Because of present or anticipated uses of the map units in the survey area, it was not considered practical or necessary to map the soils or miscellaneous areas separately. The pattern and relative proportion of the soils or miscellaneous areas are somewhat similar. Alpha-Beta association, 0 to 2 percent slopes, is an example.

An *undifferentiated group* is made up of two or more soils or miscellaneous areas that could be mapped individually but are mapped as one unit because similar interpretations can be made for use and management. The pattern and proportion of the soils or miscellaneous areas in a mapped area are not uniform. An area can be made up of only one of the major soils or miscellaneous areas, or it can be made up of all of them. Alpha and Beta soils, 0 to 2 percent slopes, is an example.

Some surveys include *miscellaneous areas.* Such areas have little or no soil material and support little or no vegetation. Rock outcrop is an example.

Brunswick County, North Carolina

BO—Bohicket silty clay loam

Map Unit Setting

National map unit symbol: 3w6q
Elevation: 0 feet
Mean annual precipitation: 42 to 58 inches
Mean annual air temperature: 61 to 64 degrees F
Frost-free period: 190 to 270 days
Farmland classification: Not prime farmland

Map Unit Composition

Bohicket, tidal, and similar soils: 85 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Bohicket, Tidal

Setting

Landform: Tidal marshes
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Silty and clayey fluviomarine deposits

Typical profile

A - 0 to 8 inches: silty clay loam
Cg1 - 8 to 38 inches: silty clay
Cg2 - 38 to 80 inches: loamy sand

Properties and qualities

Slope: 0 to 1 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Very poorly drained
Runoff class: Negligible
Capacity of the most limiting layer to transmit water (Ksat): Very low to moderately low (0.00 to 0.06 in/hr)
Depth to water table: About 0 inches
Frequency of flooding: Very frequent
Frequency of ponding: Frequent
Calcium carbonate, maximum content: 5 percent
Gypsum, maximum content: 1 percent
Maximum salinity: Moderately saline to strongly saline (8.0 to 32.0 mmhos/cm)
Sodium adsorption ratio, maximum: 55.0
Available water supply, 0 to 60 inches: Moderate (about 6.5 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 8w
Hydrologic Soil Group: D
Ecological site: R153BY130NC - Tidal Marsh on Mineral Soil
Hydric soil rating: Yes

CA—Carteret loamy fine sand

Map Unit Setting

National map unit symbol: 3w6v
Elevation: 0 to 10 feet
Mean annual precipitation: 42 to 58 inches
Mean annual air temperature: 61 to 64 degrees F
Frost-free period: 190 to 270 days
Farmland classification: Not prime farmland

Map Unit Composition

Carteret, tidal, and similar soils: 85 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Carteret, Tidal

Setting

Landform: Tidal flats
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Sandy fluviomarine deposits and/or eolian sands

Typical profile

Ag - 0 to 9 inches: sand
Cg - 9 to 80 inches: sand

Properties and qualities

Slope: 0 to 2 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Very poorly drained
Runoff class: Very high
Capacity of the most limiting layer to transmit water (Ksat): High to very high (5.95 to 19.98 in/hr)
Depth to water table: About 0 to 12 inches
Frequency of flooding: Frequent
Frequency of ponding: None
Maximum salinity: Strongly saline (16.0 to 80.0 mmhos/cm)
Sodium adsorption ratio, maximum: 60.0
Available water supply, 0 to 60 inches: Low (about 3.6 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 8w
Hydrologic Soil Group: A/D
Ecological site: R153BY130NC - Tidal Marsh on Mineral Soil
Hydric soil rating: Yes

Co—Corolla fine sand

Map Unit Setting

National map unit symbol: 3w6y
Elevation: 0 to 10 feet
Mean annual precipitation: 42 to 58 inches
Mean annual air temperature: 61 to 64 degrees F
Frost-free period: 190 to 270 days
Farmland classification: Not prime farmland

Map Unit Composition

Corolla and similar soils: 85 percent
Minor components: 7 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Corolla

Setting

Landform: Troughs on barrier islands
Landform position (two-dimensional): Backslope, toeslope
Landform position (three-dimensional): Base slope
Down-slope shape: Concave
Across-slope shape: Concave
Parent material: Eolian sands and/or beach sand

Typical profile

A - 0 to 3 inches: fine sand
C - 3 to 26 inches: fine sand
Ab - 26 to 32 inches: sand
Cg - 32 to 80 inches: sand

Properties and qualities

Slope: 0 to 6 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Moderately well drained
Runoff class: Very high
Capacity of the most limiting layer to transmit water (Ksat): Very high (19.98 to 39.96 in/hr)
Depth to water table: About 18 to 36 inches
Frequency of flooding: Rare
Frequency of ponding: None
Maximum salinity: Slightly saline to strongly saline (4.0 to 16.0 mmhos/cm)
Sodium adsorption ratio, maximum: 20.0
Available water supply, 0 to 60 inches: Very low (about 1.2 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 7s
Hydrologic Soil Group: A
Ecological site: R153BY110NC - Coastal Strand, Beaches, and Dunes
Hydric soil rating: No

Minor Components

Duckston

Percent of map unit: 5 percent
Landform: Depressions
Down-slope shape: Concave
Across-slope shape: Concave
Ecological site: R153BY120NC - Wet Dune Slack
Hydric soil rating: Yes

Carteret, high

Percent of map unit: 2 percent
Landform: Tidal marshes
Down-slope shape: Linear
Across-slope shape: Linear
Ecological site: R153BY130NC - Tidal Marsh on Mineral Soil
Hydric soil rating: Yes

Du—Duckston fine sand

Map Unit Setting

National map unit symbol: 3w70
Elevation: 0 to 10 feet
Mean annual precipitation: 42 to 58 inches
Mean annual air temperature: 61 to 64 degrees F
Frost-free period: 190 to 270 days
Farmland classification: Not prime farmland

Map Unit Composition

Duckston and similar soils: 90 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Duckston

Setting

Landform: Depressions
Down-slope shape: Concave
Across-slope shape: Concave
Parent material: Eolian sands and/or beach sand

Typical profile

A - 0 to 8 inches: fine sand
Cg - 8 to 13 inches: sand
Ab - 13 to 17 inches: sand
C'g - 17 to 80 inches: sand

Properties and qualities

Slope: 0 to 2 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Poorly drained

Runoff class: Very high
Capacity of the most limiting layer to transmit water (Ksat): Very high (19.98 to 39.96 in/hr)
Depth to water table: About 0 to 6 inches
Frequency of flooding: Occasional
Frequency of ponding: None
Maximum salinity: Moderately saline to strongly saline (8.0 to 16.0 mmhos/cm)
Sodium adsorption ratio, maximum: 20.0
Available water supply, 0 to 60 inches: Very low (about 3.0 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 7w
Hydrologic Soil Group: A/D
Ecological site: R153BY120NC - Wet Dune Slack
Hydric soil rating: Yes

NeE—Newhan fine sand, 2 to 30 percent slopes

Map Unit Setting

National map unit symbol: 3w7f
Elevation: 0 to 20 feet
Mean annual precipitation: 42 to 58 inches
Mean annual air temperature: 61 to 64 degrees F
Frost-free period: 190 to 270 days
Farmland classification: Not prime farmland

Map Unit Composition

Newhan and similar soils: 85 percent
Minor components: 5 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Newhan

Setting

Landform: Dunes
Landform position (two-dimensional): Shoulder, backslope
Landform position (three-dimensional): Side slope
Down-slope shape: Convex
Across-slope shape: Convex
Parent material: Eolian sands and/or beach sand

Typical profile

A - 0 to 2 inches: fine sand
C1 - 2 to 50 inches: fine sand
C2 - 50 to 80 inches: sand

Properties and qualities

Slope: 2 to 30 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Excessively drained
Runoff class: Very low

Capacity of the most limiting layer to transmit water (Ksat): Very high (19.98 to 39.96 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: Rare
Frequency of ponding: None
Maximum salinity: Slightly saline to strongly saline (4.0 to 16.0 mmhos/cm)
Sodium adsorption ratio, maximum: 20.0
Available water supply, 0 to 60 inches: Very low (about 1.8 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 8s
Hydrologic Soil Group: A
Ecological site: R153BY110NC - Coastal Strand, Beaches, and Dunes
Hydric soil rating: No

Minor Components

Beaches

Percent of map unit: 5 percent
Landform: Barrier beaches, barrier flats
Ecological site: R153BY110NC - Coastal Strand, Beaches, and Dunes, R153BY120NC - Wet Dune Slack
Hydric soil rating: Yes

NhE—Newhan fine sand, dredged, 2 to 30 percent slopes

Map Unit Setting

National map unit symbol: 3w7g
Elevation: 0 to 10 feet
Mean annual precipitation: 42 to 58 inches
Mean annual air temperature: 61 to 64 degrees F
Frost-free period: 190 to 270 days
Farmland classification: Not prime farmland

Map Unit Composition

Newhan and similar soils: 85 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Newhan

Setting

Landform: Dune slacks, dunes
Landform position (two-dimensional): Shoulder, backslope
Landform position (three-dimensional): Side slope
Down-slope shape: Convex
Across-slope shape: Convex
Parent material: Sandy dredge spoils

Typical profile

A - 0 to 1 inches: fine sand

C - 1 to 80 inches: fine sand

Properties and qualities

Slope: 2 to 30 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Excessively drained
Runoff class: Very low
Capacity of the most limiting layer to transmit water (Ksat): Very high (19.98 to 39.96 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: Rare
Frequency of ponding: None
Maximum salinity: Slightly saline to strongly saline (4.0 to 16.0 mmhos/cm)
Sodium adsorption ratio, maximum: 20.0
Available water supply, 0 to 60 inches: Very low (about 1.8 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 8s
Hydrologic Soil Group: A
Ecological site: R153BY110NC - Coastal Strand, Beaches, and Dunes
Hydric soil rating: No

W—Water

Map Unit Composition

Water: 100 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Water

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 8
Hydric soil rating: No

References

American Association of State Highway and Transportation Officials (AASHTO). 2004. Standard specifications for transportation materials and methods of sampling and testing. 24th edition.

American Society for Testing and Materials (ASTM). 2005. Standard classification of soils for engineering purposes. ASTM Standard D2487-00.

Cowardin, L.M., V. Carter, F.C. Golet, and E.T. LaRoe. 1979. Classification of wetlands and deep-water habitats of the United States. U.S. Fish and Wildlife Service FWS/OBS-79/31.

Federal Register. July 13, 1994. Changes in hydric soils of the United States.

Federal Register. September 18, 2002. Hydric soils of the United States.

Hurt, G.W., and L.M. Vasilas, editors. Version 6.0, 2006. Field indicators of hydric soils in the United States.

National Research Council. 1995. Wetlands: Characteristics and boundaries.

Soil Survey Division Staff. 1993. Soil survey manual. Soil Conservation Service. U.S. Department of Agriculture Handbook 18. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/soils/?cid=nrcs142p2_054262

Soil Survey Staff. 1999. Soil taxonomy: A basic system of soil classification for making and interpreting soil surveys. 2nd edition. Natural Resources Conservation Service, U.S. Department of Agriculture Handbook 436. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/soils/?cid=nrcs142p2_053577

Soil Survey Staff. 2010. Keys to soil taxonomy. 11th edition. U.S. Department of Agriculture, Natural Resources Conservation Service. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/soils/?cid=nrcs142p2_053580

Tiner, R.W., Jr. 1985. Wetlands of Delaware. U.S. Fish and Wildlife Service and Delaware Department of Natural Resources and Environmental Control, Wetlands Section.

United States Army Corps of Engineers, Environmental Laboratory. 1987. Corps of Engineers wetlands delineation manual. Waterways Experiment Station Technical Report Y-87-1.

United States Department of Agriculture, Natural Resources Conservation Service. National forestry manual. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/home/?cid=nrcs142p2_053374

United States Department of Agriculture, Natural Resources Conservation Service. National range and pasture handbook. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/landuse/rangepasture/?cid=stelprdb1043084

United States Department of Agriculture, Natural Resources Conservation Service. National soil survey handbook, title 430-VI. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/scientists/?cid=nrcs142p2_054242

United States Department of Agriculture, Natural Resources Conservation Service. 2006. Land resource regions and major land resource areas of the United States, the Caribbean, and the Pacific Basin. U.S. Department of Agriculture Handbook 296. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/soils/?cid=nrcs142p2_053624

United States Department of Agriculture, Soil Conservation Service. 1961. Land capability classification. U.S. Department of Agriculture Handbook 210. http://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs142p2_052290.pdf

NOAA Atlas 14, Volume 2, Version 3 SOUTHPORT
5 N
Station ID: 31-8113
Location name: Southport, North Carolina, USA*
Latitude: 33.9922°, Longitude: -78.01°
Elevation:
Elevation (station metadata): 20 ft**
* source: ESRI Maps
** source: USGS

POINT PRECIPITATION FREQUENCY ESTIMATES

G.M. Bonnin, D. Martin, B. Lin, T. Parzybok, M.Yekta, and D. Riley

NOAA, National Weather Service, Silver Spring, Maryland

PF_tabular | PF_graphical | Maps_&_aerials

PF tabular

PDS-based point precipitation frequency estimates with 90% confidence intervals (in inches)[1]

Duration	Average recurrence interval (years)									
	1	2	5	10	25	50	100	200	500	1000
5-min	0.544 (0.506-0.588)	0.647 (0.601-0.699)	0.750 (0.695-0.808)	0.837 (0.774-0.902)	0.943 (0.867-1.01)	1.02 (0.940-1.10)	1.11 (1.01-1.19)	1.19 (1.08-1.28)	1.30 (1.16-1.41)	1.39 (1.24-1.51)
10-min	0.869 (0.808-0.939)	1.04 (0.961-1.12)	1.20 (1.11-1.29)	1.34 (1.24-1.44)	1.50 (1.38-1.62)	1.63 (1.50-1.76)	1.76 (1.60-1.90)	1.89 (1.71-2.04)	2.06 (1.84-2.22)	2.19 (1.95-2.38)
15-min	1.09 (1.01-1.17)	1.30 (1.21-1.40)	1.52 (1.41-1.64)	1.69 (1.56-1.82)	1.90 (1.75-2.05)	2.07 (1.90-2.23)	2.23 (2.03-2.40)	2.38 (2.16-2.57)	2.59 (2.32-2.80)	2.75 (2.44-2.99)
30-min	1.49 (1.38-1.61)	1.80 (1.67-1.94)	2.16 (2.00-2.33)	2.45 (2.27-2.64)	2.82 (2.59-3.03)	3.11 (2.85-3.35)	3.41 (3.11-3.67)	3.71 (3.36-4.00)	4.12 (3.69-4.46)	4.46 (3.96-4.84)
60-min	1.86 (1.73-2.01)	2.26 (2.09-2.43)	2.77 (2.56-2.98)	3.20 (2.95-3.44)	3.76 (3.45-4.04)	4.22 (3.87-4.54)	4.70 (4.28-5.06)	5.20 (4.71-5.61)	5.91 (5.29-6.39)	6.51 (5.78-7.06)
2-hr	2.22 (2.05-2.43)	2.71 (2.50-2.96)	3.41 (3.14-3.72)	4.03 (3.70-4.39)	4.87 (4.45-5.31)	5.60 (5.09-6.10)	6.38 (5.76-6.95)	7.23 (6.48-7.87)	8.47 (7.51-9.24)	9.56 (8.40-10.5)
3-hr	2.38 (2.18-2.61)	2.90 (2.66-3.18)	3.66 (3.36-4.02)	4.36 (3.98-4.78)	5.34 (4.86-5.85)	6.22 (5.61-6.81)	7.16 (6.42-7.84)	8.21 (7.30-8.98)	9.79 (8.58-10.7)	11.2 (9.70-12.3)
6-hr	2.98 (2.73-3.30)	3.64 (3.34-4.02)	4.62 (4.22-5.09)	5.50 (5.01-6.06)	6.77 (6.12-7.44)	7.90 (7.08-8.68)	9.13 (8.13-10.0)	10.5 (9.26-11.5)	12.6 (10.9-13.9)	14.5 (12.4-16.0)
12-hr	3.50 (3.18-3.91)	4.27 (3.87-4.75)	5.45 (4.93-6.07)	6.53 (5.88-7.26)	8.10 (7.22-8.98)	9.50 (8.42-10.5)	11.1 (9.71-12.2)	12.8 (11.1-14.2)	15.5 (13.3-17.2)	17.9 (15.1-19.8)
24-hr	4.08 (3.76-4.47)	4.94 (4.57-5.44)	6.40 (5.89-7.02)	7.67 (7.04-8.43)	9.64 (8.76-10.6)	11.4 (10.2-12.5)	13.4 (11.9-14.7)	15.7 (13.6-17.3)	19.2 (16.3-21.3)	22.2 (18.6-24.9)
2-day	4.68 (4.34-5.11)	5.66 (5.26-6.18)	7.25 (6.71-7.96)	8.64 (7.94-9.49)	10.7 (9.76-11.8)	12.6 (11.3-13.9)	14.7 (13.1-16.3)	17.1 (15.0-19.0)	20.7 (17.8-23.1)	23.9 (20.2-26.9)
3-day	4.90 (4.56-5.33)	5.92 (5.51-6.44)	7.54 (6.99-8.22)	8.94 (8.24-9.76)	11.0 (10.1-12.1)	12.9 (11.6-14.1)	14.9 (13.3-16.4)	17.2 (15.2-19.0)	20.8 (18.0-23.3)	23.9 (20.3-27.0)
4-day	5.13 (4.78-5.55)	6.18 (5.76-6.70)	7.82 (7.27-8.49)	9.24 (8.54-10.0)	11.3 (10.4-12.3)	13.1 (11.9-14.3)	15.1 (13.6-16.5)	17.4 (15.4-19.1)	20.9 (18.2-23.4)	24.0 (20.5-27.1)
7-day	5.79 (5.44-6.19)	6.98 (6.56-7.48)	8.77 (8.22-9.40)	10.3 (9.58-11.0)	12.5 (11.5-13.4)	14.3 (13.2-15.4)	16.3 (14.9-17.6)	18.5 (16.6-20.0)	21.7 (19.2-23.7)	24.3 (21.2-27.4)
10-day	6.50 (6.12-6.94)	7.78 (7.32-8.32)	9.63 (9.02-10.3)	11.2 (10.5-12.0)	13.4 (12.5-14.4)	15.3 (14.1-16.5)	17.4 (15.9-18.7)	19.6 (17.7-21.2)	22.7 (20.2-24.8)	25.4 (22.2-27.9)
20-day	8.72 (8.20-9.32)	10.4 (9.77-11.1)	12.6 (11.9-13.6)	14.5 (13.6-15.6)	17.2 (16.0-18.4)	19.4 (17.9-20.8)	21.7 (19.9-23.4)	24.2 (22.0-26.2)	27.7 (24.8-30.3)	30.5 (27.0-33.6)
30-day	10.8 (10.2-11.5)	12.8 (12.1-13.7)	15.4 (14.5-16.4)	17.5 (16.5-18.6)	20.4 (19.1-21.7)	22.7 (21.1-24.2)	25.0 (23.2-26.8)	27.5 (25.3-29.6)	30.9 (28.1-33.5)	33.6 (30.2-36.6)
45-day	13.3 (12.6-14.1)	15.7 (14.9-16.7)	18.7 (17.6-19.8)	21.0 (19.8-22.3)	24.3 (22.8-25.8)	26.8 (25.1-28.5)	29.5 (27.3-31.4)	32.2 (29.6-34.4)	35.8 (32.6-38.7)	38.7 (35.0-42.1)
60-day	16.3 (15.5-17.3)	19.2 (18.3-20.3)	22.5 (21.3-23.8)	25.1 (23.7-26.5)	28.5 (26.9-30.2)	31.2 (29.4-33.1)	33.9 (31.7-36.0)	36.6 (34.0-39.0)	40.2 (37.0-43.1)	42.9 (39.3-46.2)

[1] Precipitation frequency (PF) estimates in this table are based on frequency analysis of partial duration series (PDS).

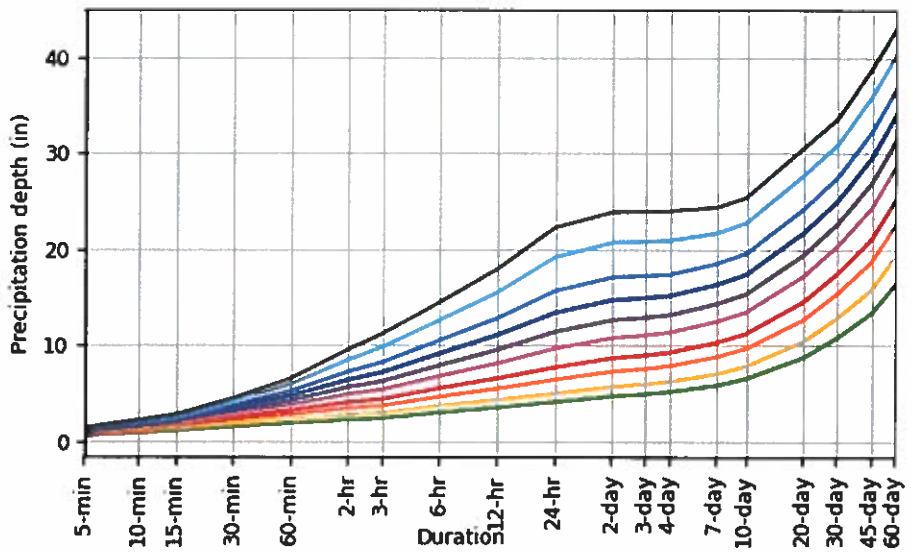
Numbers in parenthesis are PF estimates at lower and upper bounds of the 90% confidence interval. The probability that precipitation frequency estimates (for a given duration and average recurrence interval) will be greater than the upper bound (or less than the lower bound) is 5%. Estimates at upper bounds are not checked against probable maximum precipitation (PMP) estimates and may be higher than currently valid PMP values.

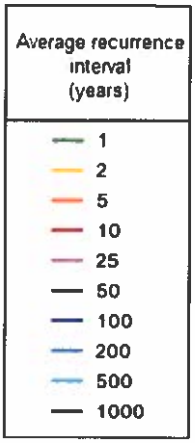
Please refer to NOAA Atlas 14 document for more information.

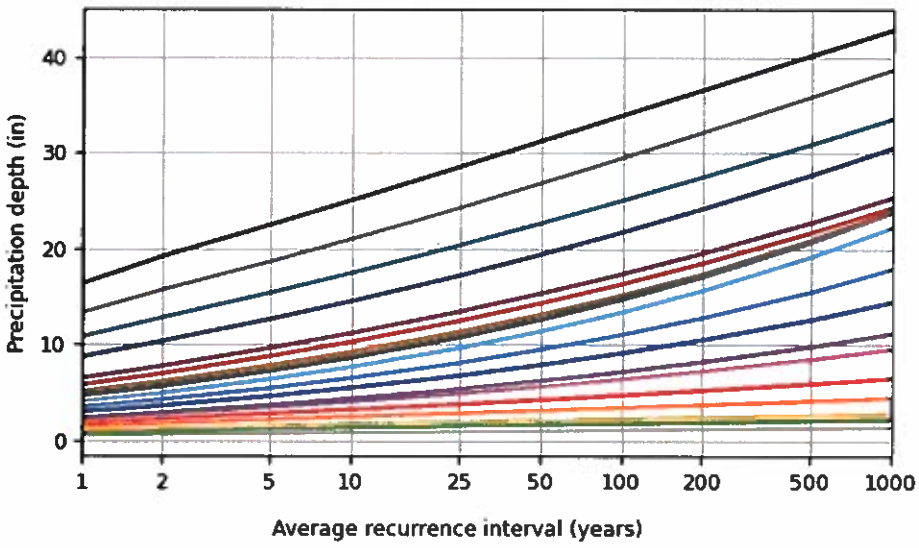
Back to Top

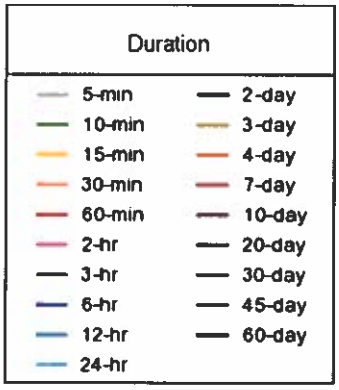
PF graphical

PDS-based depth-duration-frequency (DDF) curves
Latitude: 33.9922°, Longitude: -78.0100°









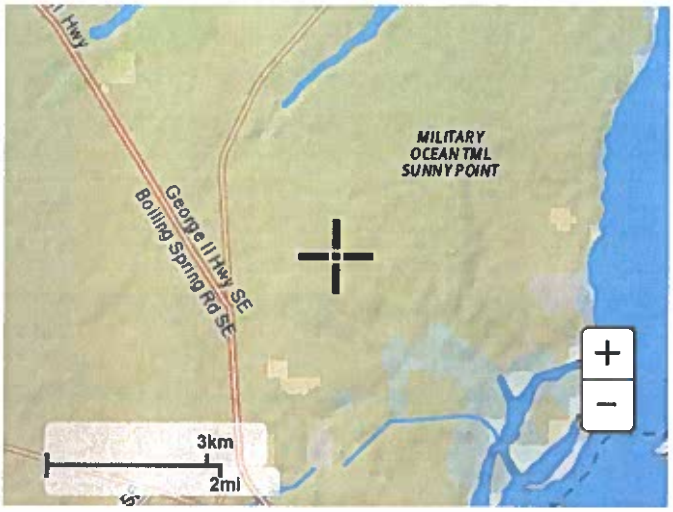
NOAA Atlas 14, Volume 2, Version 3

Created (GMT): Mon Mar 18 20:34:04 2024

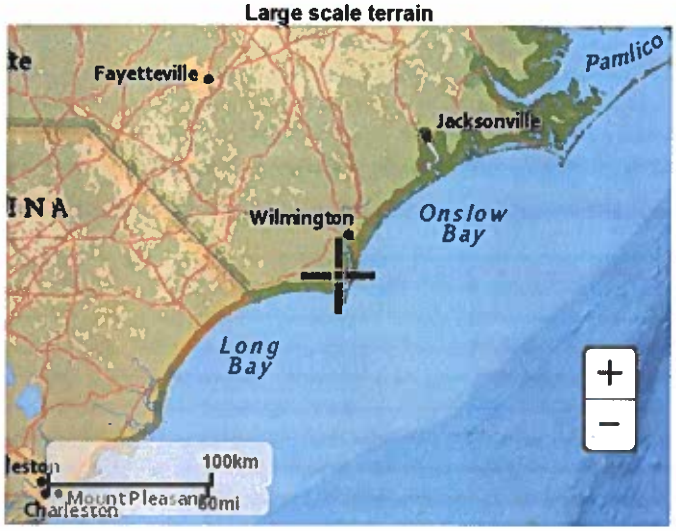
Back to Top

Maps & aerials

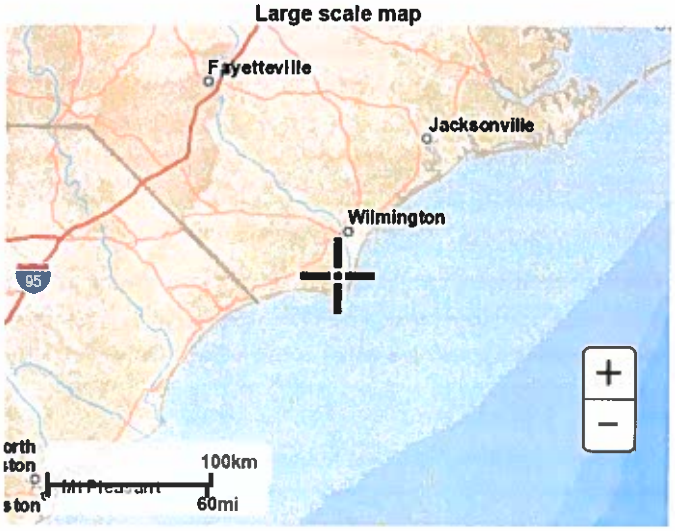
Small scale terrain



Large scale terrain



Large scale map



Large scale aerial

Back to Top

US Department of Commerce
National Oceanic and Atmospheric Administration
National Weather Service
National Water Center
1325 East West Highway
Silver Spring, MD 20910
Questions?: HDSC.Questions@noaa.gov

Datums for 8659665, BOWEN POINT, SHALLOTTE INLET

NOTICE: All data values are relative to the MLLW.

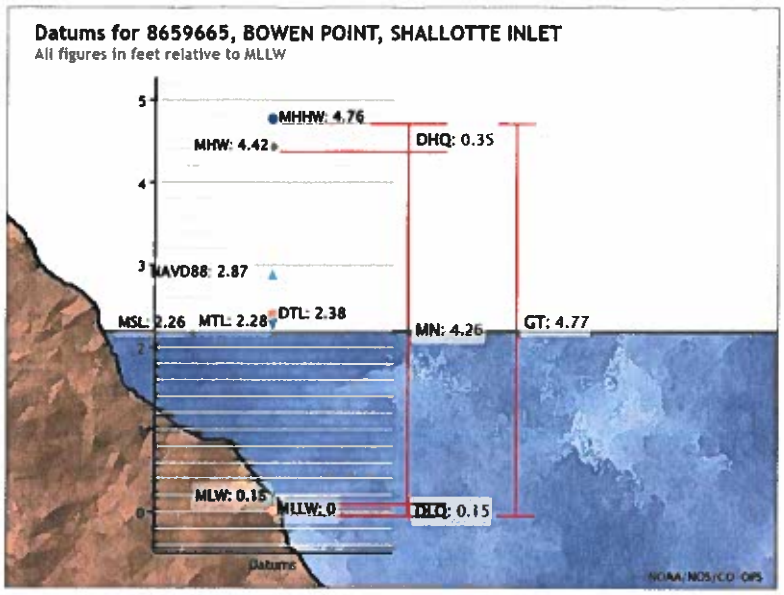
Elevations on Mean Lower Low Water

Station: 8659665, BOWEN POINT, SHALLOTTE INLET
Status: Accepted (Jan 31 2023)
Units: Feet
Control Station: 8658120 Wilmington, NC
T.M.: 0
Epoch: (/datum_options.html#NTDE) 1983-2001
Datum: MLLW

Datum	Value	Description
MHHW (/datum_options.html#MHHW)	4.76	Mean Higher-High Water
MHW (/datum_options.html#MHW)	4.42	Mean High Water
MTL (/datum_options.html#MTL)	2.28	Mean Tide Level
MSL (/datum_options.html#MSL)	2.26	Mean Sea Level
DTL (/datum_options.html#DTL)	2.38	Mean Diurnal Tide Level
MLW (/datum_options.html#MLW)	0.15	Mean Low Water
MLLW (/datum_options.html#MLLW)	0.00	Mean Lower-Low Water
NAVD88 (/datum_options.html)	2.87	North American Vertical Datum of 1988
STND (/datum_options.html#STND)	-23.90	Station Datum
GT (/datum_options.html#GT)	4.77	Great Diurnal Range
MN (/datum_options.html#MN)	4.26	Mean Range of Tide
DHQ (/datum_options.html#DHQ)	0.35	Mean Diurnal High Water Inequality
DLQ (/datum_options.html#DLQ)	0.15	Mean Diurnal Low Water Inequality
HWI (/datum_options.html#HWI)	0.52	Greenwich High Water Interval (in hours)
LWI (/datum_options.html#LWI)	6.90	Greenwich Low Water Interval (in hours)
Max Tide (/datum_options.html#MAXTIDE)		Highest Observed Tide
Max Tide Date & Time (/datum_options.html#MAXTIDEDT)		Highest Observed Tide Date & Time
Min Tide (/datum_options.html#MINTIDE)		Lowest Observed Tide
Min Tide Date & Time (/datum_options.html#MINTIDEDT)		Lowest Observed Tide Date & Time
HAT (/datum_options.html#HAT)	6.16	Highest Astronomical Tide
HAT Date & Time	10/28/2011 13:30	HAT Date and Time
LAT (/datum_options.html#LAT)	-1.52	Lowest Astronomical Tide
LAT Date & Time	02/09/2001 07:24	LAT Date and Time

Tidal Datum Analysis Periods

01/01/2022 - 05/31/2022



Showing datums for

1611347 PORT ALLEN, HAN...

Datum

MLLW

Data Units (•) Feet ( ) Meters

Epoch (•) Present (1983-2001) ( ) Superseded (1960-1978)

Submit

Hide nearby stations

NEAR BOWEN POINT, SHALLOTTE INLET

Wilmington, NC (datums.html?id=8658120&name=Wilmington&state=NC)

Springmaid Pier, SC (datums.html?id=8661070&name=Springmaid Pier&state=SC)

Wrightsville Beach, NC (datums.html?id=8658163&name=Wrightsville Beach&state=NC)

Beaufort, Duke Marine Lab, NC (datums.html?id=8656483&name=Beaufort, Duke Marine Lab&state=NC)

Don Holt Bridge Air Gap, SC (datums.html?id=8664753&name=Don Holt Bridge Air Gap&state=SC)

Ravenel Bridge Air Gap, SC (datums.html?id=8665353&name=Ravenel Bridge Air Gap&state=SC)

Charleston, SC (datums.html?id=8665530&name=Charleston&state=SC)

ORIENTAL, NEUSE RI, R, (datums.html?id=8655133&name=ORIENTAL, NEUSE RI&state=R,)

CEDAR ISL, D, (datums.html?id=8655151&name=CEDAR ISL&state=D,)

Ocracoke, Pamlico So, d, (datums.html?id=8654769&name=Ocracoke, Pamlico So&state=d,)

Fort Pulaski, GA (datums.html?id=8670870&name=Fort Pulaski&state=GA)

Datums for 8659414, Varnamtown, Lockwoods Folly River

NOTICE: All data values are relative to the MLLW.

Elevations on Mean Lower Low Water

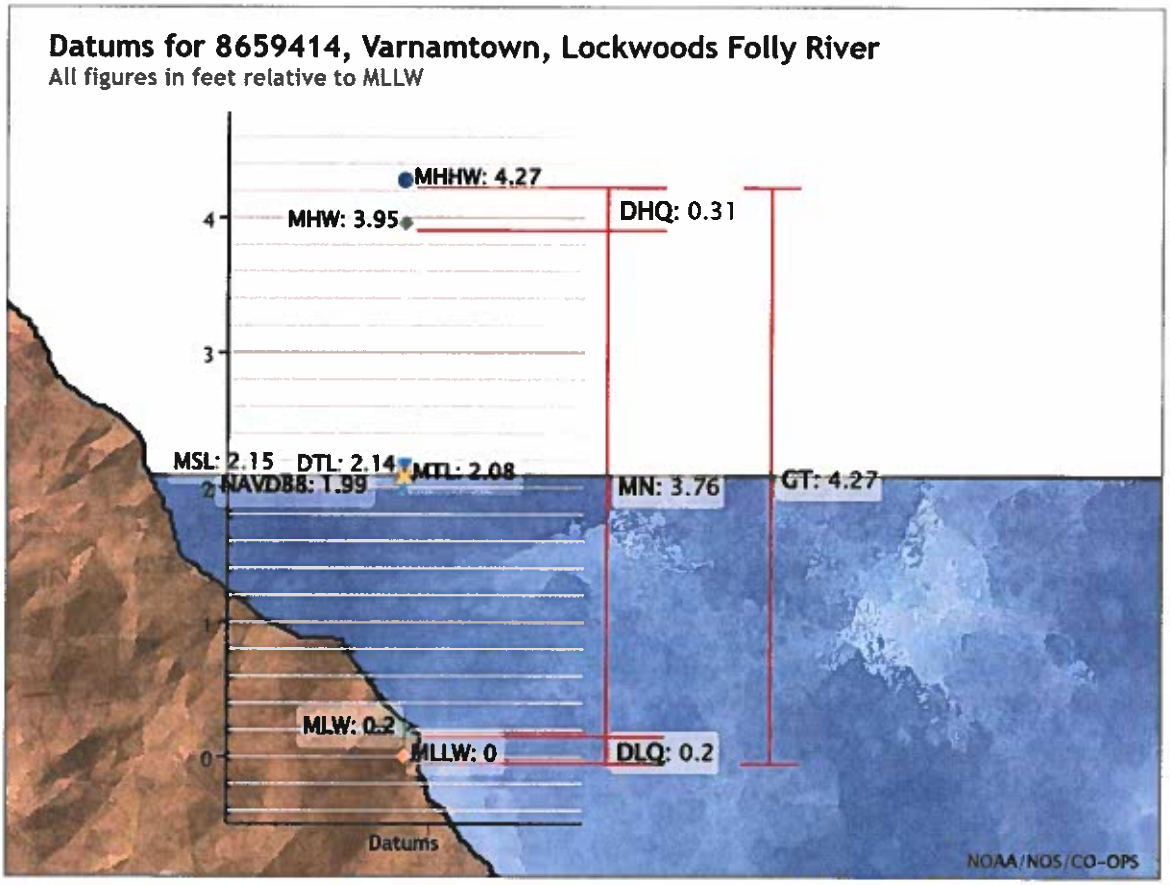
Station: 8659414, Varnamtown, Lockwoods Folly River
Status: Accepted (Apr 26 2023)
Units: Feet
Control Station: 8658163 Wrightsville Beach, NC
T.M.: 0
Epoch: (/datum_options.html#NTDE) 1983-2001
Datum: MLLW

Datum	Value	Description
MHHW (/datum_options.html#MHHW)	4.27	Mean Higher-High Water
MHW (/datum_options.html#MHW)	3.95	Mean High Water
MTL (/datum_options.html#MTL)	2.08	Mean Tide Level
MSL (/datum_options.html#MSL)	2.15	Mean Sea Level
DTL (/datum_options.html#DTL)	2.14	Mean Diurnal Tide Level
MLW (/datum_options.html#MLW)	0.20	Mean Low Water
MLLW (/datum_options.html#MLLW)	0.00	Mean Lower-Low Water
NAVD88 (/datum_options.html)	1.99	North American Vertical Datum of 1988
STND (/datum_options.html#STND)	-26.13	Station Datum
GT (/datum_options.html#GT)	4.27	Great Diurnal Range
MN (/datum_options.html#MN)	3.76	Mean Range of Tide
DHQ (/datum_options.html#DHQ)	0.31	Mean Diurnal High Water Inequality
DLQ (/datum_options.html#DLQ)	0.20	Mean Diurnal Low Water Inequality

Datum	Value	Description
HWI (/datum_options.html#HWI)	1.05	Greenwich High Water Interval (in hours)
LWI (/datum_options.html#LWI)	7.62	Greenwich Low Water Interval (in hours)
Max Tide (/datum_options.html#MAXTIDE)		Highest Observed Tide
Max Tide Date & Time (/datum_options.html#MAXTIDEDT)		Highest Observed Tide Date & Time
Min Tide (/datum_options.html#MINTIDE)		Lowest Observed Tide
Min Tide Date & Time (/datum_options.html#MINTIDEDT)		Lowest Observed Tide Date & Time
HAT (/datum_options.html#HAT)	5.63	Highest Astronomical Tide
HAT Date & Time	10/27/2007 13:54	HAT Date and Time
LAT (/datum_options.html#LAT)	-0.91	Lowest Astronomical Tide
LAT Date & Time	01/31/2014 07:30	LAT Date and Time

Tidal Datum Analysis Periods

04/01/2022 - 06/30/2022

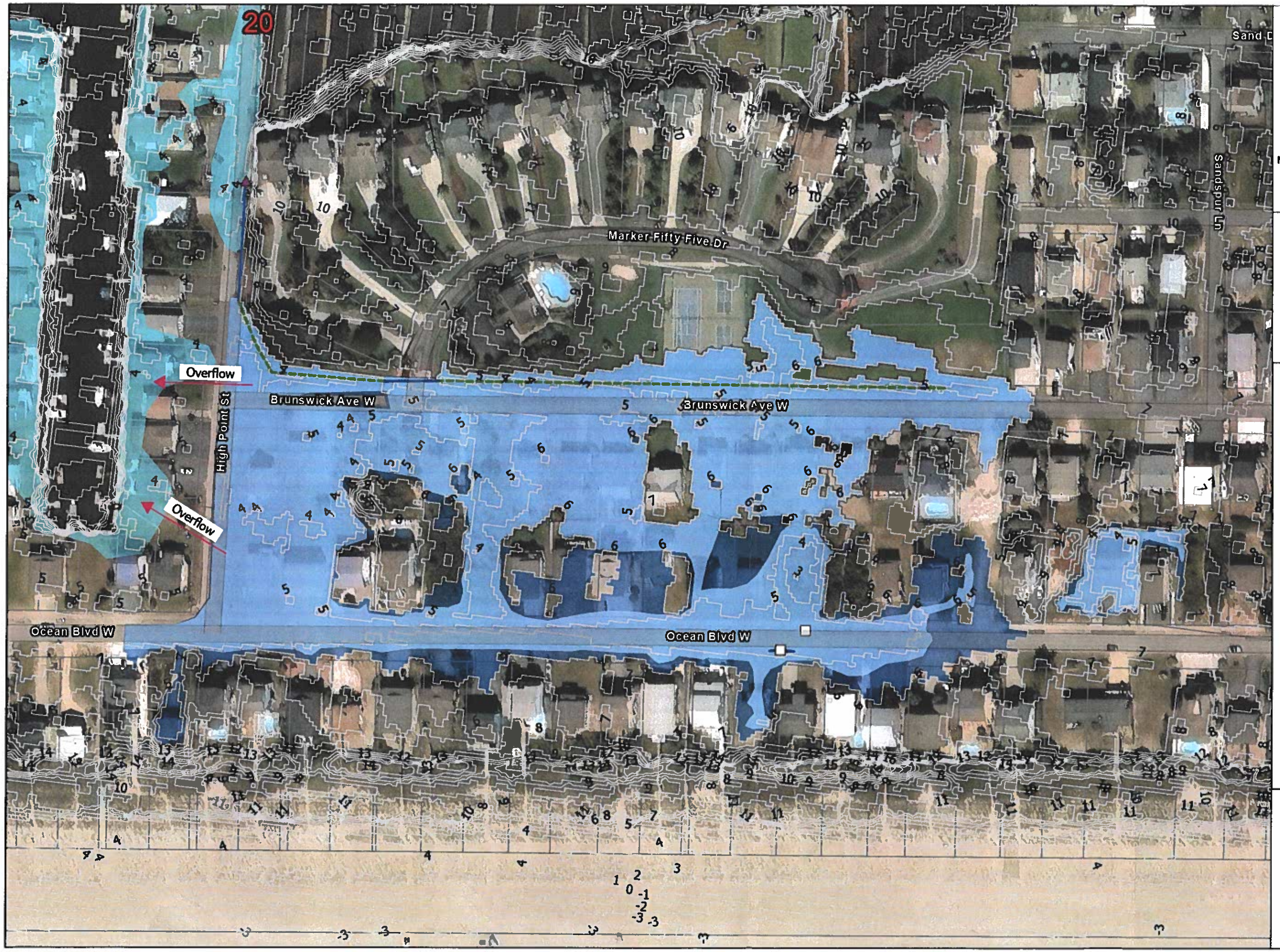


Appendix D

Existing Conditions Maps

Appendix D

Existing Conditions Maps



Holden Beach Stormwater Masterplan

Attachment D.1
Existing Conditions
Problem Area 1
300 Block OBW

MAP PROJECTION:
NORTH CAROLINA STATE PLANE (FEET)

DATUM:
NAD 1983 (HORIZONTAL)
NAVD 1988 (VERTICAL)

DESIGNER: CA
REVIEWER: MH
DATE: April 2024

N
W E
S

Legend

- Outfall
- Ex. Catch Basin
- Ex. Drainage Pipe
- Ex. Channel
- Parcels
- Contours
- 2-YR Flooding Area
- 10-YR Flooding Area
- Sunny Day MHHW Flooding

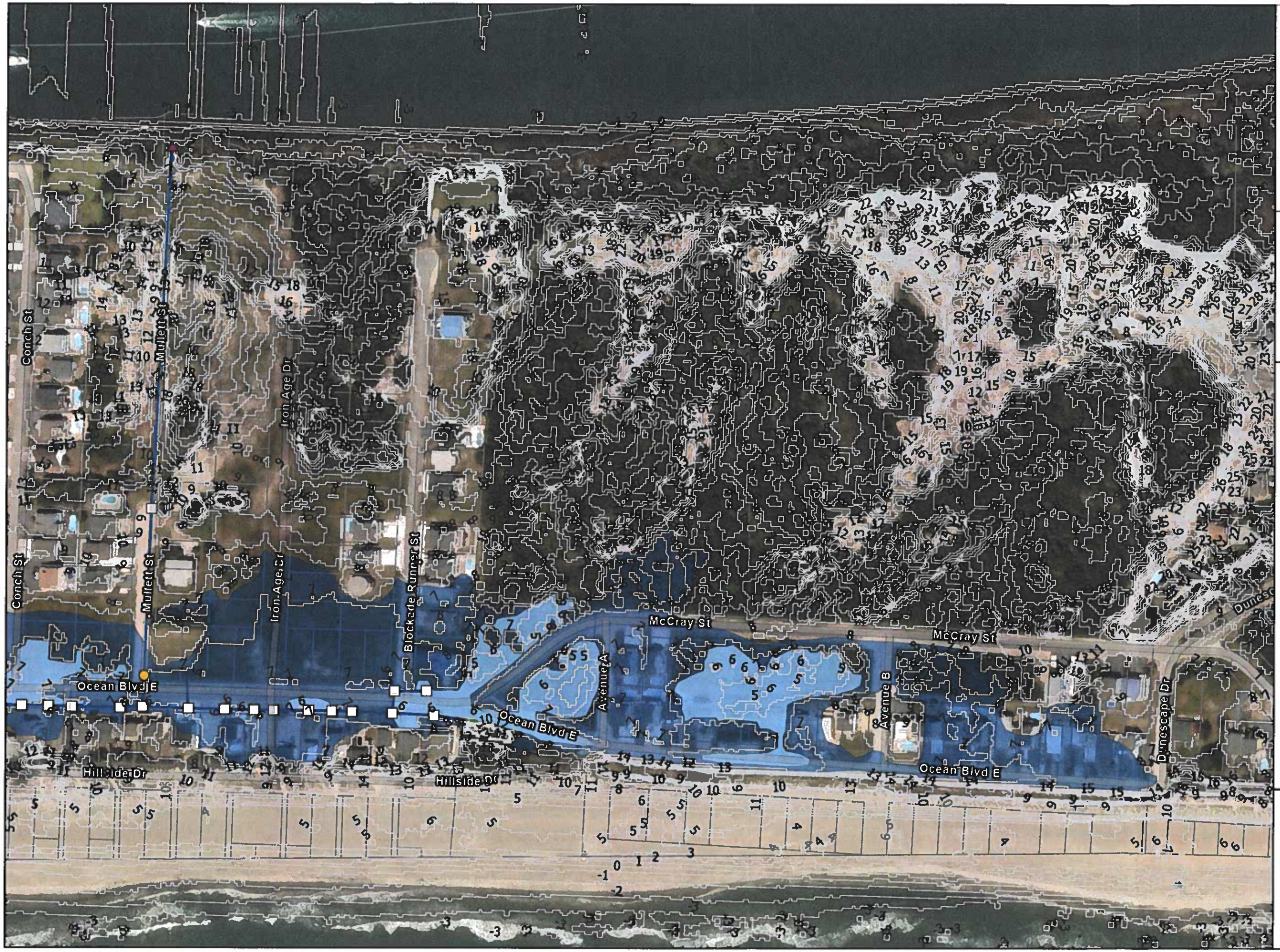
0 60 120 Feet

1 inch = 120 feet

mcgill

712 Village Rd. Suite 103
Shallotte, NC 28470
910.755.5872

NC Firm License # C-0459



Holden Beach Stormwater Masterplan

Attachment D.2 Existing Conditions Problem Area 2 East End Mullet St. & East End Ave. A

MAP PROJECTION:
NORTH CAROLINA STATE PLANE (FEET)

DATUM:
NAD 1983 (HORIZONTAL)
NAVD 1988 (VERTICAL)

DESIGNER: CA
REVIEWER: MH
DATE: April 2024

N
W E
S

Legend

- Outfall
- Ex. Catch Basin
- Ex. Junction Box
- Ex. Drainage Pipe
- Ex. Channel
- Parcels
- Contours
- 2-YR Flooding Area
- 10-YR Flooding Area
- Sunny Day MHHW Flooding

0 87.5 175 Feet

1 inch = 175 feet

mcgill

712 Village Rd. Suite 103
Shallotte, NC 28470
910 755.5872

NC Firm License # C-0459

Holden Beach Stormwater Masterplan

Attachment D.4
Existing Conditions
Problem Area 4
760 Block OBW

MAP PROJECTION:
NORTH CAROLINA STATE PLANE (FEET)

DATUM:
NAD 1983 (HORIZONTAL)
NAVD 1988 (VERTICAL)

DESIGNER: CA
REVIEWER: MH
DATE: April 2024

N
W E
S

Legend

- Ex. Catch Basin
- Ex. Drainage Pipe
- Parcels
- Contours
- 2-YR Flooding Area
- 10-YR Flooding Area
- Sunny Day MHHW Flooding

0 60 120 Feet

1 inch = 120 feet

mcgill

712 Village Rd. Suite 103
Shallotte, NC 28470
910.755.5872

NC Firm License # C-0459

Holden Beach Stormwater Masterplan

Attachment D.5 Existing Conditions Problem Area 5 Carolina Ave.

MAP PROJECTION:
NORTH CAROLINA STATE PLANE (FEET)

DATUM:
NAD 1983 (HORIZONTAL)
NAVD 1988 (VERTICAL)

DESIGNER: CA
REVIEWER: MH
DATE: April 2024

N
W E
S

Legend

- Ex. Catch Basin
- Ex. Drainage Pipe
- Parcels
- Contours
- 2-YR Flooding Area
- 10-YR Flooding Area
- Sunny Day MHHW Flooding

0 37.5 75 Feet

1 inch = 75 feet

mcgill

712 Village Rd. Suite 103
Shallotte, NC 28470
910.755.5872

NC Firm License # C-0459

Holden Beach Stormwater Masterplan

Attachment D.6
Existing Conditions
Problem Area 6
Davis St.

MAP PROJECTION:
NORTH CAROLINA STATE PLANE (FEET)

DATUM:
NAD 1983 (HORIZONTAL)
NAVD 1988 (VERTICAL)

DESIGNER: CA
REVIEWER: MH
DATE: April 2024

N
W E
S

Legend

- Ex. Drainage Pipe
- Ex. Channel
- Parcels
- Contours
- 2-YR Flooding Area
- 10-YR Flooding Area
- Sunny Day MHHW Flooding

0 20 40 Feet

1 inch = 40 feet

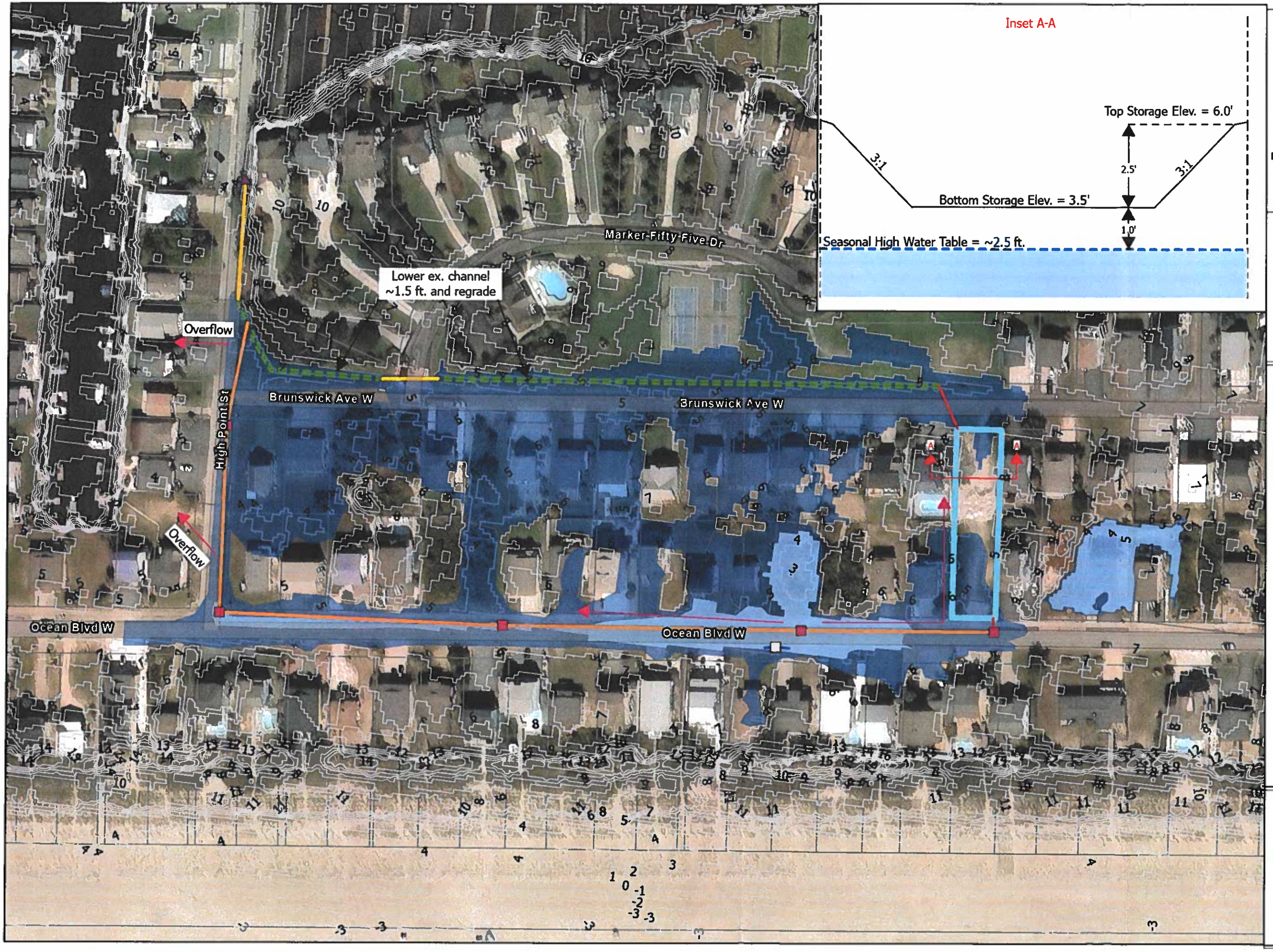
mcgill

712 Village Rd. Suite 103
Shallotte, NC 28470
910.755.5872

NC Firm License # C-0459

Appendix E

Proposed Conditions Maps



Holden Beach Stormwater Masterplan

Attachment E.1.1A
Proposed Alternative 1
Phase 1
Problem Area 1
300 Block OBW

MAP PROJECTION:
NORTH CAROLINA STATE PLANE (FEET

DATUM:
NAD 1983 (HORIZONTAL)
NAVD 1988 (VERTICAL)

DESIGNER: CA
REVIEWER: MH
DATE: April 2024

N
W E
S

Legend

- Outfall
- Ex. Catch Basin
- Ex. Drainage Pipe
- Ex. Drainage Channel
- Prop. Catch Basin
- Prop. 12" HDPE
- Prop. 15" HPPP
- Prop. 18" RCP
- Prop. Storage Depression
- 2-YR Flood Area
- 10-YR Flood Area
- Parcels
- Contours
- Flow Direction

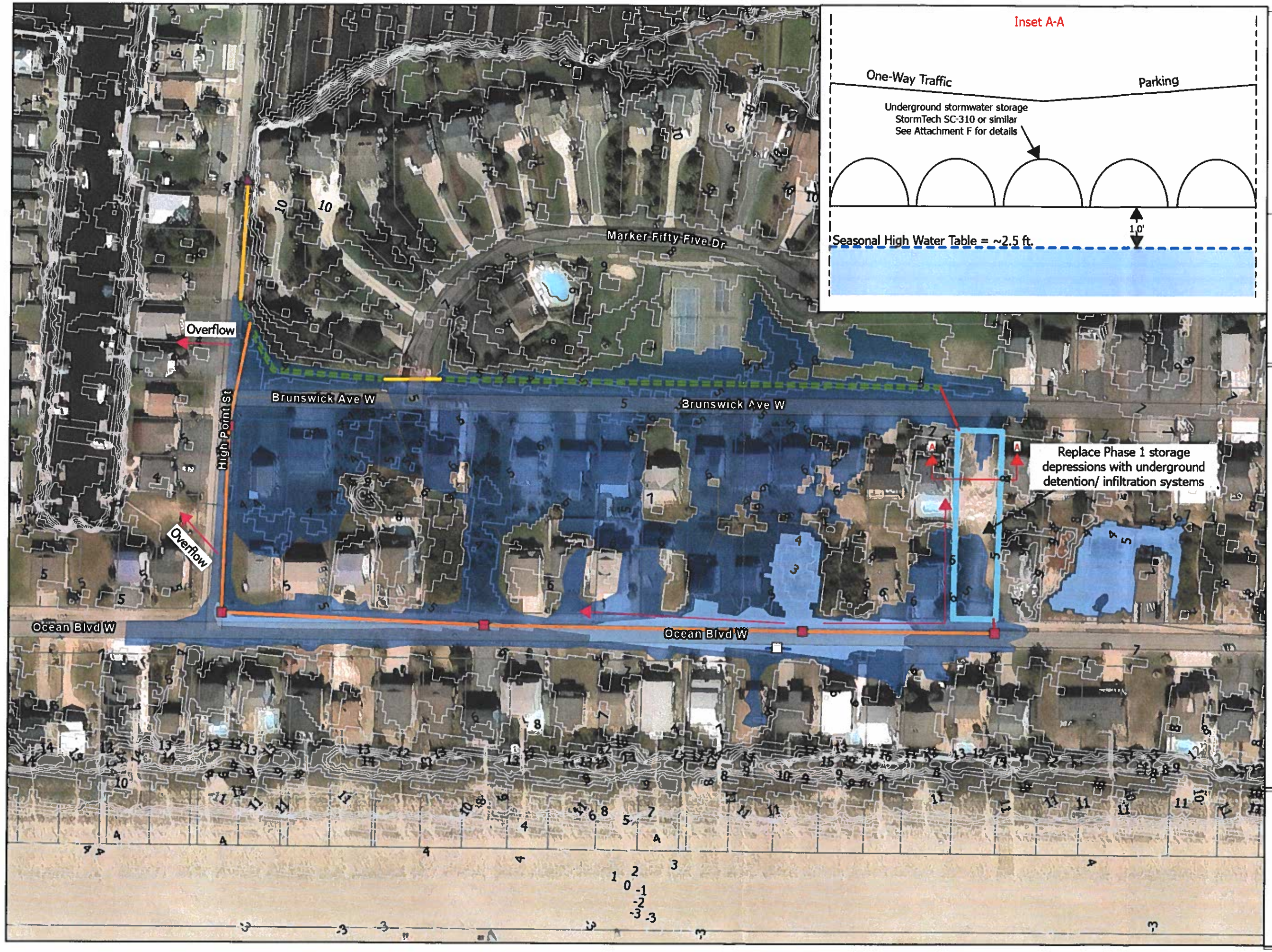
0 60 120 Feet

1 inch = 120 feet

mcgill

712 Village Rd. Suite #103
Shallotte, NC 28470
910.755.5872

NC Firm License # C-0459



Holden Beach Stormwater Masterplan

Attachment E.1.1B
Proposed Alternative 1
Phase 2
Problem Area 1
300 Block OBW

MAP PROJECTION:
NORTH CAROLINA STATE PLANE (FEET

DATUM:
NAD 1983 (HORIZONTAL)
NAVD 1988 (VERTICAL)

DESIGNER: CA
REVIEWER: MH
DATE: April 2024

Legend

- Outfall
- Ex. Catch Basin
- Ex. Drainage Pipe
- Ex. Drainage Channel
- Prop. Catch Basin
- Prop. 12" HDPE
- Prop. 15" HPPP
- Prop. 18" RCP
- Prop. Underground Storage
- 2-YR Flood Area
- 10-YR Flood Area
- Parcels
- Contours
- Flow Direction

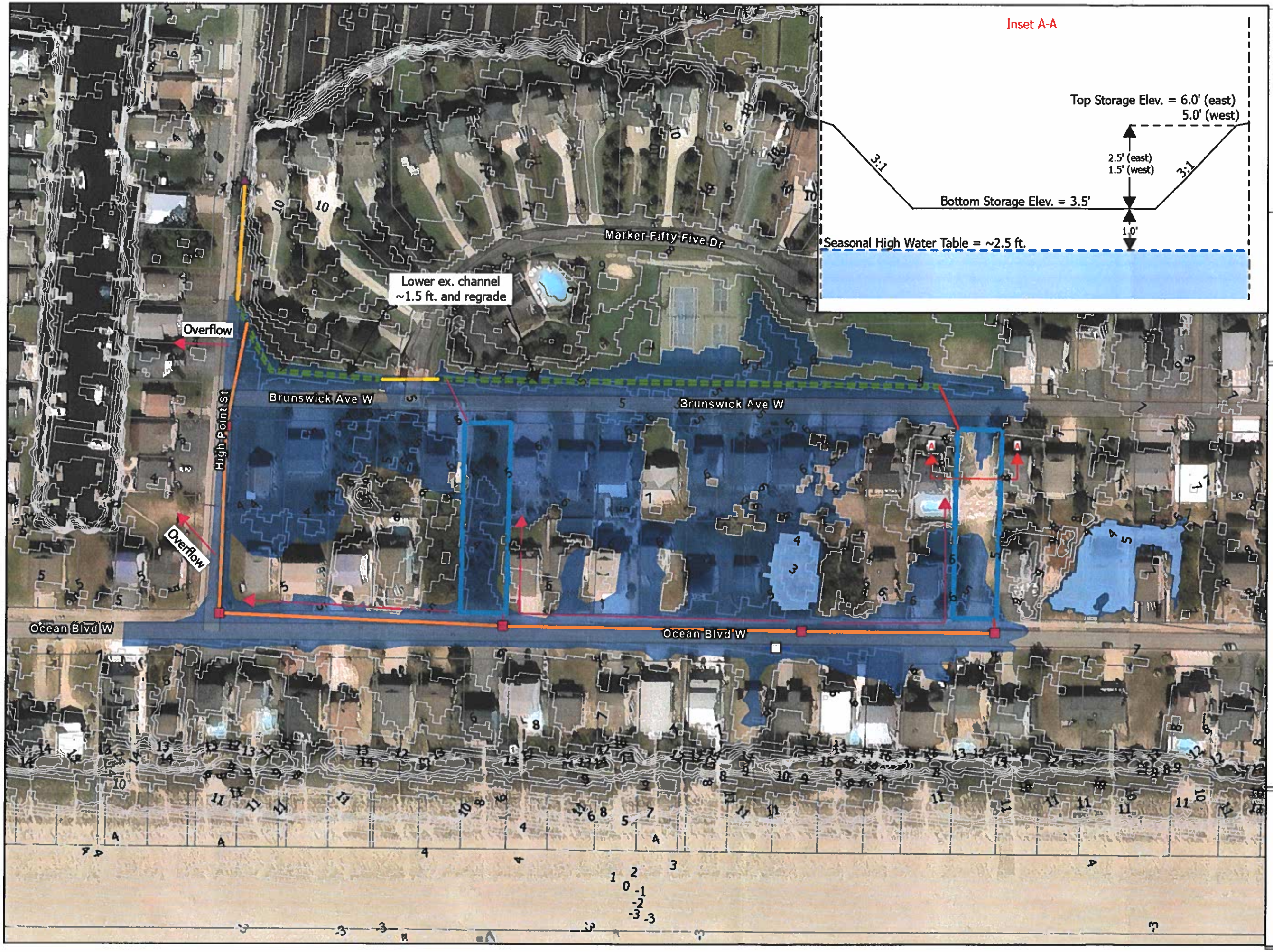
0 60 120 Feet

1 inch = 120 feet

mcgill

712 Village Rd. Suite #103
Shallotte, NC 28470
910.755.5872

NC Firm License # C-0459



Holden Beach Stormwater Masterplan

Attachment E.1.2A
Proposed Alternative 2
Phase 1
Problem Area 1
300 Block OBW

MAP PROJECTION:
NORTH CAROLINA STATE PLANE (FEET

DATUM:
NAD 1983 (HORIZONTAL)
NAVD 1988 (VERTICAL)

DESIGNER: CA
REVIEWER: MH
DATE: April 2024

N
W E
S

Legend

- Outfall
- Ex. Catch Basin
- Ex. Drainage Pipe
- Ex. Drainage Channel
- Prop. Catch Basin
- Prop. 8" HDPE
- Prop. 12" HDPE
- Prop. 15" HPPP
- Prop. 18" RCP
- Prop. Storage Depression
- 2-YR Flood Area
- 10-YR Flood Area
- Parcels
- Contours
- Flow Direction

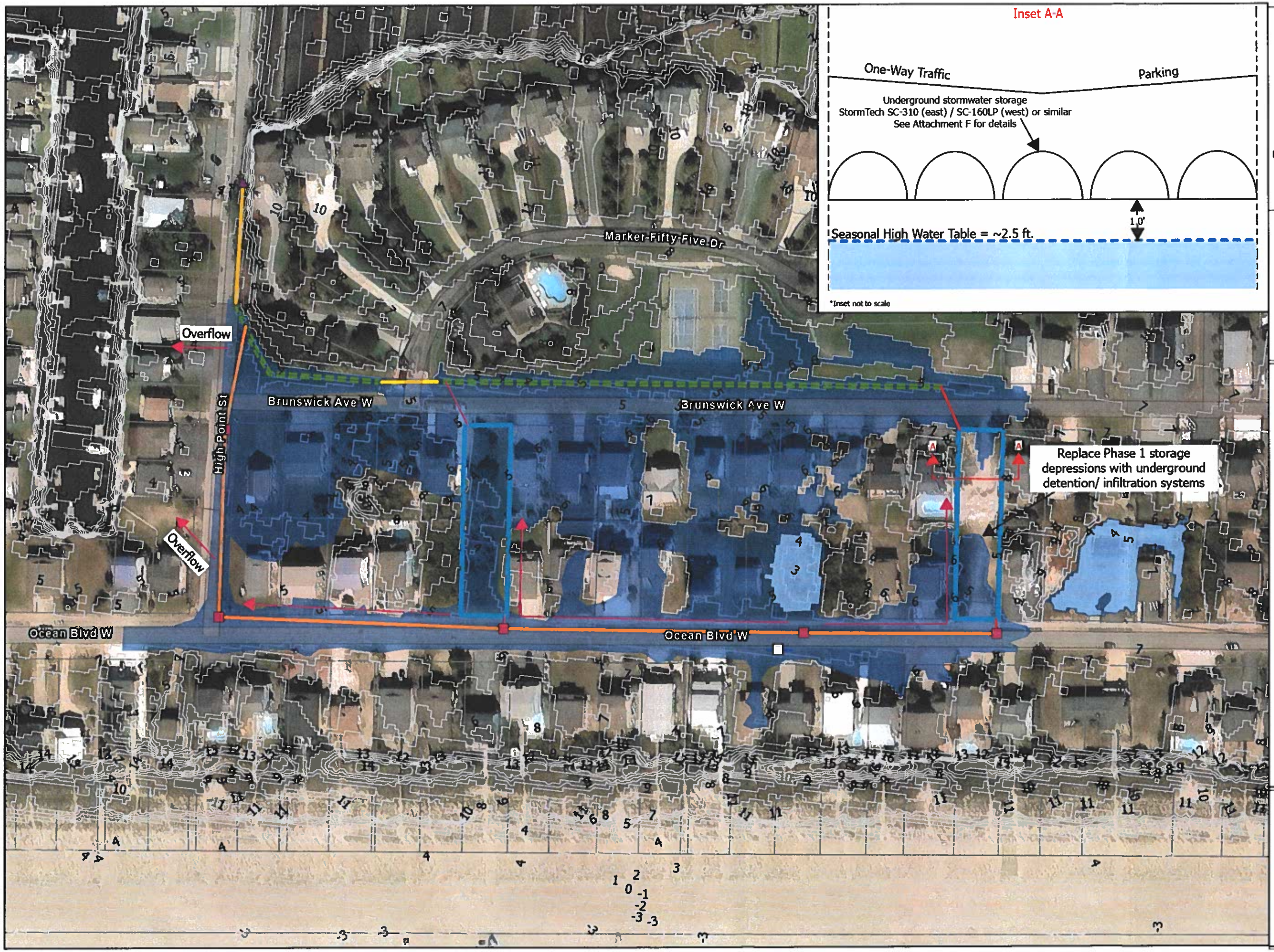
0 60 120 Feet

1 inch = 120 feet

mcgill

712 Village Rd. Suite #103
Shallotte, NC 28470
910 755 5872

NC Firm License # C-0459



Holden Beach Stormwater Masterplan

Attachment E.1.2B
Proposed Alternative 2
Phase 2
Problem Area 1
300 Block OBW

MAP PROJECTION:
NORTH CAROLINA STATE PLANE (FEET)

DATUM:
NAD 1983 (HORIZONTAL)
NAVD 1988 (VERTICAL)

DESIGNER: CA
REVIEWER: MH
DATE: April 2024

N
W E
S

Legend

- Outfall
- Ex. Catch Basin
- Ex. Drainage Pipe
- Ex. Drainage Channel
- Prop. Catch Basin
- Prop. 8" HDPE
- Prop. 12" HDPE
- Prop. 15" HPPP
- Prop. 18" RCP
- Prop. Storage Depression
- 2-YR Flood Area
- 10-YR Flood Area
- Parcels
- Contours
- Flow Direction

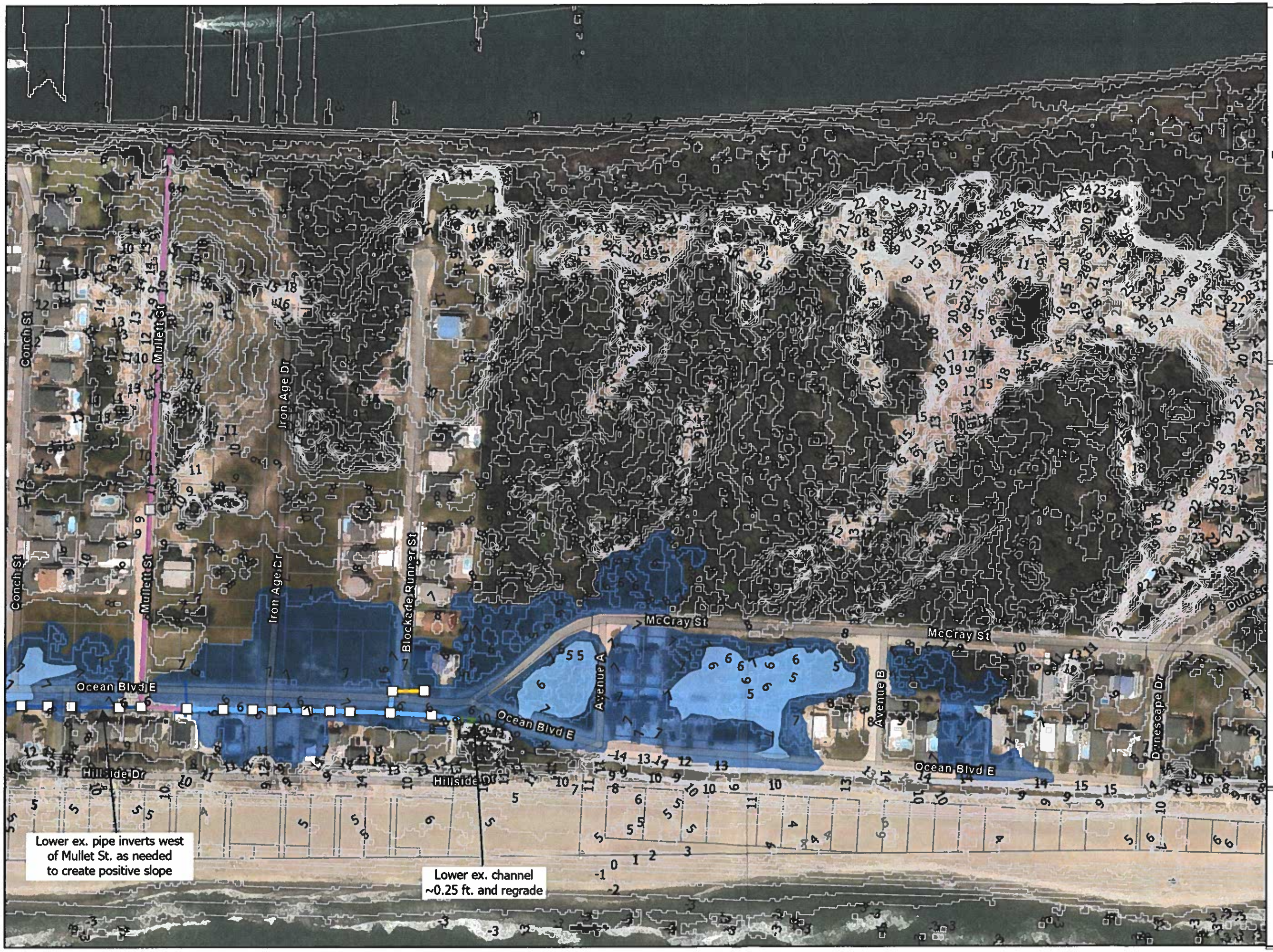
0 60 120 Feet

1 inch = 120 feet

mcgill

712 Village Rd. Suite #103
Shallotte, NC 28470
910.755.5872

NC Firm License # C-0459



Holden Beach Stormwater Masterplan
Attachment E.2.1
Proposed Alternative 1
Problem Area 2
East End Mullet St. & East End Ave. A

MAP PROJECTION:
NORTH CAROLINA STATE PLANE (FEET

DATUM:
NAD 1983 (HORIZONTAL)
NAVD 1988 (VERTICAL)

DESIGNER: CA
REVIEWER: MH
DATE: April 2024

N
W E
S

Legend

- Outfall
- Ex. Catch Basin
- Ex. Drainage Pipe
- Ex. Drainage Channel
- Prop. 18" RCP
- Prop. 24" RCP
- Prop. 30" RCP
- 2-YR Flood Area
- 10-YR Flood Area
- Parcels
- Contours

0 87.5 175 Feet
1 inch = 175 feet

mcgill

712 Village Rd. Suite #103
Shallotte, NC 28470
910.755.5872

NC Firm License # C-0459

Holden Beach Stormwater Masterplan
Attachment E.2.2
Proposed Alternative 2
Problem Area 2
East End Mullet St. & East End Ave. A

MAP PROJECTION:
NORTH CAROLINA STATE PLANE (FEET

DATUM:
NAD 1983 (HORIZONTAL)
NAVD 1988 (VERTICAL)

DESIGNER: CA
REVIEWER: MH
DATE: April 2024

N
W E
S

Legend

- Outfall
- Ex. Catch Basin
- Ex. Drainage Pipe
- Ex. Drainage Channel
- Prop. 12" HPPP
- Prop. 18" RCP
- Prop. 24" RCP
- Prop. 30" RCP
- Prop. Channel
- 2-YR Flood Area
- 10-YR Flood Area
- Parcels
- Contours

0 87.5 175 Feet
1 inch = 175 feet

Conch St
Mullett St
Iron Age Dr
Blockade Runner St
Avenue A
Avenue B
Dunescape Dr
McCray St
Ocean Blvd E
Hillside Dr

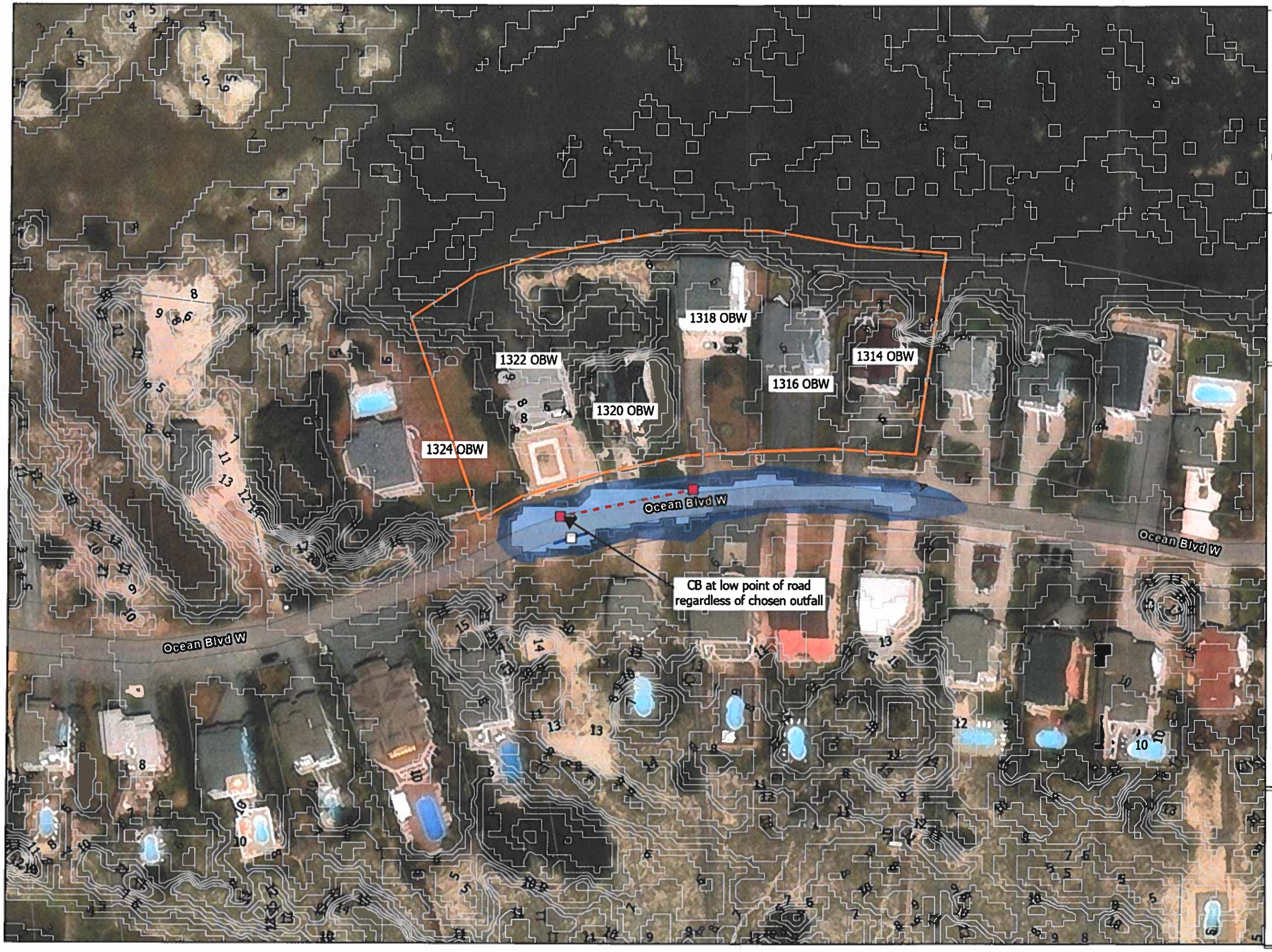
Lower ex. pipe inverts west of Mullet St. as needed to create positive slope

Lower ex. channel ~0.25 ft. and regrade

Prop. Channel 1' Depth, 4:1 SS

mcgill
712 Village Rd. Suite #103
Shallotte, NC 28470
910.755.5872

NC Firm License # C-0459



Holden Beach Stormwater Masterplan

Attachment E.3.1 Proposed Alternative 1 Problem Area 3 West End ROW

MAP PROJECTION:
NORTH CAROLINA STATE PLANE (FEET

DATUM:
NAD 1983 (HORIZONTAL)
NAVD 1988 (VERTICAL)

DESIGNER: CA
REVIEWER: MH
DATE: April 2024

N
W E
S

Legend

- Ex. Catch Basin
- Ex. Drainage Pipe
- Prop. Catch Basin
- Prop. 12" HPPP
- 2-YR Flood Area
- 10-YR Flood Area
- Parcels
- Contours
- Potential Outfall Area

0 37.5 75 Feet
1 inch = 75 feet

mcgill

712 Village Rd. Suite #103
Shallotte, NC 28470
910.755.5872

NC Firm License # C-0459

Holden Beach Stormwater Masterplan

Attachment E.3.2 Proposed Alternative 2 Problem Area 3 West End ROW

MAP PROJECTION:
NORTH CAROLINA STATE PLANE (FEET

DATUM:
NAD 1983 (HORIZONTAL)
NAVD 1988 (VERTICAL)

DESIGNER: CA
REVIEWER: MH
DATE: April 2024

N
W E
S

Legend

- Ex. Catch Basin
- Ex. Drainage Pipe
- Prop. Catch Basin
- Prop. 12" HPPP
- 2-YR Flood Area
- 10-YR Flood Area
- Parcels
- Contours
- Potential Outfall Area

0 37.5 75 Feet

1 inch = 75 feet

mcgill

712 Village Rd. Suite #103
Shallotte, NC 28470
910.755.5872

NC Firm License # C-0459

Holden Beach
Stormwater Masterplan

Attachment E.4.1
Proposed Alternative 1
Problem Area 4
760 Block OBW

MAP PROJECTION:
NORTH CAROLINA STATE PLANE (FEET

DATUM:
NAD 1983 (HORIZONTAL)
NAVD 1988 (VERTICAL)

DESIGNER: CA
REVIEWER: MH
DATE: April 2024

N
W E
S

Legend

- Ex. Catch Basin
- Ex. Drainage Pipe
- Prop. Catch Basin
- Prop. 15" RCP
- Prop. 24" RCP
- 10-YR Flood Area
- Parcels
- Contours
- Potential Outfall Area

0 60 120
Feet
1 inch = 120 feet

mcgill

712 Village Rd. Suite #103
Shallotte, NC 28470
910.755.5872

NC Firm License # C-0459

Holden Beach Stormwater Masterplan

Attachment E.4.2
Proposed Alternative 2
Problem Area 4
760 Block OBW

MAP PROJECTION:
NORTH CAROLINA STATE PLANE (FEET

DATUM:
NAD 1983 (HORIZONTAL)
NAVD 1988 (VERTICAL)

DESIGNER: CA
REVIEWER: MH
DATE: April 2024

N
W E
S

Legend

- New Outfall
- Ex. Catch Basin
- Ex. Drainage Pipe
- Prop. Catch Basin
- Prop. 15" RCP
- Prop. 24" RCP
- 2-YR Flood Area
- 10-YR Flood Area
- Parcels
- Contours

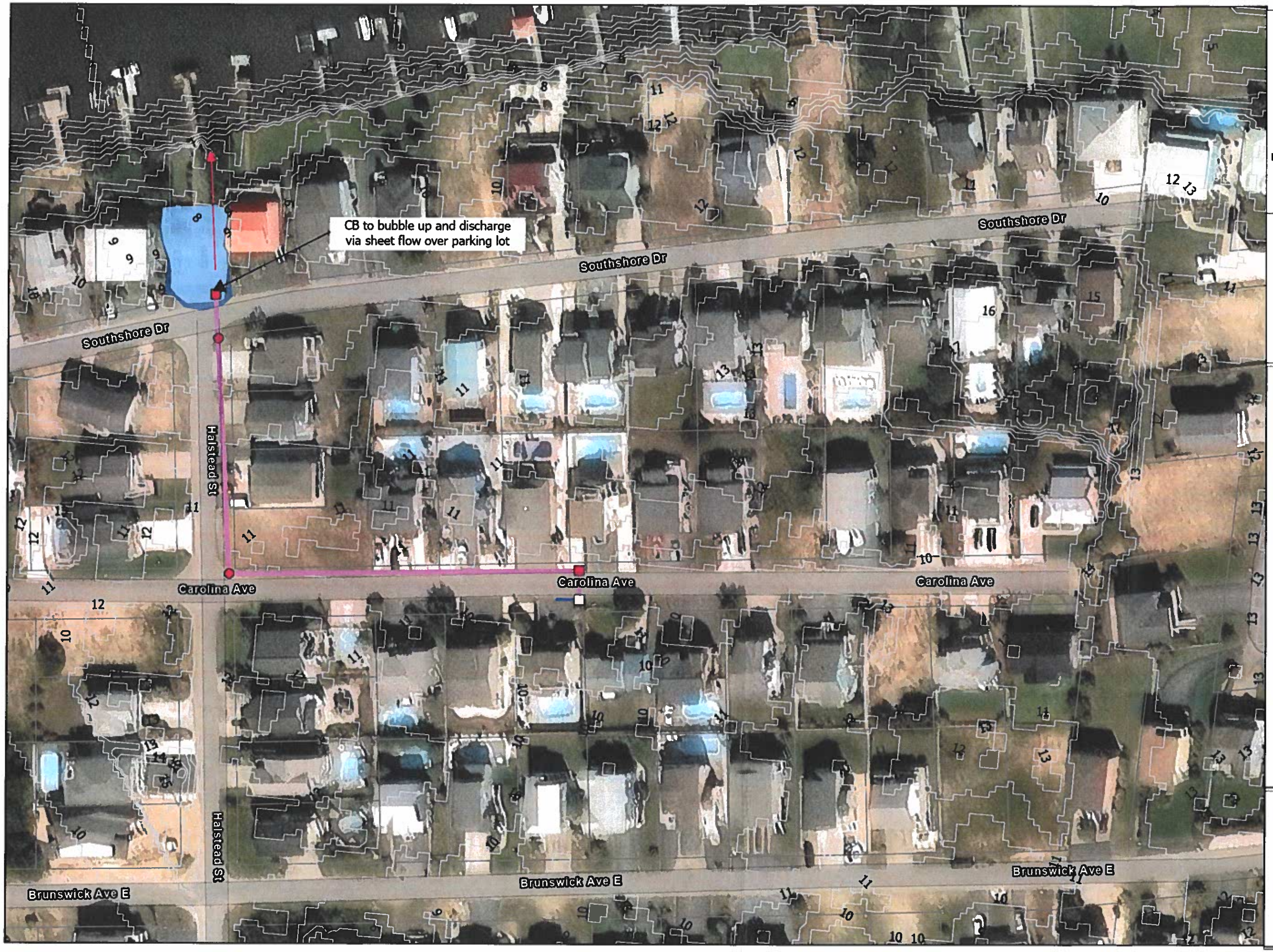
0 60 120 Feet

1 inch = 120 feet

mcgill

712 Village Rd. Suite #103
Shallotte, NC 28470
910.755.5872

NC Firm License # C-0459



Holden Beach Stormwater Masterplan

Attachment E.5.1
Proposed Alternative 1
Problem Area 5
Carolina Ave.

MAP PROJECTION:
NORTH CAROLINA STATE PLANE (FEET)

DATUM:
NAD 1983 (HORIZONTAL)
NAVD 1988 (VERTICAL)

DESIGNER: CA
REVIEWER: MH
DATE: April 2024

N
W E
S

Legend

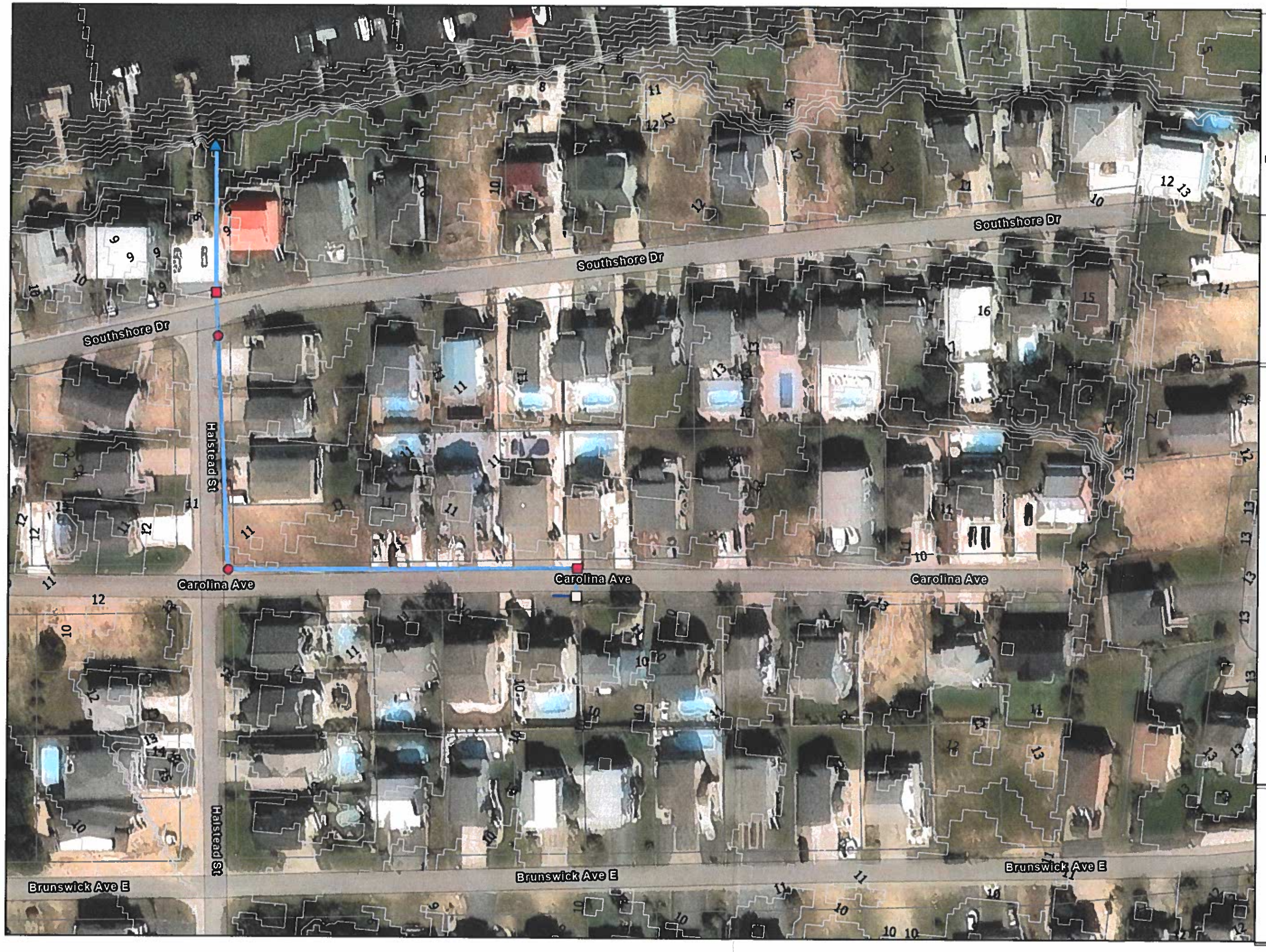
- Ex. Catch Basin
- Ex. Drainage Pipe
- Prop. Catch Basin
- Prop. Junction Box
- Prop. 30" RCP
- 2-YR Flood Area
- 10-YR Flood Area
- Parcels
- Contours

0 37.5 75 Feet
1 inch = 75 feet

mcgill

712 Village Rd. Suite #103
Shallotte, NC 28470
910.755.5872

NC Firm License # C-0459



Holden Beach Stormwater Masterplan

Attachment E.5.2
Proposed Alternative 2
Problem Area 5
Carolina Ave.

MAP PROJECTION:
NORTH CAROLINA STATE PLANE (FEET)

DATUM:
NAD 1983 (HORIZONTAL)
NAVD 1988 (VERTICAL)

DESIGNER: CA
REVIEWER: MH
DATE: April 2024

N
W E
S

Legend

- New Outfall
- Ex. Catch Basin
- Ex. Drainage Pipe
- Prop. Catch Basin
- Prop. Junction Box
- Prop. 24" RCP
- Parcels
- Contours

0 37.5 75
Feet
1 inch = 75 feet

mcgill

712 Village Rd. Suite #103
Shallotte, NC 28470
910.755.5872

NC Firm License # C-0459

Appendix F

Engineering Details

Advanced Drainage Systems, Inc.

ADS SiteAssist
FOR STORMTECH INSTALLATION INSTRUCTIONS VISIT OUR APP

SC-160LP STORMTECH CHAMBER SPECIFICATIONS

1. CHAMBERS SHALL BE STORMTECH SC-160LP
2. CHAMBERS SHALL BE ARCH-SHAPED AND SHALL BE MANUFACTURED FROM VIRGIN, IMPACT-MODIFIED POLYPROPYLENE COPOLYMERS
3. CHAMBERS SHALL MEET THE REQUIREMENTS OF ASTM F2418, "STANDARD SPECIFICATION FOR POLYPROPYLENE (PP) CORRUGATED WALL STORMWATER COLLECTION CHAMBERS"
4. CHAMBER ROWS SHALL PROVIDE CONTINUOUS, UNOBSTRUCTED INTERNAL SPACE WITH NO INTERNAL SUPPORTS THAT WOULD IMPEDE FLOW OR LIMIT ACCESS FOR INSPECTION
5. 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
6. CHAMBERS SHALL BE DESIGNED, TESTED AND ALLOWABLE LOAD COMBINATIONS DETERMINED IN ACCORDANCE WITH ASTM F2787, "STANDARD PRACTICE FOR STRUCTURAL DESIGN OF THERMOPLASTIC CORRUGATED WALL STORMWATER COLLECTION CHAMBERS". LOAD CONFIGURATIONS SHALL INCLUDE: 1) INSTANTANEOUS (<1 MIN) AASHTO DESIGN TRUCK LIVE LOAD ON MINIMUM COVER 2) MAXIMUM PERMANENT (75-YR) COVER LOAD AND 3) ALLOWABLE COVER WITH PARKED (1-WEEK) AASHTO DESIGN TRUCK
7. REQUIREMENTS FOR HANDLING AND INSTALLATION:
   - TO MAINTAIN THE WIDTH OF CHAMBERS DURING SHIPPING AND HANDLING, CHAMBERS SHALL HAVE INTEGRAL, INTERLOCKING STACKING LUGS
   - TO ENSURE A SECURE JOINT DURING INSTALLATION AND BACKFILL, THE HEIGHT OF THE CHAMBER JOINT SHALL NOT BE LESS THAN 1.3"
   - TO ENSURE THE INTEGRITY OF THE ARCH SHAPE DURING INSTALLATION, a) THE ARCH STIFFNESS CONSTANT SHALL BE GREATER THAN OR EQUAL TO 400 LBS/FT/% . THE ASC IS DEFINED IN SECTION 6.2.8 OF ASTM F2418 AND b) TO RESIST CHAMBER DEFORMATION DURING INSTALLATION AT ELEVATED TEMPERATURES (ABOVE 73° F / 23° C), CHAMBERS SHALL BE PRODUCED FROM REFLECTIVE GOLD OR YELLOW COLORS
8. ONLY CHAMBERS THAT ARE APPROVED BY THE SITE DESIGN ENGINEER WILL BE ALLOWED UPON REQUEST BY THE SITE DESIGN ENGINEER OR OWNER. THE CHAMBER MANUFACTURER SHALL SUBMIT A STRUCTURAL EVALUATION FOR APPROVAL BEFORE DELIVERING CHAMBERS TO THE PROJECT SITE AS FOLLOWS:
   - THE STRUCTURAL EVALUATION SHALL BE SEALED BY A REGISTERED PROFESSIONAL ENGINEER.
   - THE STRUCTURAL EVALUATION SHALL DEMONSTRATE 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 SECTIONS 5 AND 12 12 OF THE AASHTO LRFD BRIDGE DESIGN SPECIFICATIONS FOR THERMOPLASTIC PIPE
   - THE TEST DERIVED CREEP MODULUS AS SPECIFIED IN ASTM F2418 SHALL BE USED FOR PERMANENT DEAD LOAD DESIGN EXCEPT THAT IT SHALL BE THE 75-YEAR MODULUS USED FOR DESIGN
9. CHAMBERS AND END CAPS SHALL BE PRODUCED AT AN ISO 9001 CERTIFIED MANUFACTURING FACILITY

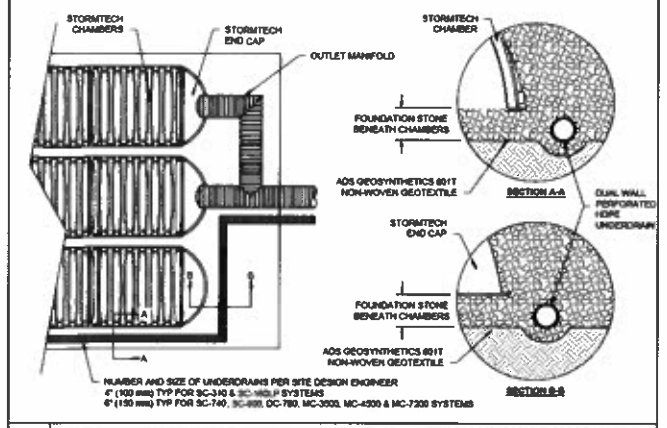
IMPORTANT - NOTES FOR THE BIDDING AND INSTALLATION OF THE SC-160LP SYSTEM

1. STORMTECH SC-160LP CHAMBERS SHALL NOT BE INSTALLED UNTIL THE MANUFACTURER'S REPRESENTATIVE HAS COMPLETED A PRE-CONSTRUCTION MEETING WITH THE INSTALLERS
2. STORMTECH SC-160LP CHAMBERS SHALL BE INSTALLED IN ACCORDANCE WITH THE "STORMTECH SC-160LP CONSTRUCTION GUIDE"
3. FOUNDATION STONE AND EMBEDMENT STONE SURROUNDING CHAMBERS MUST BE A CLEAN, CRUSHED, ANGULAR STONE, AASHTO M43 #3,357, 4, 467, 5, 56, OR 57
4. THE FOUNDATION STONE SHALL BE LEVELED AND COMPACTED PRIOR TO PLACING CHAMBERS
5. THE DEPTH OF FOUNDATION STONE SHALL BE DETERMINED BASED ON THE SUBGRADE BEARING CAPACITY PROVIDED BY THE SITE DESIGN ENGINEER
6. THE CONTRACTOR MUST REPORT ANY DISCREPANCIES CONCERNING CHAMBER FOUNDATION DESIGN AND SUBGRADE BEARING CAPACITIES TO THE SITE DESIGN ENGINEER
7. JOINTS BETWEEN CHAMBERS SHALL BE PROPERLY SEATED PRIOR TO PLACING STONE
8. CHAMBERS SHALL BE INSTALLED "TOE TO TOE" NO ADDITIONAL SPACING BETWEEN ROWS IS REQUIRED
9. 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
10. 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

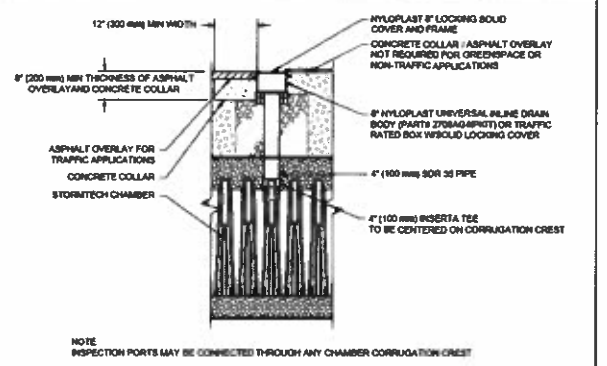
NOTES FOR CONSTRUCTION EQUIPMENT

1. THE USE OF CONSTRUCTION EQUIPMENT OVER SC-160LP 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-160LP CONSTRUCTION GUIDE"
   - WEIGHT LIMITS FOR CONSTRUCTION EQUIPMENT CAN BE FOUND IN THE "STORMTECH SC-160LP CONSTRUCTION GUIDE"
2. FULL 36" (900 mm) OF STABILIZED COVER MATERIALS OVER THE CHAMBERS IS REQUIRED FOR DUMP TRUCK TRAVEL OR DUMPING

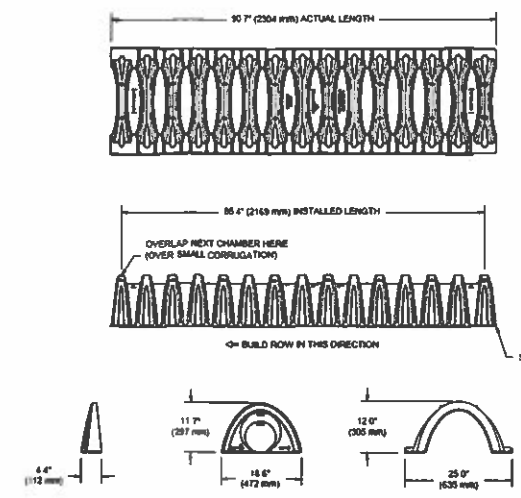
CONTACT STORMTECH AT 1-888-892-2694 WITH ANY QUESTIONS ON INSTALLATION REQUIREMENTS OR WEIGHT LIMITS FOR CONSTRUCTION EQUIPMENT



5 UNDERDRAIN DETAIL



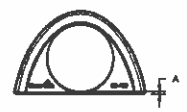
4 4" PVC INSPECTION PORT DETAIL (SC SERIES CHAMBER)



NOMINAL CHAMBER SPECIFICATIONS		
SIZE (W X H X INSTALLED LENGTH)	25.0" X 13.0" X 85.4"	(635 mm X 305 mm X 2169 mm)
CHAMBER STORAGE	6.65 CUBIC FEET	(0.19 m³)
MINIMUM INSTALLED STORAGE*	16.0 CUBIC FEET	(0.45 m³)
WEIGHT	34.0 lbs	(10.9 kg)

*ASSUMES 6" (152 mm) ABOVE, 6" (152 mm) BELOW, AND STONE BETWEEN CHAMBERS WITH 40% STONE POROSITY

PART #	STUB	A
SC160EPP	6" (150 mm)	0.66" (16 mm)
	8" (200 mm)	0.80" (20 mm)
SC160EPP08	8" (200 mm)	0.96" (24 mm)



ALL STUBS 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

NOTE: ALL DIMENSIONS ARE NOMINAL

2 SC-160LP TECHNICAL SPECIFICATIONS

3 SC-160LP ISOLATOR ROW PLUS DETAIL

INSPECTION & MAINTENANCE

STEP 1) INSPECT ISOLATOR ROW PLUS 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 PLUS FOR VISUAL INSPECTION OF SEDIMENT LEVELS (OPTIONAL)
  - A.5 IF SEDIMENT IS AT, OR ABOVE, 3" (80 mm) PROCEED TO STEP 3. IF NOT, PROCEED TO STEP 4
- B. ALL ISOLATOR PLUS ROWS
  - B.1 REMOVE COVER FROM STRUCTURE AT UPSTREAM END OF ISOLATOR ROW PLUS
  - B.2 USING A FLASHLIGHT, INSPECT DOWN THE ISOLATOR ROW PLUS 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 PLUS 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

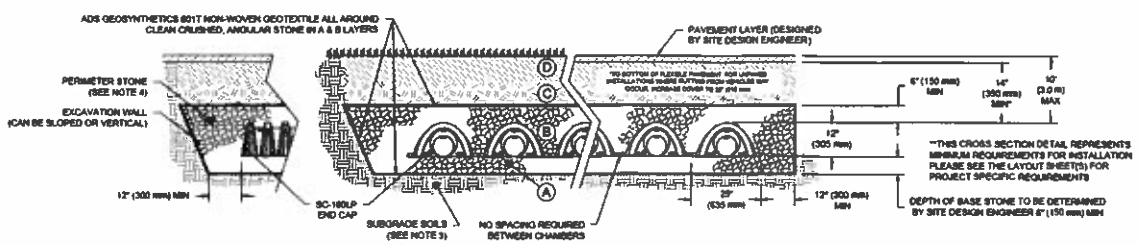
NOTES

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

ACCEPTABLE FILL MATERIALS: STORMTECH SC-160LP 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 (9" LAYER) TO 14" (355 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[4] A-1, A-2-4, A-3 OR AASHTO M43[4] 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 OR RECYCLED CONCRETE[5]	AASHTO M43[4] 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 OR RECYCLED CONCRETE[5]	AASHTO M43[4] 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.
4. 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.
5. WHERE RECYCLED CONCRETE AGGREGATE IS USED IN LAYERS 'A' OR 'B' THE MATERIAL SHOULD ALSO MEET THE ACCEPTABILITY CRITERIA OUTLINED IN TECHNICAL NOTE 6.20 "RECYCLED CONCRETE STRUCTURAL BACKFILL".



**THIS CROSS SECTION DETAIL REPRESENTS MINIMUM REQUIREMENTS FOR INSTALLATION. PLEASE SEE THE LAYOUT SHEET(S) FOR PROJECT SPECIFIC REQUIREMENTS

NOTES:

1. CHAMBERS SHALL MEET THE REQUIREMENTS OF ASTM F2418, "STANDARD SPECIFICATION FOR POLYPROPYLENE (PP) CORRUGATED WALL STORMWATER COLLECTION CHAMBERS"
2. CHAMBERS SHALL BE DESIGNED, TESTED AND ALLOWABLE LOAD CONFIGURATIONS DETERMINED IN ACCORDANCE WITH ASTM F2787, "STANDARD PRACTICE FOR STRUCTURAL DESIGN OF THERMOPLASTIC CORRUGATED WALL STORMWATER COLLECTION CHAMBERS". LOAD CONFIGURATIONS SHALL INCLUDE: 1) INSTANTANEOUS (<1 MIN) AASHTO DESIGN TRUCK LIVE LOAD ON MINIMUM COVER 2) MAXIMUM PERMANENT (75-YR) COVER LOAD AND 3) ALLOWABLE COVER WITH PARKED (1-WEEK) AASHTO DESIGN TRUCK
3. 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
4. PERIMETER STONE MUST BE EXTENDED HORIZONTALLY TO THE EXCAVATION WALL FOR BOTH VERTICAL AND SLOPED EXCAVATION WALLS
5. REQUIREMENTS FOR HANDLING AND INSTALLATION:
   - TO MAINTAIN THE WIDTH OF CHAMBERS DURING SHIPPING AND HANDLING, CHAMBERS SHALL HAVE INTEGRAL, INTERLOCKING STACKING LUGS
   - TO ENSURE A SECURE JOINT DURING INSTALLATION AND BACKFILL, THE HEIGHT OF THE CHAMBER JOINT SHALL NOT BE LESS THAN 1.3"
   - TO ENSURE THE INTEGRITY OF THE ARCH SHAPE DURING INSTALLATION, a) THE ARCH STIFFNESS CONSTANT AS DEFINED IN SECTION 6.2.8 OF ASTM F2418 SHALL BE GREATER THAN OR EQUAL TO 400 LBS/FT/% AND b) TO RESIST CHAMBER DEFORMATION DURING INSTALLATION AT ELEVATED TEMPERATURES (ABOVE 73° F / 23° C), CHAMBERS SHALL BE PRODUCED FROM REFLECTIVE GOLD OR YELLOW COLORS

1 SC-160LP CROSS SECTION DETAIL

DRAWN: JLM | DATE: 01/09/24
REVIEWED: JLM | PROJECT NO
REV: | NOT TO SCALE

SC-160LP STANDARD DETAILS

StormTech® Chamber System
888-892-2694 | WWW.STORMTECH.COM

4640 TRUEMAN BLVD
HILLIARD, OH 43026

SHEET 1

Advanced Drainage Systems, Inc.

ADS SiteAssist™ FOR STORMTECH INSTALLATION INSTRUCTIONS VISIT OUR APP

SC-310 STORMTECH CHAMBER SPECIFICATIONS

1. CHAMBERS SHALL BE STORMTECH SC-310.
2. CHAMBERS SHALL BE ARCH-SHAPED AND SHALL BE MANUFACTURED FROM VIRGIN, IMPACT-MODIFIED POLYPROPYLENE OR POLYETHYLENE COPOLYMERS.
3. CHAMBERS SHALL MEET THE REQUIREMENTS OF ASTM F2922 (POLETHYLENE) OR ASTM F2418 (POLYPROPYLENE), "STANDARD SPECIFICATION FOR CORRUGATED WALL STORMWATER COLLECTION CHAMBERS".
4. CHAMBER ROWS SHALL PROVIDE CONTINUOUS, UNOBSTRUCTED INTERNAL SPACE WITH NO INTERNAL SUPPORTS THAT WOULD IMPEDE FLOW OR LIMIT ACCESS FOR INSPECTION.
5. 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.
6. CHAMBERS SHALL BE DESIGNED, TESTED AND ALLOWABLE LOAD CONFIGURATIONS DETERMINED IN ACCORDANCE WITH ASTM F2787, "STANDARD PRACTICE FOR STRUCTURAL DESIGN OF THERMOPLASTIC CORRUGATED WALL STORMWATER COLLECTION CHAMBERS". LOAD CONFIGURATIONS SHALL INCLUDE: 1) INSTANTANEOUS (+1 MIN) AASHTO DESIGN TRUCK LIVE LOAD ON MINIMUM COVER 2) MAXIMUM PERMANENT (75-YR) COVER LOAD AND 3) ALLOWABLE COVER WITH PARKED (1-WEEK) AASHTO DESIGN TRUCK.
7. REQUIREMENTS FOR HANDLING AND INSTALLATION:
   - TO MAINTAIN THE WIDTH OF CHAMBERS DURING SHIPPING AND HANDLING, CHAMBERS SHALL HAVE INTEGRAL, INTERLOCKING STACKING LUGS
   - TO ENSURE A SECURE JOINT DURING INSTALLATION AND BACKFILL, THE HEIGHT OF THE CHAMBER JOINT SHALL NOT BE LESS THAN 2"
   - TO ENSURE THE INTEGRITY OF THE ARCH SHAPE DURING INSTALLATION, a) THE ARCH STIFFNESS CONSTANT SHALL BE GREATER THAN OR EQUAL TO 400 LBS/FT/%. THE ASC IS DEFINED IN SECTION 6.2.6 OF ASTM F2418. AND b) TO RESIST CHAMBER DEFORMATION DURING INSTALLATION AT ELEVATED TEMPERATURES (ABOVE 73° F / 23° C), CHAMBERS SHALL BE PRODUCED FROM REFLECTIVE GOLD OR YELLOW COLORS
8. ONLY CHAMBERS THAT ARE APPROVED BY THE SITE DESIGN ENGINEER WILL BE ALLOWED UPON REQUEST BY THE SITE DESIGN ENGINEER OR OWNER, THE CHAMBER MANUFACTURER SHALL SUBMIT A STRUCTURAL EVALUATION FOR APPROVAL BEFORE DELIVERING CHAMBERS TO THE PROJECT SITE AS FOLLOWS:
   - THE STRUCTURAL EVALUATION SHALL BE SEALED BY A REGISTERED PROFESSIONAL ENGINEER.
   - THE STRUCTURAL EVALUATION SHALL DEMONSTRATE 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 SECTIONS 3 AND 12.12 OF THE AASHTO LRFD BRIDGE DESIGN SPECIFICATIONS FOR THERMOPLASTIC PIPE.
   - THE TEST DERIVED CREEP MODULUS AS SPECIFIED IN ASTM F2922 SHALL BE USED FOR PERMANENT DEAD LOAD DESIGN EXCEPT THAT IT SHALL BE THE 75-YEAR MODULUS USED FOR DESIGN
9. CHAMBERS AND END CAPS SHALL BE PRODUCED AT AN ISO 9001 CERTIFIED MANUFACTURING FACILITY.

IMPORTANT - NOTES FOR THE BIDDING AND INSTALLATION OF THE SC-310 SYSTEM

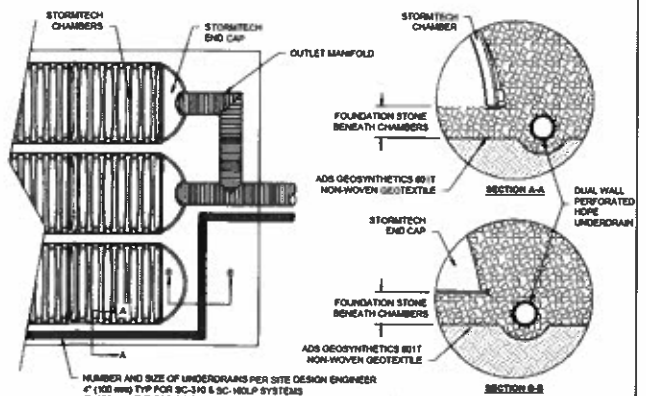
1. STORMTECH SC-310 CHAMBERS SHALL NOT BE INSTALLED UNTIL THE MANUFACTURER'S REPRESENTATIVE HAS COMPLETED A PRE-CONSTRUCTION MEETING WITH THE INSTALLERS
2. STORMTECH SC-310 CHAMBERS SHALL BE INSTALLED IN ACCORDANCE WITH THE "STORMTECH SC-310/SC-740/DC-780 CONSTRUCTION GUIDE"
3. CHAMBERS ARE NOT TO BE 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

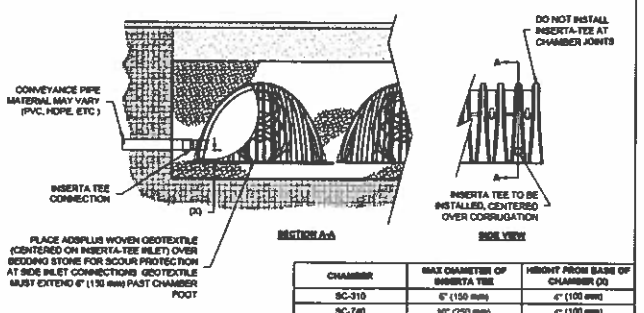
1. STORMTECH SC-310 CHAMBERS SHALL BE INSTALLED IN ACCORDANCE WITH THE "STORMTECH SC-310/SC-740/DC-780 CONSTRUCTION GUIDE"
2. THE USE OF CONSTRUCTION EQUIPMENT OVER SC-310 & SC-740 CHAMBERS IS LIMITED:
   - NO EQUIPMENT IS ALLOWED ON BARE CHAMBERS
   - NO RUBBER TIRED LOADERS, DUMP TRUCKS, OR EXCAVATORS 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

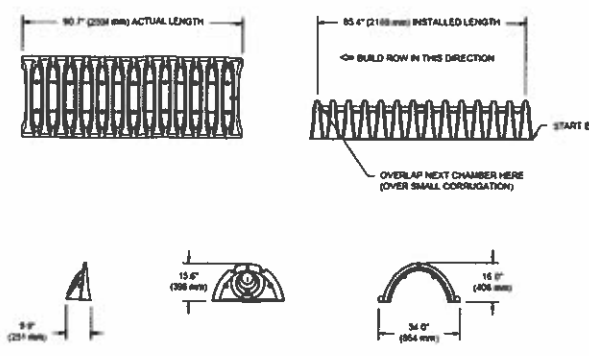


CHAMBER	MAX DIAMETER OF INSERTA TEE	HEIGHT FROM BASE OF CHAMBER (X)
SC-310	6" (150 mm)	4" (100 mm)
SC-740	10" (250 mm)	4" (100 mm)
SC-800	10" (250 mm)	4" (100 mm)
DC-780	10" (250 mm)	4" (100 mm)
MC-3500	12" (300 mm)	6" (150 mm)
MC-4500	12" (300 mm)	8" (200 mm)
MC-7200	12" (300 mm)	8" (200 mm)

INSERTA TEE FITTINGS AVAILABLE FOR SCH 26, SCH 35, SCH 40 IPS GASKETED & SOLVENT WELD, N-12, HP STORM, C-900 OR DUCTILE IRON

NOTES:
- PART NUMBERS WILL VARY BASED ON INLET PIPE MATERIALS. CONTACT STORMTECH FOR MORE INFORMATION.
- CONTACT ADS ENGINEERING SERVICES IF INSERTA TEE INLET MUST BE RAISED AS NOT ALL INVERTS ARE POSSIBLE

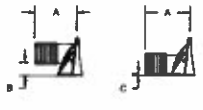
6 INSERTA-TEE SIDE INLET DETAIL



NOMINAL CHAMBER SPECIFICATIONS

SIZE (W X H X INSTALLED LENGTH)	34.0" X 16.0" X 85.4"	(864 mm X 406 mm X 2169 mm)
CHAMBER STORAGE	14.7 CUBIC FEET	(0.42 m³)
MINIMUM INSTALLED STORAGE*	31.0 CUBIC FEET	(0.88 m³)
WEIGHT	35.0 lbs	(16.0 kg)

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



PRE-FAB STUBS AT BOTTOM OF END CAP FOR PART NUMBERS ENDING WITH "B"
PRE-FAB STUBS AT TOP OF END CAP FOR PART NUMBERS ENDING WITH "T"
PRE CORED END CAPS END WITH "PC"

PART #	STUB	A	B	C
SC310EPE06T / SC310EPE06TPC	6" (150 mm)	9.6" (244 mm)	5.9" (147 mm)	—
SC310EPE06B / SC310EPE06BPC			—	0.3" (13 mm)
SC310EPE09T / SC310EPE09TPC	9" (200 mm)	11.9" (302 mm)	3.9" (99 mm)	—
SC310EPE09B / SC310EPE09BPC			—	0.6" (15 mm)
SC310EPE10T / SC310EPE10TPC	10" (250 mm)	12.7" (325 mm)	1.4" (36 mm)	—
SC310EPE10B / SC310EPE10BPC			—	0.7" (18 mm)
SC310ECEZ*	12" (300 mm)	13.5" (343 mm)	—	0.9" (23 mm)

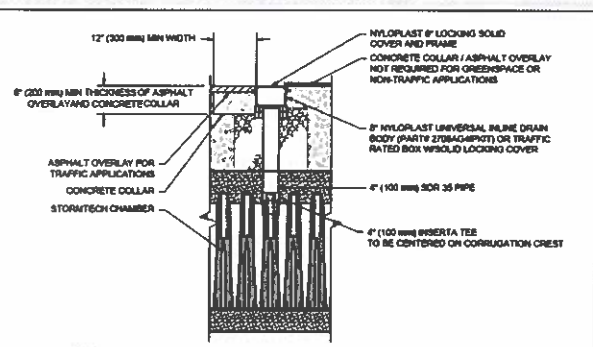
ALL STUBS, EXCEPT FOR THE SC310ECEZ ARE PLACED AT BOTTOM OF END CAP SUCH THAT THE OUTSIDE DIAMETER OF THE STUB IS FLUSH WITH THE BOTTOM OF THE END CAP. FOR ADDITIONAL INFORMATION CONTACT STORMTECH AT 1-866-892-2694

* FOR THE SC310ECEZ THE 12" (300 mm) STUB LIES BELOW THE BOTTOM OF THE END CAP APPROXIMATELY 0.25" (6 mm) BACKFILL MATERIAL SHOULD BE REMOVED FROM BELOW THE N-12 STUB SO THAT THE FITTING SITS LEVEL

NOTE: ALL DIMENSIONS ARE NOMINAL

2 SC-310 TECHNICAL SPECIFICATIONS

3 SC-310 ISOLATOR ROW PLUS DETAIL



NOTE
INSPECTION PORTS MAY BE CONNECTED THROUGH ANY CHAMBER CORRUGATION CREST

4 4" PVC INSPECTION PORT DETAIL (SC SERIES CHAMBER)

INSPECTION & MAINTENANCE

STEP 1) INSPECT ISOLATOR ROW PLUS 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 PLUS 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 PLUS ROWS
  - B.1 REMOVE COVER FROM STRUCTURE AT UPSTREAM END OF ISOLATOR ROW PLUS
  - B.2 USING A FLASHLIGHT, INSPECT DOWN THE ISOLATOR ROW PLUS 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 PLUS 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.

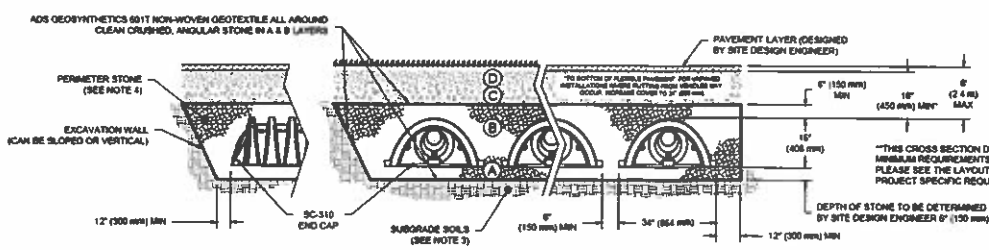
NOTES

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

ACCEPTABLE FILL MATERIALS: STORMTECH SC-310 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 OR RECYCLED CONCRETE[2]	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 OR RECYCLED CONCRETE[2]	AASHTO M43[1] 3, 357, 4, 467, 5, 56, 57	PLATE COMPACT OR ROLL TO ACHIEVE A FLAT SURFACE[3,4]

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.
4. 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.
5. WHERE RECYCLED CONCRETE AGGREGATE IS USED IN LAYERS 'A' OR 'B' THE MATERIAL SHOULD ALSO MEET THE ACCEPTABILITY CRITERIA OUTLINED IN TECHNICAL NOTE 6.20 "RECYCLED CONCRETE STRUCTURAL BACKFILL".



*THIS CROSS SECTION DETAIL REPRESENTS MINIMUM REQUIREMENTS FOR INSTALLATION. PLEASE SEE THE LAYOUT SHEET(S) FOR PROJECT SPECIFIC REQUIREMENTS.

NOTES:

1. CHAMBERS SHALL MEET THE REQUIREMENTS OF ASTM F2922 (POLETHYLENE) OR ASTM F2418 (POLYPROPYLENE) "STANDARD SPECIFICATION FOR CORRUGATED WALL STORMWATER COLLECTION CHAMBERS"
2. SC-310 CHAMBERS SHALL BE DESIGNED IN ACCORDANCE WITH ASTM F2787 "STANDARD PRACTICE FOR STRUCTURAL DESIGN OF THERMOPLASTIC CORRUGATED WALL STORMWATER COLLECTION CHAMBERS"
3. 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
4. PERIMETER STONE MUST BE EXTENDED HORIZONTALLY TO THE EXCAVATION WALL FOR BOTH VERTICAL AND SLOPED EXCAVATION WALLS
5. REQUIREMENTS FOR HANDLING AND INSTALLATION:
   - TO MAINTAIN THE WIDTH OF CHAMBERS DURING SHIPPING AND HANDLING, CHAMBERS SHALL HAVE INTEGRAL, INTERLOCKING STACKING LUGS
   - TO ENSURE A SECURE JOINT DURING INSTALLATION AND BACKFILL, THE HEIGHT OF THE CHAMBER JOINT SHALL NOT BE LESS THAN 2"
   - TO ENSURE THE INTEGRITY OF THE ARCH SHAPE DURING INSTALLATION, a) THE ARCH STIFFNESS CONSTANT AS DEFINED IN SECTION 6.2.6 OF ASTM F2922 SHALL BE GREATER THAN OR EQUAL TO 400 LBS/FT/% AND b) TO RESIST CHAMBER DEFORMATION DURING INSTALLATION AT ELEVATED TEMPERATURES (ABOVE 73° F / 23° C), CHAMBERS SHALL BE PRODUCED FROM REFLECTIVE GOLD OR YELLOW COLORS

1 SC-310 CROSS SECTION DETAIL

DRAWN: JLM | DATE: 01/09/24
REVIEWED: JLM | PROJECT NO:
REV: | NOT TO SCALE

SC-310 STANDARD DETAIL

StormTech® Chamber System
800-821-6244 | www.stormtech.com

4640 TRUEMAN BLVD
HILLIARD, OH 43026

ADS Advanced Drainage Systems, Inc.

SHEET 1

Appendix G

Existing Island-Wide Flooding Heat Map

mcgill Shaping Communities Together®

Legend

Sunny Day MHHW Flooding
Contours
Parcels

2-Year Flood Depth
0-0.49 ft
0.5-0.99 ft
1-1.49 ft
1.5-1.99 ft
2-2.49 ft

Holden Beach Stormwater Masterplan

Brunswick County, North Carolina

0 50 100 200 300 400 Feet

1 in = 100 ft

N
W E
S

Heat Map of Existing Flooding

Designer: CMA
Basemap Credit: ESRI Imagery Basemap
Basemap Publication: December 2022

mcgill Shaping Communities Together®

Legend

Sunny Day NHHW Flooding
Contours
Parcels

2-Year Flood Depth
0-0.49 ft
0.5-0.99 ft
1-1.49 ft
1.5-1.99 ft
2-2.49 ft

Holden Beach Stormwater Masterplan

Brunswick County, North Carolina

0 50 100 200 300 400 Feet

1 in = 100 ft

N W E S

Heat Map of Existing Flooding

Designer:	CMA
Basemap Credit:	ESRI Imagery Basemap
Basemap Publication:	December 2022

mcgill Shaping Communities Together®

Legend

Sunny Day MHHW Flooding
Contours
Parcels

2-Year Flood Depth
0-0.49 ft
0.5-0.99 ft
1-1.49 ft
1.5-1.99 ft
2-2.49 ft

Holden Beach Stormwater Masterplan

Brunswick County, North Carolina

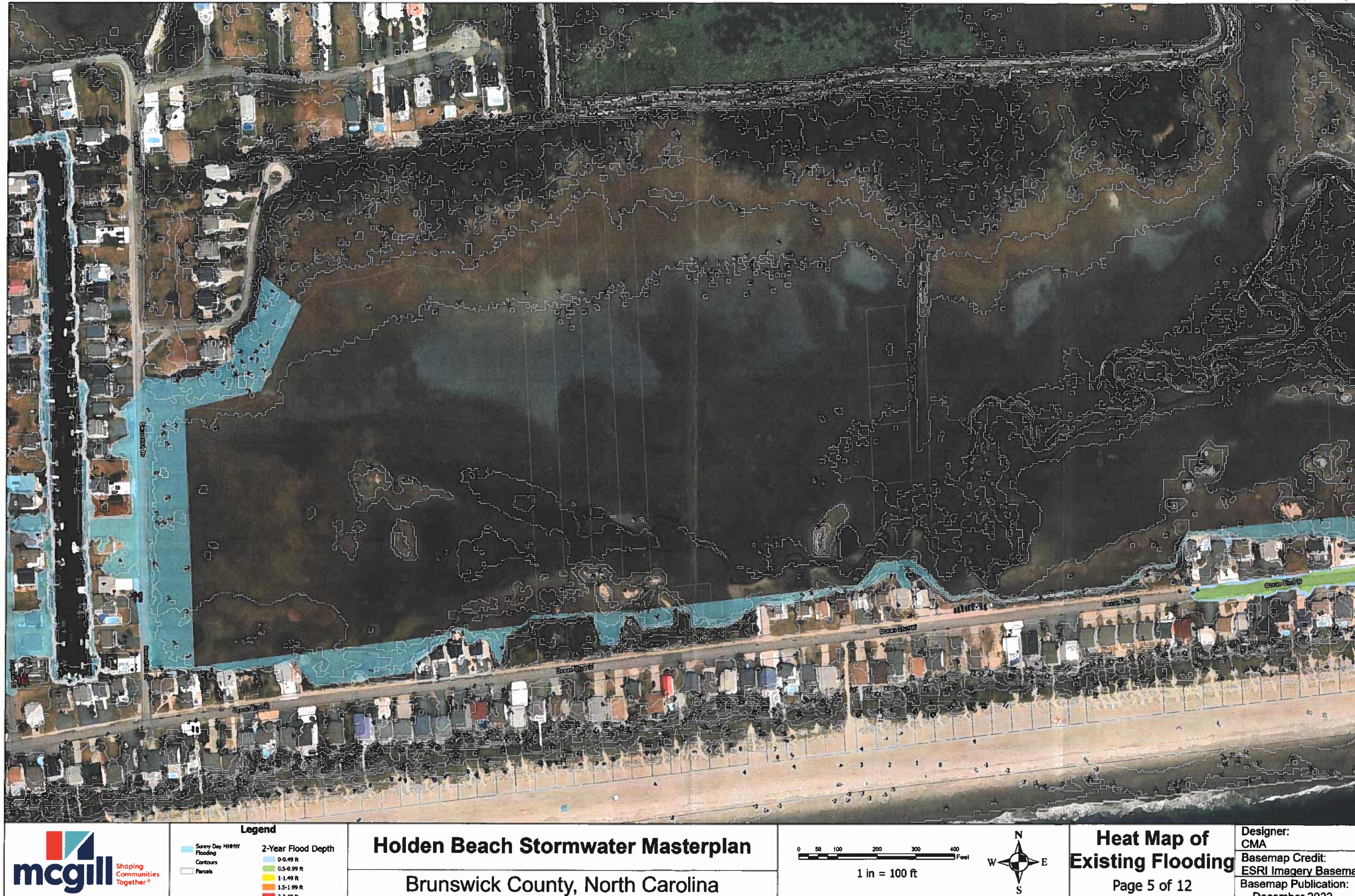
0 50 100 200 300 400 Feet

1 in = 100 ft

N W E S

Heat Map of Existing Flooding

Designer: CMA
Basemap Credit: ESRI Imagery Basemap
Basemap Publication: December 2022



mcgill Shaping Communities Together®

Holden Beach Stormwater Masterplan

Brunswick County, North Carolina

Heat Map of Existing Flooding

Page 5 of 12

Designer: CMA

Basemap Credit: ESRI Imagery Basemap

Basemap Publication: December 2022

EX. PROBLEM AREA 4

Ocean Blvd W

mcgill Shaping Communities Together®

Legend

Sunny Day NHHW Flooding Contours

Parcels

2-Year Flood Depth

0-0.49 ft

0.5-0.99 ft

1-1.49 ft

1.5-1.99 ft

2-2.49 ft

Holden Beach Stormwater Masterplan

Brunswick County, North Carolina

0 50 100 200 300 400 Feet

1 in = 100 ft

N W E S

Heat Map of Existing Flooding

Designer: CMA

Basemap Credit: ESRI Imagery Basemap

Basemap Publication: December 2022

mcgill Shaping Communities Together®

Legend

Sunny Day MHHW Flooding
Contours
Parcels

2-Year Flood Depth
0-0.49 ft
0.5-0.99 ft
1-1.49 ft
1.5-1.99 ft
2-2.49 ft

Holden Beach Stormwater Masterplan

Brunswick County, North Carolina

0 50 100 200 300 400 Feet

1 in = 100 ft

N W E S

Heat Map of Existing Flooding

Designer: CMA
Basemap Credit: ESRI Imagery Basemap
Basemap Publication: December 2022

EX. PROBLEM AREA 1

mcgill Shaping Communities Together®

Legend

Sunny Day NHHW Flooding Contours
Parcels

2-Year Flood Depth
0-0.49 ft
0.5-0.99 ft
1-1.49 ft
1.5-1.99 ft
2-2.49 ft

Holden Beach Stormwater Masterplan

Brunswick County, North Carolina

0 50 100 200 300 400 Feet

1 in = 100 ft

N W E S

Heat Map of Existing Flooding

Designer: CMA
Basemap Credit: ESRI Imagery Basemap
Basemap Publication: December 2022

mcgill Shaping Communities Together®

Legend

Sunny Day MHHW Flooding
Contours
Parcels

2-Year Flood Depth
0-0.49 ft
0.5-0.99 ft
1-1.49 ft
1.5-1.99 ft
2-2.49 ft

Holden Beach Stormwater Masterplan

Brunswick County, North Carolina

0 50 100 200 300 400 Feet

1 in = 100 ft

N W E S

Heat Map of Existing Flooding

Designer:	CMA
Basemap Credit:	ESRI Imagery Basemap
Basemap Publication:	December 2022

mcgill Shaping Communities Together®

Legend

Sunny Day NHHW Flooding Contours
Parcels

2-Year Flood Depth
0-0.49 ft
0.5-0.99 ft
1-1.49 ft
1.5-1.99 ft
2-2.49 ft

Holden Beach Stormwater Masterplan

Brunswick County, North Carolina

0 50 100 200 300 400 Feet

1 in = 100 ft

N W E S

Heat Map of Existing Flooding

Designer: CMA
Basemap Credit: ESRI Imagery Basemap
Basemap Publication: December 2022

Appendix H

Construction Cost Estimates

Holden Beach Stormwater Improvements
300 Block OBW - Alternative 1 Phase 1
Opinion of Probable Construction Cost
May 29, 2024

Item No.	Description	Qty	Unit	Unit Cost	Total Cost*
1	MOBILIZATION	1	LS	$ 19,150	$ 19,500.00
2	MAINTENANCE OF TRAFFIC	1	LS	$ 11,490	$ 11,500.00
3	EROSION CONTROL	1	LS	$ 11,490	$ 11,500.00
4	CLEARING & GRUBBING	1	LS	$ 1,500	$ 1,500.00
5	REMOVE & REPLACE CATCH BASIN	1	EA	$ 9,000.00	$ 9,000.00
6	INSTALL NEW CATCH BASIN	4	EA	$ 5,000.00	$ 20,000.00
7	CONTROL OF WATER/ DEWATERING	1	LS	$ 3,000.00	$ 3,000.00
8	BREAKING OF EXT ASPH PVMT	2,389	SY	$ 3.00	$ 7,500.00
9	REMOVAL OF EXT ASPHALT PVMT	2,389	SY	$ 9.50	$ 23,000.00
10	2" ASP CONC SURF CRS S9.5B OR S9.5C	215	TON	$ 60.50	$ 13,500.00
11	8" ASP CONC BASE CRS B25.0C	860	TON	$ 79.00	$ 68,000.00
12	REMOVE & REPLACE SIDEWALK	167	SY	$ 122.00	$ 20,500.00
13	12" HDPE	60	LF	$ 160.00	$ 10,000.00
14	15" HPPP	1,365	LF	$ 95.00	$ 130,000.00
15	18" CLASS III RCP	230	LF	$ 87.00	$ 20,500.00
16	REMOVE & REPLACE TIDE GATE	1	EA	$ 10,000.00	$ 10,000.00
17	CLASS B RIP RAP 18" THICK	1.0	TON	$ 80.00	$ 500.00
18	GEOTEXTILE FOR DRAINAGE	1,594	SY	$ 3.50	$ 6,000.00
19	SEEDING AND MULCHING	1.00	AC	$ 2,900.00	$ 3,000.00
20	EXCAVATION	1,338	CY	$ 6.60	$ 9,000.00
21	GRADING	4,840	SY	$ 3.00	$ 15,000.00
22	HAULING EXCESS MATERIAL	1,338	CY	$ 28.00	$ 37,500.00
				Subtotal*	**$ 450,000.00**
	*Contingencies (30%)**				$ 135,000.00
	*Price Escalation Factor (20%)**				$ 90,000.00
				Total*	**$ 675,000.00**
Opinion of Probable Construction Cost Range*: $450,000.00 to $675,000.00					

* Rounded to the nearest $1000

Holden Beach Stormwater Improvements
300 Block OBW - Alternative 1 Phase 2

Opinion of Probable Construction Cost

May 29, 2024

Item No.	Description	Qty	Unit	Unit Cost	Total Cost*
1	MOBILIZATION	1	LS	$ 32,675	$ 33,000.00
2	MAINTENANCE OF TRAFFIC	1	LS	$ 19,605	$ 20,000.00
3	EROSION CONTROL	1	LS	$ 19,605	$ 20,000.00
4	CLEARING & GRUBBING	1	LS	$ 1,500	$ 1,500.00
5	CONTROL OF WATER/ DEWATERING	1	LS	$ 3,000.00	$ 3,000.00
6	2" ASP CONC SURF CRS S9.5B OR S9.5C	130	TON	$ 60.50	$ 8,000.00
7	8" ASP CONC BASE CRS B25.0C	520	TON	$ 79.00	$ 41,500.00
8	SC-310 INFILTRATION SYSTEM	19,796	CF	$ 30.00	$ 594,000.00
9	SEEDING AND MULCHING	0.30	AC	$ 2,900.00	$ 1,000.00
10	EXCAVATION/ FILL	614	CY	$ 6.60	$ 4,500.00
11	GRADING	1,452	SY	$ 3.00	$ 4,500.00
				Subtotal*	**$ 731,000.00**
	*Contingencies (30%)**				$ 219,300.00
	*Price Escalation Factor (20%)**				$ 146,200.00
				Total*	**$ 1,096,500.00**
Opinion of Probable Construction Cost Range*: $731,000.00 to $1,096,500.00					

* Rounded to the nearest $1000

Holden Beach Stormwater Improvements
300 Block OBW - Alternative 2 Phase 1

Opinion of Probable Construction Cost

May 29, 2024

Item No.	Description	Qty	Unit	Unit Cost	Total Cost*
1	MOBILIZATION	1	LS	$ 21,300	$ 21,500.00
2	MAINTENANCE OF TRAFFIC	1	LS	$ 12,780	$ 13,000.00
3	EROSION CONTROL	1	LS	$ 12,780	$ 13,000.00
4	CLEARING & GRUBBING	1	LS	$ 1,500	$ 1,500.00
5	REMOVE & REPLACE CATCH BASIN	1	EA	$ 9,000.00	$ 9,000.00
6	INSTALL NEW CATCH BASIN	4	EA	$ 5,000.00	$ 20,000.00
7	CONTROL OF WATER/ DEWATERING	1	LS	$ 3,000.00	$ 3,000.00
8	BREAKING OF EXT ASPH PVMT	2,433	SY	$ 3.00	$ 7,500.00
9	REMOVAL OF EXT ASPHALT PVMT	2,433	SY	$ 9.50	$ 23,500.00
10	2" ASP CONC SURF CRS S9.5B OR S9.5C	219	TON	$ 60.50	$ 13,500.00
11	8" ASP CONC BASE CRS B25.0C	876	TON	$ 79.00	$ 69,500.00
12	REMOVE & REPLACE SIDEWALK	167	SY	$ 122.00	$ 20,500.00
13	12" HDPE	120	LF	$ 160.00	$ 19,500.00
14	15" HPPP	1,365	LF	$ 95.00	$ 130,000.00
15	18" CLASS III RCP	230	LF	$ 87.00	$ 20,500.00
16	REMOVE & REPLACE TIDE GATE	1	EA	$ 10,000.00	$ 10,000.00
17	CLASS B RIP RAP 18" THICK	1.0	TON	$ 80.00	$ 500.00
18	GEOTEXTILE FOR DRAINAGE	3,183	SY	$ 3.50	$ 11,500.00
19	SEEDING AND MULCHING	1.11	AC	$ 2,900.00	$ 3,500.00
20	EXCAVATION	2,033	CY	$ 6.60	$ 13,500.00
21	GRADING	5,382	SY	$ 3.00	$ 16,500.00
22	HAULING EXCESS MATERIAL	2,033	CY	$ 28.00	$ 57,000.00
				Subtotal*	**$ 498,000.00**
	*Contingencies (30%)**				$ 149,400.00
	*Price Escalation Factor (20%)**				$ 99,600.00
				Total*	**$ 747,000.00**
Opinion of Probable Construction Cost Range*: $498,000.00 to $747,000.00					

* Rounded to the nearest $1000

Holden Beach Stormwater Improvements
300 Block OBW - Alternative 2 Phase 2
Opinion of Probable Construction Cost
May 29, 2024

Item No.	Description	Qty	Unit	Unit Cost	Total Cost*
1	MOBILIZATION	1	LS	$ 69,575	$ 70,000.00
2	MAINTENANCE OF TRAFFIC	1	LS	$ 41,745	$ 42,000.00
3	EROSION CONTROL	1	LS	$ 41,745	$ 42,000.00
4	CLEARING & GRUBBING	1	LS	$ 1,500	$ 1,500.00
5	CONTROL OF WATER/ DEWATERING	1	LS	$ 3,000.00	$ 3,000.00
6	2" ASP CONC SURF CRS S9.5B OR S9.5C	260	TON	$ 60.50	$ 16,000.00
7	8" ASP CONC BASE CRS B25.0C	1,040	TON	$ 79.00	$ 82,500.00
8	SC-310 INFILTRATION SYSTEM	19,796	CF	$ 30.00	$ 594,000.00
9	SC-160LP INFILTRATION SYSTEM	17,741	CF	$ 38.00	$ 674,500.00
10	SEEDING AND MULCHING	1.11	AC	$ 2,900.00	$ 3,500.00
11	EXCAVATION/ FILL	646	CY	$ 6.60	$ 4,500.00
12	GRADING	5,382	SY	$ 3.00	$ 16,500.00
				Subtotal*	**$ 1,550,000.00**
	*Contingencies (30%)**				$ 465,000.00
	*Price Escalation Factor (20%)**				$ 310,000.00
				Total*	**$ 2,325,000.00**
Opinion of Probable Construction Cost Range*: $1,550,000.00 to $2,325,000.00					

* Rounded to the nearest $1000

Holden Beach Stormwater Improvements
East End Mullet Street & East End Avenue A - Alternative 1
Opinion of Probable Construction Cost
May 29, 2024

Item No.	Description	Qty	Unit	Unit Cost	Total Cost*
1	MOBILIZATION	1	LS	$ 28,075.00	$ 28,500.00
2	MAINTENANCE OF TRAFFIC	1	LS	$ 16,845.00	$ 17,000.00
3	EROSION CONTROL	1	LS	$ 16,845.00	$ 17,000.00
4	CLEARING & GRUBBING	1	LS	$ 5,615.00	$ 6,000.00
5	REMOVE & REPLACE CATCH BASIN	15	EA	$ 9,000.00	$ 135,000.00
6	ADJUST EXISTING CATCH BASIN/ PIPE	15	EA	$ 1,560.00	$ 23,500.00
7	REMOVE BLIND JUNCTION BOX	1	EA	$ 2,800.00	$ 3,000.00
8	CONTROL OF WATER/ DEWATERING	1	LS	$ 16,845.00	$ 17,000.00
9	BREAKING OF EXT ASPH PVMT	1,889	SY	$ 3.00	$ 6,000.00
10	REMOVAL OF EXT ASPHALT PVMT	1,889	SY	$ 9.50	$ 18,000.00
11	2" ASP CONC SURF CRS S9.5B OR S9.5C	170	TON	$ 60.50	$ 10,500.00
12	8" ASP CONC BASE CRS B25.0C	680	TON	$ 79.00	$ 54,000.00
13	PIPE REMOVAL	1,794	LF	$ 28.00	$ 50,500.00
14	18" CLASS III RCP	60	LF	$ 87.00	$ 5,500.00
15	24" CLASS III RCP	566	LF	$ 110.00	$ 62,500.00
16	30" CLASS III RCP	1,180	LF	$ 146.00	$ 172,500.00
17	TIDE GATE	1	EA	$ 8,000.00	$ 8,000.00
18	CLASS B RIP RAP 18" THICK	1.0	TON	$ 80.00	$ 500.00
19	GEOTEXTILE FOR DRAINAGE	2	SY	$ 3.50	$ 500.00
20	SEEDING AND MULCHING	0.75	AC	$ 2,900.00	$ 2,500.00
21	EXCAVATION	2	CY	$ 6.60	$ 500.00
22	GRADING	3,630	SY	$ 3.00	$ 11,000.00
23	HAULING EXCESS MATERIAL	2	CY	$ 28.00	$ 500.00
				Subtotal*	**$ 650,000.00**
	*Contingencies (30%)**				$ 195,000.00
	*Price Escalation Factor (20%)**				$ 130,000.00
				Total*	**$ 975,000.00**
Opinion of Probable Construction Cost Range*: $650,000.00 to $975,000.00					

* Rounded to the nearest $1000

Holden Beach Stormwater Improvements
East End Mullet Street & East End Avenue A - Alternative 2
Opinion of Probable Construction Cost
May 29, 2024

Item No.	Description	Qty	Unit	Unit Cost	Total Cost*
1	MOBILIZATION	1	LS	$ 35,000.00	$ 35,000.00
2	MAINTENANCE OF TRAFFIC	1	LS	$ 21,000.00	$ 21,000.00
3	EROSION CONTROL	1	LS	$ 21,000.00	$ 21,000.00
4	CLEARING & GRUBBING	1	LS	$ 7,000.00	$ 7,000.00
5	REMOVE & REPLACE CATCH BASIN	15	EA	$ 9,000.00	$ 135,000.00
6	ADJUST EXISTING CATCH BASIN/ PIPE	15	EA	$ 1,560.00	$ 23,500.00
7	REMOVE BLIND JUNCTION BOX	1	EA	$ 2,800.00	$ 3,000.00
8	CONTROL OF WATER/ DEWATERING	1	LS	$ 21,000.00	$ 21,000.00
9	BREAKING OF EXT ASPH PVMT	1,889	SY	$ 3.00	$ 6,000.00
10	REMOVAL OF EXT ASPHALT PVMT	1,889	SY	$ 9.50	$ 18,000.00
11	2" ASP CONC SURF CRS S9.5B OR S9.5C	170	TON	$ 60.50	$ 10,500.00
12	8" ASP CONC BASE CRS B25.0C	680	TON	$ 79.00	$ 54,000.00
13	REMOVE & REPLACE CONCRETE DRIVE & SIDEWALK	565	SY	$ 122.00	$ 69,000.00
14	PIPE REMOVAL	1,794	LF	$ 28.00	$ 50,500.00
15	12" HPPP PIPE	215	LF	$ 274.50	$ 59,500.00
16	18" CLASS III RCP	60	LF	$ 87.00	$ 5,500.00
17	24" CLASS III RCP	566	LF	$ 110.00	$ 62,500.00
18	30" CLASS III RCP	1,180	LF	$ 146.00	$ 172,500.00
19	TIDE GATE	1	EA	$ 8,000.00	$ 8,000.00
20	CLASS B RIP RAP 18" THICK	1.0	TON	$ 80.00	$ 500.00
21	GEOTEXTILE FOR DRAINAGE	2	SY	$ 3.50	$ 500.00
22	SEEDING AND MULCHING	1.00	AC	$ 2,900.00	$ 3,000.00
23	EXCAVATION	166	CY	$ 6.60	$ 1,500.00
24	GRADING	4,840	SY	$ 3.00	$ 15,000.00
25	HAULING EXCESS MATERIAL	166	CY	$ 28.00	$ 5,000.00
				Subtotal*	**$ 808,000.00**
	*Contingencies (30%)**				$ 242,400.00
	*Price Escalation Factor (20%)**				$ 161,600.00
				Total*	**$ 1,212,000.00**
Opinion of Probable Construction Cost Range*: $808,000.00 to $1,212,000.00					

* Rounded to the nearest $1000

Holden Beach Stormwater Improvements
West End ROW - Alternative 1

Opinion of Probable Construction Cost

May 29, 2024

Item No.	Description	Qty	Unit	Unit Cost	Total Cost*
1	MOBILIZATION	1	LS	$ 4,775.00	$ 5,000.00
2	MAINTENANCE OF TRAFFIC	1	LS	$ 2,865.00	$ 3,000.00
3	EROSION CONTROL	1	LS	$ 2,865.00	$ 3,000.00
4	CLEARING & GRUBBING	1	LS	$ 955.00	$ 1,000.00
5	REMOVE & REPLACE CATCH BASIN	1	EA	$ 9,000.00	$ 9,000.00
6	INSTALL NEW CATCH BASIN	2	EA	$ 5,000.00	$ 10,000.00
7	CONTROL OF WATER/ DEWATERING	1	LS	$ 2,865.00	$ 3,000.00
8	BREAKING OF EXT ASPH PVMT	167	SY	$ 3.00	$ 500.00
9	REMOVAL OF EXT ASPHALT PVMT	167	SY	$ 9.50	$ 2,000.00
10	2" ASP CONC SURF CRS S9.5B OR S9.5C	15	TON	$ 60.50	$ 1,000.00
11	8" ASP CONC BASE CRS B25.0C	60	TON	$ 79.00	$ 5,000.00
12	REMOVE & REPLACE CONCRETE DRIVE	42	SY	$ 122.00	$ 5,500.00
13	12" HPPP PIPE	145	LF	$ 274.50	$ 40,000.00
14	12" CLASS III RCP	155	LF	$ 183.00	$ 28,500.00
15	CLASS B RIP RAP 18" THICK	1.0	TON	$ 80.00	$ 500.00
16	GEOTEXTILE FOR DRAINAGE	2	SY	$ 3.50	$ 500.00
17	SEEDING AND MULCHING	0.10	AC	$ 2,900.00	$ 500.00
18	GRADING	484	SY	$ 3.00	$ 1,500.00
19	HAULING EXCESS MATERIAL	25	CY	$ 28.00	$ 1,000.00
				Subtotal*	**$ 120,500.00**
	*Contingencies (30%)**				$ 36,150.00
	Easement Acquisition				$ 60,000.00
	*Price Escalation Factor (20%)**				$ 24,100.00
				Total*	**$ 240,750.00**
Opinion of Probable Construction Cost Range*: $120,500.00 to $240,750.00					

* Rounded to the nearest $1000

Holden Beach Stormwater Improvements
West End ROW - Alternative 2
Opinion of Probable Construction Cost
May 29, 2024

Item No.	Description	Qty	Unit	Unit Cost	Total Cost*
1	MOBILIZATION	1	LS	$ 8,725.00	$ 9,000.00
2	MAINTENANCE OF TRAFFIC	1	LS	$ 5,235.00	$ 5,500.00
3	EROSION CONTROL	1	LS	$ 5,235.00	$ 5,500.00
4	CLEARING & GRUBBING	1	LS	$ 1,745.00	$ 2,000.00
5	REMOVE & REPLACE CATCH BASIN	1	EA	$ 9,000.00	$ 9,000.00
6	INSTALL NEW CATCH BASIN	2	EA	$ 5,000.00	$ 10,000.00
7	CONTROL OF WATER/ DEWATERING	1	LS	$ 5,235.00	$ 5,500.00
8	BREAKING OF EXT ASPH PVMT	189	SY	$ 3.00	$ 1,000.00
9	REMOVAL OF EXT ASPHALT PVMT	189	SY	$ 9.50	$ 2,000.00
10	2" ASP CONC SURF CRS S9.5B OR S9.5C	17	TON	$ 60.50	$ 1,500.00
11	8" ASP CONC BASE CRS B25.0C	68	TON	$ 79.00	$ 5,500.00
12	REMOVE & REPLACE CONCRETE DRIVE	42	SY	$ 122.00	$ 5,500.00
13	12" HPPP PIPE	400	LF	$ 274.50	$ 110,000.00
14	18" CLASS III RCP	390	LF	$ 87.00	$ 34,000.00
15	CLASS B RIP RAP 18" THICK	1.0	TON	$ 80.00	$ 500.00
16	GEOTEXTILE FOR DRAINAGE	2	SY	$ 3.50	$ 500.00
17	SEEDING AND MULCHING	0.15	AC	$ 2,900.00	$ 500.00
18	GRADING	726	SY	$ 3.00	$ 2,500.00
19	HAULING EXCESS MATERIAL	66	CY	$ 28.00	$ 2,000.00
				Subtotal*	**$ 212,000.00**
	*Contingencies (30%)**				$ 63,600.00
	Easement Acquisition				$ 60,000.00
	*Price Escalation Factor (20%)**				$ 42,400.00
				Total*	**$ 378,000.00**
Opinion of Probable Construction Cost Range*: $212,000.00 to $378,000.00					

* Rounded to the nearest $1000

Holden Beach Stormwater Improvements
760 Block OBW - Alternative 1
Opinion of Probable Construction Cost
May 29, 2024

Item No.	Description	Qty	Unit	Unit Cost	Total Cost*
1	MOBILIZATION	1	LS	$ 3,800.00	$ 4,000.00
2	MAINTENANCE OF TRAFFIC	1	LS	$ 2,280.00	$ 2,500.00
3	EROSION CONTROL	1	LS	$ 2,280.00	$ 2,500.00
4	CLEARING & GRUBBING	1	LS	$ 760.00	$ 1,000.00
5	INSTALL NEW CATCH BASIN	2	EA	$ 5,000.00	$ 10,000.00
6	CONTROL OF WATER/ DEWATERING	1	LS	$ 2,280.00	$ 2,500.00
7	BREAKING OF EXT ASPH PVMT	300	SY	$ 3.00	$ 1,000.00
8	REMOVAL OF EXT ASPHALT PVMT	300	SY	$ 9.50	$ 3,000.00
9	2" ASP CONC SURF CRS S9.5B OR S9.5C	27	TON	$ 60.50	$ 2,000.00
10	8" ASP CONC BASE CRS B25.0C	108	TON	$ 79.00	$ 9,000.00
11	REMOVE & REPLACE CONCRETE DRIVE & SIDEWALK	139	SY	$ 122.00	$ 17,000.00
12	15" CLASS III RCP	35	LF	$ 62.00	$ 2,500.00
13	24" CLASS III RCP	250	LF	$ 110.00	$ 27,500.00
14	CLASS B RIP RAP 18" THICK	1.0	TON	$ 80.00	$ 500.00
15	GEOTEXTILE FOR DRAINAGE	2	SY	$ 3.50	$ 500.00
16	SEEDING AND MULCHING	0.10	AC	$ 2,900.00	$ 500.00
17	GRADING	484	SY	$ 3.00	$ 1,500.00
18	HAULING EXCESS MATERIAL	21	CY	$ 28.00	$ 1,000.00
				Subtotal*	**$ 148,500.00**
	*Contingencies (30%)**				$ 44,550.00
	Easment Acquisition OR				$ 60,000.00
	Property Acquisition				$ 250,000.00
	*Price Escalation Factor (20%)**				$ 29,700.00
				Total*	**$ 472,750.00**
Opinion of Probable Construction Cost Range*: $148,500.00 to $472,750.00					

* Rounded to the nearest $1000

Holden Beach Stormwater Improvements
760 Block OBW - Alternative 2
Opinion of Probable Construction Cost
May 29, 2024

Item No.	Description	Qty	Unit	Unit Cost	Total Cost*
1	MOBILIZATION	1	LS	$ 11,775.00	$ 12,000.00
2	MAINTENANCE OF TRAFFIC	1	LS	$ 7,065.00	$ 7,500.00
3	EROSION CONTROL	1	LS	$ 7,065.00	$ 7,500.00
4	CLEARING & GRUBBING	1	LS	$ 2,355.00	$ 2,500.00
5	INSTALL NEW CATCH BASIN	4	EA	$ 5,000.00	$ 20,000.00
6	CONTROL OF WATER/ DEWATERING	1	LS	$ 7,065.00	$ 7,500.00
7	BREAKING OF EXT ASPH PVMT	1,178	SY	$ 3.00	$ 4,000.00
8	REMOVAL OF EXT ASPHALT PVMT	1,178	SY	$ 9.50	$ 11,500.00
9	2" ASP CONC SURF CRS S9.5B OR S9.5C	106	TON	$ 60.50	$ 6,500.00
10	8" ASP CONC BASE CRS B25.0C	424	TON	$ 79.00	$ 33,500.00
11	REMOVE & REPLACE CONCRETE DRIVE & SIDEWALK	500	SY	$ 122.00	$ 61,000.00
12	15" CLASS III RCP	35	LF	$ 62.00	$ 2,500.00
13	24" CLASS III RCP	820	LF	$ 110.00	$ 90,500.00
14	CLASS B RIP RAP 18" THICK	1.0	TON	$ 80.00	$ 500.00
15	GEOTEXTILE FOR DRAINAGE	2	SY	$ 3.50	$ 500.00
16	SEEDING AND MULCHING	0.15	AC	$ 2,900.00	$ 500.00
17	GRADING	726	SY	$ 3.00	$ 2,500.00
18	HAULING EXCESS MATERIAL	68	CY	$ 28.00	$ 2,000.00
				Subtotal*	**$ 272,500.00**
	*Contingencies (30%)**				$ 81,750.00
	*Price Escalation Factor (20%)**				$ 54,500.00
				Total*	**$ 408,750.00**
Opinion of Probable Construction Cost Range*: $272,500.00 to $408,750.00					

* Rounded to the nearest $1000

Holden Beach Stormwater Improvements
Carolina Avenue - Alternative 1
Opinion of Probable Construction Cost
May 29, 2024

Item No.	Description	Qty	Unit	Unit Cost	Total Cost*
1	MOBILIZATION	1	LS	$ 8,475.00	$ 8,500.00
2	MAINTENANCE OF TRAFFIC	1	LS	$ 5,085.00	$ 5,500.00
3	EROSION CONTROL	1	LS	$ 5,085.00	$ 5,500.00
4	CLEARING & GRUBBING	1	LS	$ 1,695.00	$ 2,000.00
5	CATCH BASIN	2	EA	$ 5,000.00	$ 10,000.00
6	JUNCTION BOX MANHOLE	2	EA	$ 5,000.00	$ 10,000.00
7	CONTROL OF WATER/ DEWATERING	1	LS	$ 5,085.00	$ 5,500.00
8	BREAKING OF EXT ASPH PVMT	778	SY	$ 3.00	$ 2,500.00
9	REMOVAL OF EXT ASPHALT PVMT	778	SY	$ 9.50	$ 7,500.00
10	2" ASP CONC SURF CRS S9.5B OR S9.5C	70	TON	$ 60.50	$ 4,500.00
11	8" ASP CONC BASE CRS B25.0C	280	TON	$ 79.00	$ 22,500.00
12	REMOVE & REPLACE CONCRETE DRIVE	276	SY	$ 122.00	$ 34,000.00
13	30" CLASS III RCP	570	LF	$ 146.00	$ 85,000.00
14	SEEDING AND MULCHING	0.10	AC	$ 2,900.00	$ 500.00
15	GRADING	500	SY	$ 3.00	$ 1,500.00
16	HAULING EXCESS MATERIAL	48	CY	$ 28.00	$ 1,500.00
				Subtotal*	**$ 206,500.00**
	*Contingencies (30%)**				$ 61,950.00
	*Price Escalation Factor (20%)**				$ 41,300.00
				Total*	**$ 309,750.00**
Opinion of Probable Construction Cost Range*: $206,500.00 to $309,750.00					

* Rounded to the nearest $1000

Holden Beach Stormwater Improvements
Carolina Avenue - Alternative 2
Opinion of Probable Construction Cost
May 29, 2024

Item No.	Description	Qty	Unit	Unit Cost	Total Cost*
1	MOBILIZATION	1	LS	$ 8,375.00	$ 8,500.00
2	MAINTENANCE OF TRAFFIC	1	LS	$ 5,025.00	$ 5,500.00
3	EROSION CONTROL	1	LS	$ 5,025.00	$ 5,500.00
4	CLEARING & GRUBBING	1	LS	$ 1,675.00	$ 2,000.00
5	CATCH BASIN	2	EA	$ 5,000.00	$ 10,000.00
6	JUNCTION BOX MANHOLE	2	EA	$ 5,000.00	$ 10,000.00
7	CONTROL OF WATER/ DEWATERING	1	LS	$ 5,025.00	$ 5,500.00
8	BREAKING OF EXT ASPH PVMT	833	SY	$ 3.00	$ 2,500.00
9	REMOVAL OF EXT ASPHALT PVMT	833	SY	$ 9.50	$ 8,000.00
10	2" ASP CONC SURF CRS S9.5B OR S9.5C	75	TON	$ 60.50	$ 5,000.00
11	8" ASP CONC BASE CRS B25.0C	300	TON	$ 79.00	$ 24,000.00
12	REMOVE & REPLACE CONCRETE DRIVE	283	SY	$ 122.00	$ 35,000.00
13	24" CLASS III RCP	705	LF	$ 110.00	$ 78,000.00
14	SEEDING AND MULCHING	0.15	AC	$ 2,900.00	$ 500.00
15	GRADING	722	SY	$ 3.00	$ 2,500.00
16	HAULING EXCESS MATERIAL	59	CY	$ 28.00	$ 2,000.00
				Subtotal*	**$ 204,500.00**
	*Contingencies (30%)**				$ 61,350.00
	*Permitting (10%)**				$ 20,450.00
	*Price Escalation Factor (20%)**				$ 40,900.00
				Total*	**$ 327,200.00**
Opinion of Probable Construction Cost Range*: $204,500.00 to $327,200.00					

* Rounded to the nearest $1000

Holden Beach Stormwater Improvements
Davis Street Erosion Control
Opinion of Probable Construction Cost
May 29, 2024

Item No.	Description	Qty	Unit	Unit Cost	Total Cost*
1	MOBILIZATION	1	LS	$ 800.00	$ 1,000.00
2	CLEARING & GRUBBING	1	LS	$ 160.00	$ 500.00
3	BLIND SWALE/ LEVEL SPREADER	1	LS	$ 15,000.00	$ 15,000.00
4	SEEDING AND MULCHING	0.20	AC	$ 2,900.00	$ 1,000.00
				Subtotal*	**$ 17,500.00**
	*Contingencies (30%)**				$ 5,250.00
	*Price Escalation Factor (20%)**				$ 3,500.00
				Total*	**$ 26,250.00**
Opinion of Probable Construction Cost Range*: $17,500.00 to $26,250.00					

* Rounded to the nearest $1000

Appendix I

Stormwater Utility Financial Model Outcomes

Town of Holden Beach
Stormwater Utility Feasibility Analysis
Capital Improvements Plan

Scenario A: CIP 100% Funded by User Fees

Stormwater System

Project Number	Project Description	10-Yr CIP Cost Cost	FY 1 2025	FY 2 2026	FY 3 2027	FY 4 2028	FY 5 2029	FY 6 2030	FY 7 2031	FY 8 2032	FY 9 2033	FY 10 2034
Vehicles and Equipment												
1	Sewer Jet / Vacuum Truck	321,900						321,900				
Subtotal Vehicles and Equipment		**321,900**	-	-	-	-	-	**321,900**	-	-	-	-
Collection Infrastructure												
1	Davis Street (ESC Measures)	23,300	23,300									
2	300 block Ocean Boulevard West	808,000			808,000							
3	East End Mullet Street area & East End Avenue A	1,363,300				1,363,300						
4	West End ROW (Gated Emergency Outfall)	266,800		266,800								
5	760 block Ocean Boulevard West (Gated Emergency Outfall)	488,700					488,700					
6	Carolina Avenue (Blind Outfall)	361,500					361,500					
Subtotal - Stormwater Collection Infrastructure		**3,311,600**	**23,300**	**266,800**	**808,000**	**1,363,300**	**850,200**	-	-	-	-	-
10-Yr CIP: Stormwater System Total		**3,633,500**	**23,300**	**266,800**	**808,000**	**1,363,300**	**850,200**	**321,900**	-	-	-	-

Capital Project funded or patially funded using debt issue(s)

Town of Holden Beach, North Carolina

Stormwater Utility Feasibility Study

Scenario A: Capital Investment 100% Funded by User Fees

Revenue

Description	Startup	FY25	FY26	FY27	FY28	FY29	FY30	FY31	FY32	FY33	FY34
Operating Revenue Base User Fee		313,000	314,000	314,000	315,000	316,000	316,000	317,000	317,000	318,000	319,000
New Revenue - Fee Adjustment (Cumulative)	300,000	-	9,000	17,000	26,000	31,000	40,000	48,000	62,000	71,000	80,000
Total Projected Revenue		313,000	323,000	331,000	341,000	347,000	356,000	365,000	379,000	389,000	399,000

Expenses

Cash Financed CIP		23,000	-	-	-	-	-	-	-	-	-
Projected Debt Service		-	62,000	128,000	238,000	307,000	307,000	245,000	245,000	245,000	245,000
Existing Debt Service											
Operating Expenses		132,000	178,000	177,000	176,000	171,000	171,000	178,000	170,000	161,000	151,000

Percent Increase Applied

Revenue Adjustment Percentage		0.0%	2.9%	2.5%	2.9%	1.6%	2.8%	2.5%	4.4%	2.8%	2.8%

Financial Outcomes

Expenses to Cover	-	155,000	240,000	305,000	414,000	478,000	478,000	423,000	415,000	406,000	396,000
Difference / (Shortage)		158,000	83,000	26,000	(73,000)	(131,000)	(122,000)	(58,000)	(36,000)	(17,000)	3,000

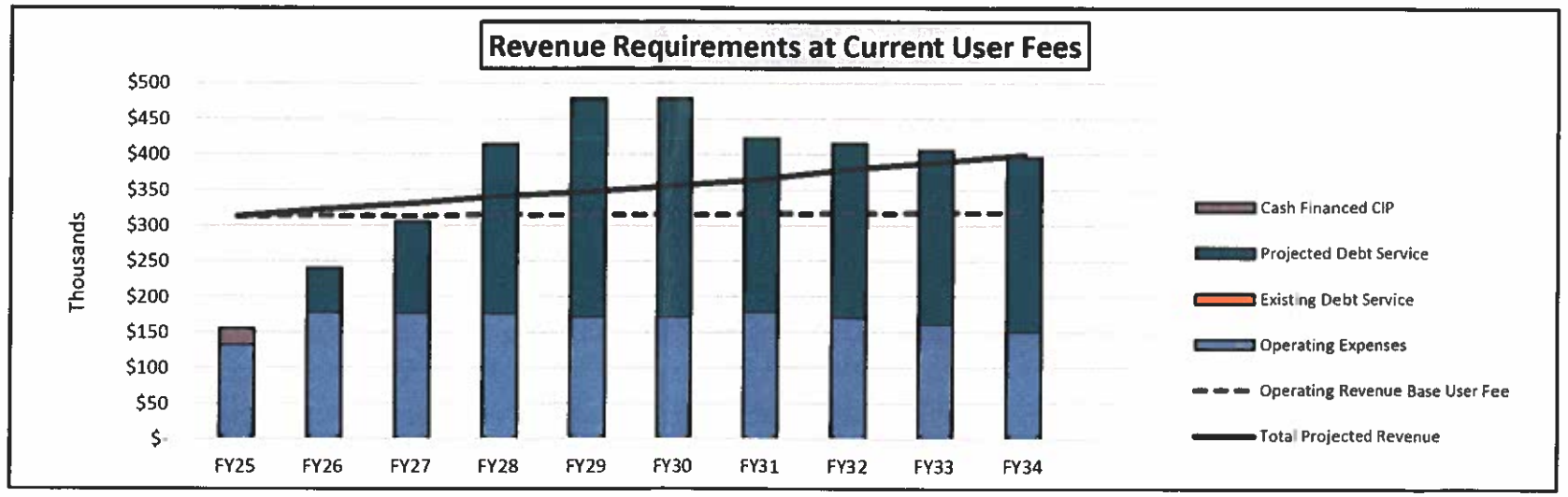
Effect on User Fees

Monthly Per-Parcel User Fee		$7.20	$7.40	$7.60	$7.80	$7.90	$8.10	$8.30	$8.60	$8.80	$9.00
Monthly Per-Parcel User Fee Change			$0.20	$0.20	$0.20	$0.10	$0.20	$0.20	$0.30	$0.20	$0.20

Financial Indicators

Fund Balance Tracker	300,000	458,000	541,000	567,000	494,000	363,000	241,000	183,000	147,000	130,000	133,000
Days Cash on Hand - Target 90 Days		1,079	823	679	436	277	184	158	129	117	123
Sinking Fund Balance	-	62,000	124,000	154,000	214,000	269,000	2,000	62,000	117,000	167,000	205,000

Summary Chart



Capital Investment

Description	10-Year Total	FY25	FY26	FY27	FY28	FY29	FY30	FY31	FY32	FY33	FY34
Stormwater Infrastructure	3,311,600	23,300	266,800	808,000	1,363,300	850,200	-	-	-	-	-
Vehicles and Equipment	321,900	-	-	-	-	-	321,900	-	-	-	-
Total	3,633,500	23,300	266,800	808,000	1,363,300	850,200	321,900	-	-	-	-

Revenue

Description		FY33	FY34
Operating Revenue Base User Fee	)00	234,000	234,000
New Revenue - Fee Adjustment	)00	53,000	58,000
Total Projected Revenue	)00	287,000	292,000

Expenses

Cash Financed CIP	-	-	-
Projected Debt Service	)00	45,000	-
Existing Debt Service			
Operating Expenses	)00	231,000	288,000

Percent Increase Applied

Revenue Adjustment Percentage	.8%	3.8%	2.1%

Financial Outcomes

Expenses to Cover	)00	276,000	288,000
Difference / (Shortage)	)00)	11,000	4,000

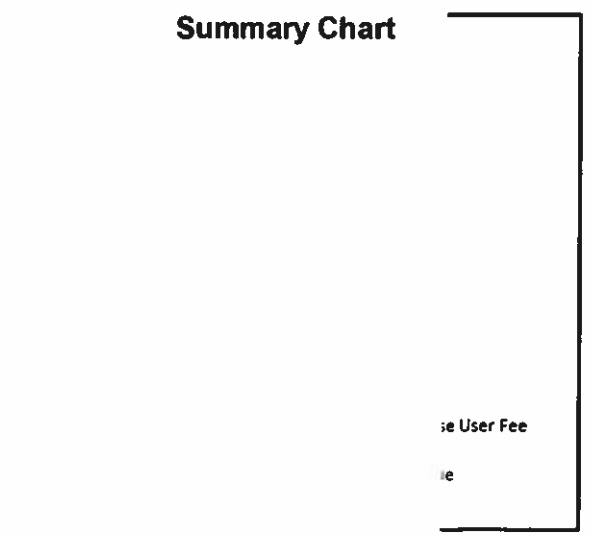
Effect on User Fees

Monthly Per-Parcel User Fee	6.30	$6.50	$6.60
Monthly Per-Parcel User Fee Change	0.20	$0.20	$0.10

Financial Indicators

Fund Balance Tracker	)00	91,000	95,000
Days Cash on Hand - Target 90 Days	103	120	120
Sinking Fund Balance	)00	217,000	392,000

Summary Chart



Capital Investment

Description		FY33	FY34
Stormwater Infrastructure	-	-	-
Vehicles and Equipment	-	-	-
Total	-	-	-

Town of Holden Beach, North Carolina

Stormwater Utility Feasibility Study

Scenario B: Capital Investment 75% Funded by USACE Environmental Infrastructure Assistance

Revenue

Description	Startup	FY25	FY26	FY27	FY28	FY29	FY30	FY31	FY32	FY33	FY34
Operating Revenue Base User Fee		230,000	231,000	231,000	232,000	232,000	233,000	233,000	234,000	234,000	234,000
New Revenue - Fee Adjustment	300,000		4,000	13,000	17,000	26,000	31,000	35,000	44,000	53,000	58,000
Total Projected Revenue		230,000	235,000	244,000	249,000	258,000	264,000	268,000	278,000	287,000	292,000

Expenses

Cash Financed CIP		23,000	67,000	-	-	-	-	-	-	-	-
Projected Debt Service		-	-	51,000	134,000	181,000	173,000	166,000	118,000	45,000	-
Existing Debt Service											
Operating Expenses		132,000	178,000	177,000	186,000	191,000	166,000	138,000	165,000	231,000	288,000

Percent Increase Applied

Revenue Adjustment Percentage		0.0%	1.7%	3.9%	1.7%	3.9%	2.1%	1.7%	3.8%	3.8%	2.1%

Financial Outcomes

Expenses to Cover	-	155,000	245,000	228,000	320,000	372,000	339,000	304,000	283,000	276,000	288,000
Difference / (Shortage)		75,000	(10,000)	16,000	(71,000)	(114,000)	(75,000)	(36,000)	(5,000)	11,000	4,000

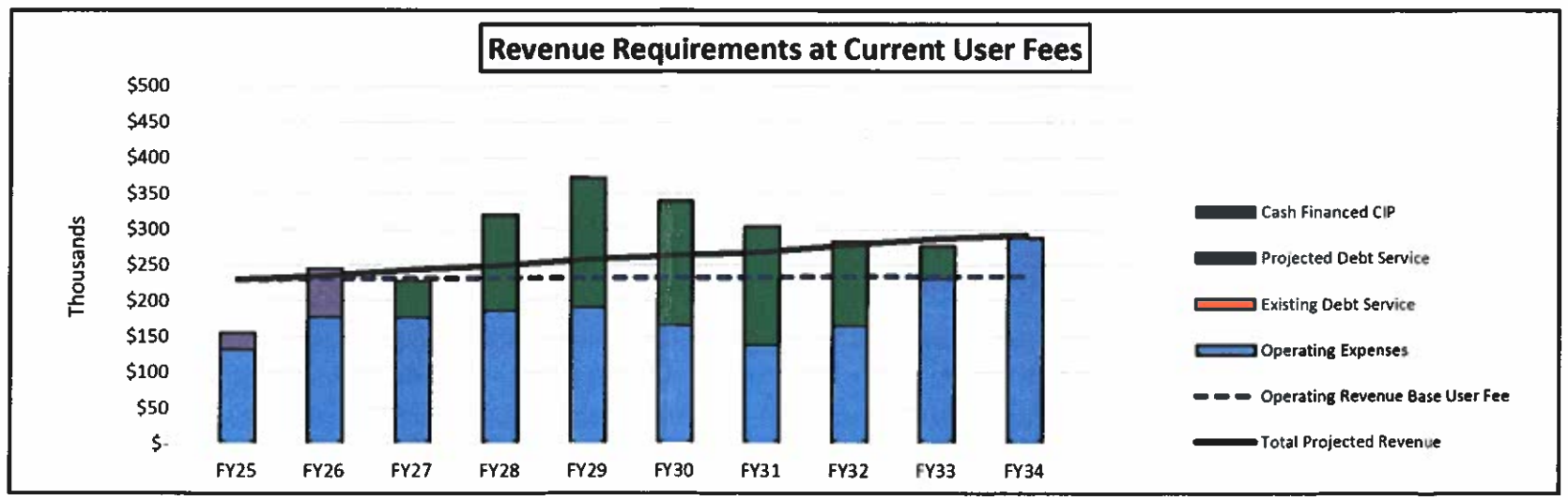
Effect on User Fees

Monthly Per-Parcel User Fee		$5.30	$5.40	$5.60	$5.70	$5.90	$6.00	$6.10	$6.30	$6.50	$6.60
Monthly Per-Parcel User Fee Change			$0.10	$0.20	$0.10	$0.20	$0.10	$0.10	$0.20	$0.20	$0.10

Financial Indicators

Fund Balance Tracker	300,000	375,000	365,000	381,000	310,000	196,000	121,000	85,000	80,000	91,000	95,000
Days Cash on Hand - Target 90 Days		883	544	610	354	192	130	102	103	120	120
Sinking Fund Balance	-	62,000	124,000	154,000	224,000	299,000	27,000	47,000	97,000	217,000	392,000

Summary Chart



Capital Investment

Description	10-Year Total	FY25	FY26	FY27	FY28	FY29	FY30	FY31	FY32	FY33	FY34
Stormwater Infrastructure	3,311,600	23,300	266,800	808,000	1,363,300	850,200	-	-	-	-	-
Vehicles and Equipment	321,900	-	-	-	-	-	321,900	-	-	-	-
Total	3,633,500	23,300	266,800	808,000	1,363,300	850,200	321,900	-	-	-	-