FINAL REPORT

South Davis Shores Resiliency Study

St. Augustine, FL

CITY OF
ST AUGUSTINE
EST. 1565

June 2021

CDM Smith

Table of Contents

List of Figures

List of Tables

Appendices

Section 1

Introduction

CDM Smith Inc. (CDM Smith) was contracted by the City of St. Augustine (City) to conduct a flood risk resiliency study for the South Davis Shores area. The City is requesting the study to develop a larger concept of the whole neighborhood. The main goal of the plan is to protect the neighborhood up to an elevation of 7 feet, referenced to the North American Vertical Datum of 1988 (NAVD88). Three specific project elements were considered:

1) Capacity of the stormwater collection system,

2) Capacity of Coquina Ditch to detain stormwater during high tailwater conditions; and

3) Additional protection for anticipated sea level rise up to elevation 7 ft-NAVD88.

The purpose of the report is to review the data provided, develop and evaluate a pilot model based on the existing infrastructure, and determine mitigation strategies based on the results of the model. Additional mitigation strategies beyond those recommended from the model will also be discussed, including policy options. Finally, a cost estimate for the mitigation strategies will be developed and potential funding sources will be identified.

1.1 Existing Condition

The City of St. Augustine is in St. Johns County, Florida and has a population of 12,975 inhabitants based on 2010 Census data. Founded in 1565, St. Augustine is the oldest continuously occupied European established city and port in the United States. Tidal rivers divide the City into three main land masses: Anastasia Island, Old St. Augustine, and West St. Augustine. Receiving waters are all tidal and include Salt Run, the Matanzas River, and the San Sebastian River.

The pilot area is approximately 76 acres located on Anastasia Island in the South Davis Shores area. The pilot area was delineated to account for the drainage area for the three intersections of interest that have flooding issues: Arricola Ave. and Carver St., Menendez Rd. and Carver St., and Ferdinand Ave. and Kenan St. The area drains to two ditches, the Coquina Ditch in the west and the Ferdinand Avenue Ditch to the east. Both ditches drain to Quarry Creek, a tributary of Matanzas River. For the pilot model, the Coquina Ditch is modeled to the outfall, while only one pipe drains to the Ferdinand Avenue Ditch. **Figure 1-1** shows the South Davis Shores area and the extent of the pilot model.

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Figure 1-1: Study Area and Pilot Area Extent

City of St. Augustine, FL

1.2 Data Availability

In accordance with the project scope for the South Davis Shores Resiliency Study, the City of St. Augustine has provided data for analysis and utilization in the execution of this project. The data provided by the City includes, but is not limited to: topography/LiDAR data; stormwater system inlet, pipe, and channel locations, sizes, inverts, and materials; available survey; tidal stages; building elevations; flooding problem area locations, depths and photos; groundwater levels or geotechnical data; design plans and calculations; applicable permits; and land ownership.

In accordance with Task 1.1 in the project scope, CDM Smith reviewed the data provided by the City. A list of data provided by the City is included in **Table 1-1**. Additional supporting data is accessible and available for use from public sources including the City of St. Augustine Data Hub, FL DEP, NOAA, FEMA, St. John's Data Depot, US Census Bureau, FL Fish and Wildlife, and USGS.

Table 1-1: City Provided Data

File Name	File Type
16-2400 TOPO DITCH	.dwg; .pdf
Coquina Ditch Improvements Bid Set	.pdf
Coquina Drainage Ditch Outfall - OF-115_Project Summary	.pdf
Coquina Park SJRWMD Redi-Innovative Cost Share Supporting Application Info_FINAL	.pdf
NEF FAAS Wrap Up Webinar	.pdf
Smart Sea Level Sensors Project Overview	.pdf
COSA_Smart_Tide-Valves	.pdf
Strategy Development Summary NE FL	.docx
St. Augustine Geodatabase	.gdb
101 Ferdinand Ave - Flood Mitigation Site Inspection Report	.pdf
14 Coquina Ave - Flood Mitigation Site Inspection Report	.pdf
145 Menendez Rd - Flood Mitigation Site Inspection Report	.pdf
149 Menendez Rd - Flood Mitigation Site Inspection Report	.pdf
206 Kenan St - Flood Mitigation Site Inspection Report	.pdf
467 Arricola Ave - Flood Mitigation Site Inspection Report	.pdf
84 Coquina Ave - Flood Mitigation Site Inspection Report	.pdf
Checkmate Ultraflex Brochure	.pdf
Checkmate Advantage Brochure	.pdf
Macaris Resiliency Technical Memorandum_Valve Info	.pdf
Performance Duckbill vs. WaStop	.pdf
Red Valve Checkmate – Head Loss Test Data from Independent Test Lab Macaris Out Fall Project	.msg
WaStop Fact Sheets pages 1-2	.pdf
WaStop Inline Check Valve Specification	.docx
White Paper WAPRO(1)_Flow_Coeffecient_Headloss	.pdf
AB-Herada at Menendez	.dwg; .pdf
City_OldStormlines_wFDOTlines	.shp
Hermosa Outfall Report Final	.pdf

CDM Smith received digital data from the City, and generally has divided it into two main categories: Modeling Data and GIS and Survey Data.

In general, the modeling information provided by the City is usable and complete. A few minor data gaps were identified upon review and were sent to the City. Survey data was initially not available or provided for the project area. However, there was survey data for Coquina Ditch as part of the Coquina Ditch improvement plans which proved to be sufficient for modeling the entire area. FDOT pipes were also missing along Anastasia Boulevard in the northern end of the study area. The City provided an older GIS layer showing all pipes in the system including FDOT pipes. This layer provided enough data to fully analyze the stormwater infrastructure in and around the project area. Other requests related to the drainage area for Hermosa outfall and the outfall themselves. This information was provided by the City.

GIS data collected come from USGS, NOAA, St. Johns County Data Depot, St. Augustine Data Hub, FEMA Flood Mapping Program, FDOT, The US Fish and Wildlife National Wetland Inventory, and data provided by the City of St Augustine on the current stormwater system. Of the data initially laid out in the scope, CDM Smith has been able to find most of the listed data through the sources listed above. CDM Smith had previously requested additional surveys, groundwater levels, geotechnical data, design plans, and applicable permits. The City provided as-built data, permitting documents, soil reports, old stormwater master plans, and survey data that fill in some of the data request.

The data the City has provided were useful in the preliminary analysis of the project area and preliminary modeling efforts. Additional data provided by the City were sufficient to move forward for the purpose of modeling and developing mitigation strategies.

1.2.1 Project Datum

This project is referenced to the North American Vertical Datum of 1988 (NAVD88). To have all of the City's data accessible, some of the data required a conversion from the National Geodetic Vertical datum of 1929 (NGVD29) to NAVD88. The datums were converted using the US Army Corps of Engineers CORPSCON version 6.0. Using a latitude of 29 degrees 53 minutes and 40 seconds and a longitude of 81 degrees 18 minutes and 53 seconds for the City of St. Augustine, the conversion value from NGVD29 to NAVD88 is 1.06 ft (NAVD88 + 1.06 = NGVD29).

Section 2

Model Methodology

The development of a detailed hydrologic and hydraulic model (H&H) is essential for the City to effectively assess and manage flood risk, capital improvements, and water quality issues. This section presents the data and methodology used to develop the H&H model of the study area, and how it is applied to evaluate potential mitigation strategies. CDM Smith developed a United States Environmental Protection Agency (USEPA) Stormwater Management Model Version 5 (SWMM5) model for the pilot area, using data sources provided by the City of St. Augustine.

2.1 SWMM Modeling

SWMM5 is a dynamic hydrologic and hydraulic model capable of performing continuous or event simulations of surface runoff and groundwater baseflow, and subsequent hydraulic conveyance in open channel and pipe systems. SWMM5 is also approved by FEMA for floodplain mapping and accepted as an industry standard modeling platform for urban areas with systems of combined open channels and piped networks.

The hydrologic model is based on the subdivision of the study area into hydrologic units (HU), which are each characterized by physical parameters such as area, percent directly connected impervious area (DCIA), and infiltration capacity. Precipitation is applied to the HU, and the model calculates the quantity of rainfall converted to stormwater runoff, and the runoff rate from the HU. The runoff from the HU is assigned to loading points on the user-defined stormwater management system in the hydraulic model of the study area.

SWMM5 uses a link-node representation of the stormwater management system to dynamically route flows by continuously solving the complete one-dimensional Saint-Venant flow equations. The dynamic flow routing allows for representation of channel storage, branched or looped networks, backwater effects, free surface flow, pressure flow, entrance and exit losses, weirs, orifices, pumping facilities, rating curves, and other special structures/links. Control rules may be used to operate structures based on timing and/or stage and flow conditions within the model.

2.2 Hydrologic Model Data

CDM Smith delineated the study area boundary and HU boundaries based on existing topography and hydraulic structures within the study area such as culverts, pipes, and channels. The three intersections of interest are Arricola Avenue and Carver Street, Menendez Road and Carver Street, and Ferdinand Avenue and Kenan Street. Flow in Arricola Avenue and Carver Street intersection, and Menendez Road and Carver Street intersection, discharge to Coquina Ditch via pipes to the north. To account for potential mitigation strategies along Coquina Ditch, the ditch was modeled to the outfall in Quarry Creek. Flow in Ferdinand Avenue and Kenan Street intersection discharge to Ferdinand Avenue Ditch via a 15-inch storm sewer. Because flow to Ferdinand Avenue Ditch from the intersections of interest is limited to the single storm main, the ditch itself is not included in the pilot area model, and the 15-inch pipe is directed to an outfall with the same fixed boundary condition as Quarry Creek. The total modeled study area is 76 acres and consists of 10 HUs.

In addition to rainfall and area, hydrologic parameters assigned to each HU include area, width, slope, impervious area, overland flow roughness, initial abstraction, infiltration rates, and soil storage capacities. After rainfall and area, the most critical input parameters are impervious area and the infiltration rates based on soils types and groundwater table elevation. Hydrologic parameters specified in the model are listed in **Appendix A**.

2.2.1 Rainfall

Rainfall data from the SJ 91-3 technical publication on the 24-hour rainfall distribution for areas within the St. Johns River Water Management District were used to generate stormwater runoff hydrographs for each hydrologic unit represented in the model. St. Augustine fell into Hydrologic Unit IX (HU IX), the upper coastal basin. The 24-hour distributions for varying return periods were obtained from the SJ 91-3 document. Total rainfall however, utilized the NOAA Atlas 14 rainfall total over a 24-hour period. The value was then scaled to the distribution from the SJ 91-3 document.

CDM Smith used storm distributions for the following conditions: the 5-year, 25-year, and 100-year 24-hour duration rainfall events. Based on NOAA Atlas 14, the rainfall total are 5.79 inches, 8.90 inches, and 12.40 inches for 5-year, 25-year, and 100-year, respectively. **Figure 2-1** shows the rainfall distribution for a 100-year rainfall event.

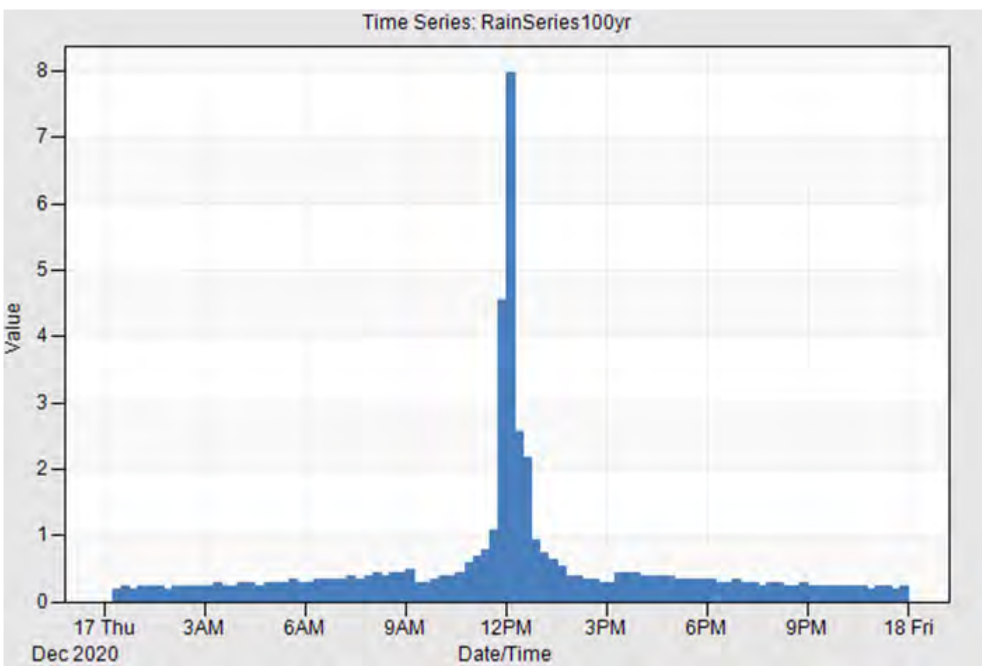

Figure 2-1: Rainfall Distribution for 100-Year Rainfall Event (12.40 inches)

2.2.2 Soils and Hydrogeology

Data extracted from the USDA Web Soil Survey were used to identify the soil within the study area. Each soil type is assigned a soil series and a Hydrologic Soil Group designated by Natural Resources Conservation Service (formerly the SCS). Hydrologic Soil Group A is comprised of soils having very high infiltration potential and low runoff potential. Hydrologic Soil Group D is characterized by soils with a very low infiltration potential and a high runoff potential. Hydrologic Soil Groups B and C are designated between these two categories. Soil group percentages for each hydrologic unit were estimated by overlaying a map of the hydrologic unit boundaries on the NRCS soil map. From the overlay map, the percentage of each soil group within a hydrologic unit is estimated using GIS software.

For the pilot area, nearly all the soil is classified as St. Augustine-Urban land complex. The soil description indicate that the soil is a mix of St. Augustine soil, which is made of fine sand, and urban land, which typically includes fill material and impervious surfaces. The soil is classified as Hydrologic Soil Group A, although available water capacity is classified as low due to depth of water table between 18 to 36 inches.

The Horton infiltration equation option in SWMM5 is used to calculate the rate and volume of water that infiltrates into the soil. According to the Horton equation, infiltration is computed as:

$$f_t = f_{min} + (f_{max} - f_{min})e^{-kt}$$

f_t = the infiltration capacity of the soil (in/hr) at time t,

f_{min} = the minimum (or final) infiltration capacity (in/hr),

f_{max} = the maximum (or initial) infiltration capacity (in/hr),

k = an exponential decay constant (hr-1), and

t = time (hr)

Table 2-1 lists the parameters used for the St. Augustine-Urban land complex soil, which is the only soil within the pilot area, and the assumptions used to set the values. The parameters are set such that there is a large rate of infiltration at the start of the rainfall event, but that infiltration largely stops once the low soil moisture capacity is reached. (Source: https://help.innovyze.com/display/xps/Infiltration)

Table 2-1: Horton Parameters for St. Augustine-Urban land complex soil

Parameter	Value	Assumption
Maximum Infiltration Rate	5 in/hr	Dry, sandy soil
Minimum Infiltration Rate	0.5 in/hr	Based on Type A soil
Decay Constant	2.002/hr	Standard Value
Drying Time	2.1 days	Standard Value
Maximum Volume	4 in	Available capacity estimated at 4.6 inches

2.2.3 Land Use and Imperviousness

Land use data are used to estimate surface friction factors and initial abstractions for each subbasin. Existing land use conditions were obtained using the City of Saint Augustine future land use plan, assuming that land use in the area is not changing, as well as available aerial imagery. Land uses were grouped into categories of relatively homogenous geophysical parameters. Present land use within the watershed include:

- Forest, Open, and Park
- Medium Density Residential
- Light Industrial, Commercial, and Institutional
- Wetlands

The values in **Table 2-2** are used in developing weighted HU characteristics based on existing land use data. The areas of the land use categories are matched with the tables below to provide a unique set of characteristics including Manning's n, DCIA, non-directly connected impervious area (NDCIA), and initial abstraction (IA). The breakdown of land use within the pilot area is shown in Table 2-2. The primary land use in the pilot area is medium density residential.

Table 2-2: Land Use Parameters

Land Use Category	Forest, Open, and Park	Medium Density Residential	Light Industrial, Commercial, and Institutional	Wetlands
Impervious Manning's n	0.015	0.015	0.015	0.100
Pervious Manning's n	0.400	0.250	0.250	N/A
Impervious Abstraction (in)	0.10	0.10	0.10	0.50
Pervious Abstraction (in)	0.25	0.25	0.25	N/A
Percent Routed to Pervious	80.0%	34.3%	10.0%	0.0%

Impervious areas were estimated using a generated GIS layer that combined roads, building footprints, open water and wetlands. The layer was joined with the HU layer, and impervious percent was calculated based on the area of impervious surface that intersects each HU. An additional 5% was added to account for additional impervious surfaces like driveways, patios, and pools.

2.2.4 Topography and Survey

Topographic data are used to define hydrologic boundaries, overland flow slopes, channel floodplain geometry, critical flood elevations, stage-area relationships, and inundation mapping. The area in the pilot area is low-lying with relatively small elevation change and slope. Most of the flow drains into Coquina Ditch due to stormwater infrastructure directing pipes to outfall into the ditch. Topography for the pilot area is shown in **Figure 2-2**.

The 2013 Light Detection and Ranging (LiDAR) elevation dataset from the St. Johns County GIS Data Depot is used within the City area. Vertical accuracy of the bare earth LiDAR is +/- 0.23-ft

RMSE for unobscured ground points. The accuracy assessment is performed using a standard method to compute the root mean square error (RMSE) based on a triangular irregular network (TIN) comparison of ground control points and filtered LiDAR data points. Filtered LiDAR data had vegetation and cultural features removed and by analysis represents bare earth elevations. RMSE is used to compute the vertical accuracy based on methods described by the National Standard for Spatial Data Accuracy (NSSDA). The coastal shoreline has a constant value of -0.6-ft that is statistically derived from the LiDAR point cloud collected within the 2-hour window of mean lower low tide.

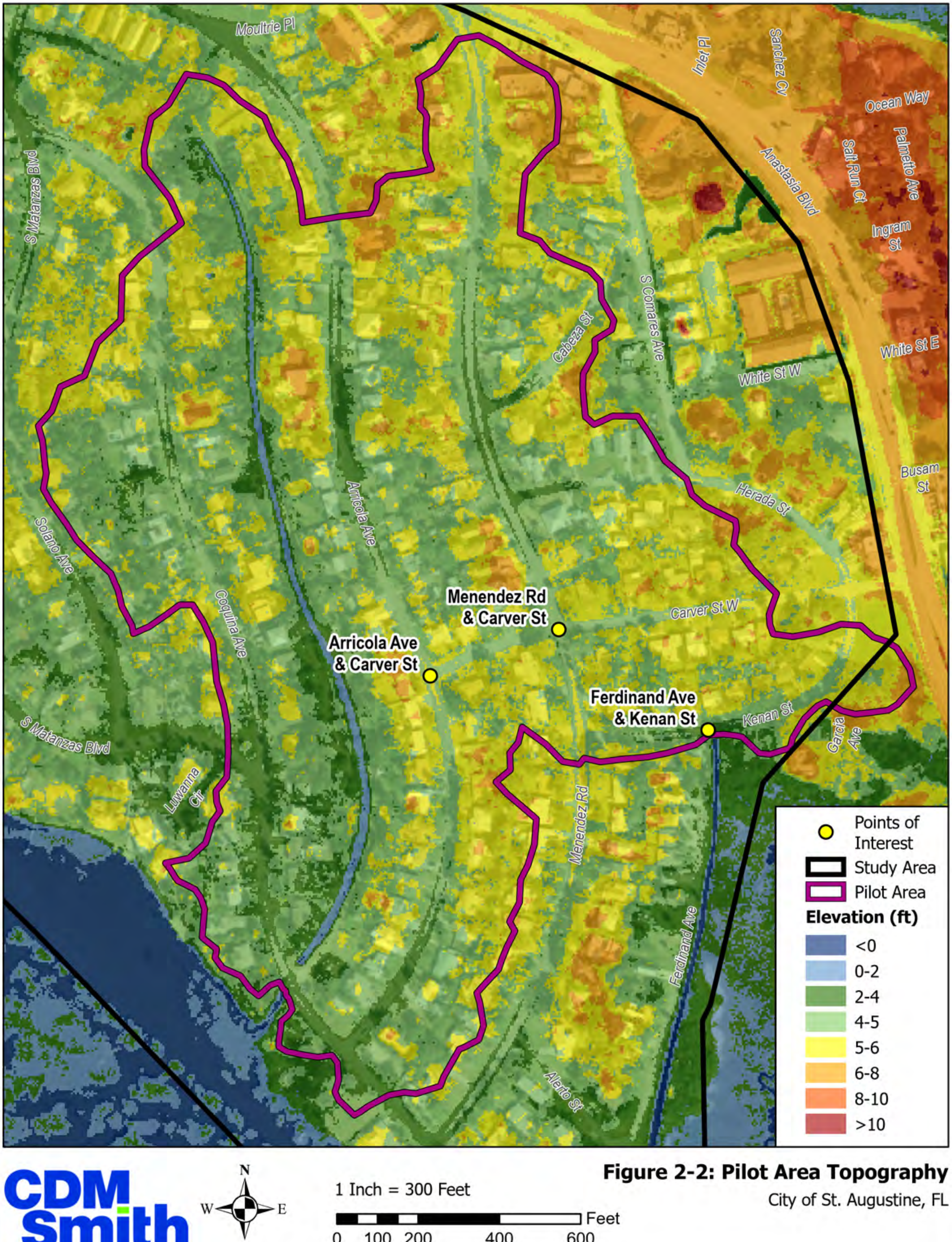

Figure 2-2: Pilot Area Topography

City of St. Augustine, FL

2.2.5 Overland Flow Parameters

SWMM5 calculates overland flow of runoff using the physical parameters input for each HU, and a non-linear reservoir approximation (Manning's equation for a wide, shallow rectangular channel). SWMM5 does not require times of concentration (Tc) to be calculated externally as input. The overland flow hydraulic length (HL) is estimated from the weighted-average travel length to the point of interest. The width of the overland flow path for sheet flow runoff is computed for every HU. To estimate this parameter for each HU, multiple flow path lengths were measured within each HU, and then the total HU area is divided by the average of these flow path lengths.

The slope for each HU is determined by using the flow path lengths and the start and end-point elevations of each flow path determined for the HU. The average slope of the multiple flow paths is selected as representative of the HU.

Overland flow Manning's n values were estimated based on land use as previously discussed in the land use section.

2.3 Hydraulic Model Data

The SWMM5 hydraulic model uses a node/link representation of the stormwater management system. For the pilot model, nodes are located at:

- The ends of culverts.
- At outfall to ditch in the stormwater management system.
- At inlets or manholes in the stormwater management system.
- At locations where the street cross section (for overland flow) changes significantly and/or at street intersections.

The pilot model contains 23 junctions, 16 outfalls, and 43 conduits. Of the conduits, 11 represent closed conduits, 4 represent Coquina Ditch, 3 represent channel overflows, and 25 represent flow along the street. The model schematic is shown in **Figure 2-3**. Model input parameter values for junctions, outfalls, and conduits are listed in **Appendix A**.

2.3.1 Stage-Area-Storage Relationships

Because the pilot area does not consist of any ponds, no storage nodes are applied in the pilot model. To account for storage in the model, conduits representing the street cross sections and ditch were used instead. To provide a better accounting of storage, cross sections for the conduits were drawn from one end of the HU to the other, perpendicular to the conduit. Available LiDAR data for the area were used to draw out the cross sections. Nodes were added at locations where the cross-section changes significantly. To retain the flooding volume in the model for all pipe, channel, and overland flow conduits to maintain numerical continuity, the rims were raised above street level and therefore do not represent actual ground elevations. To avoid double-counting storage, the length of these street conduits was adjusted to prevent overlaps.

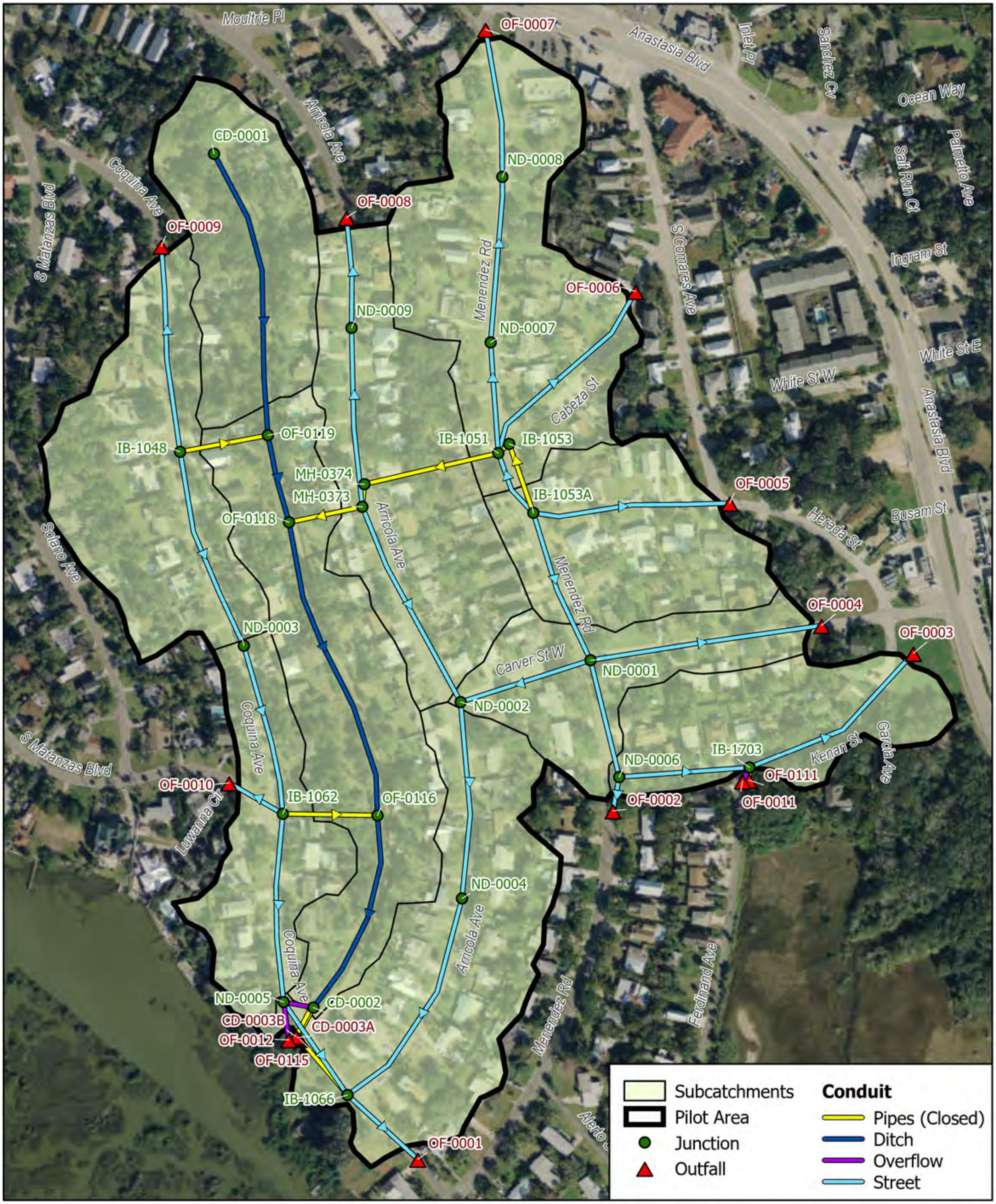

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Figure 2-3: Existing Condition Model Schematic

City of St. Augustine, FL

2.3.2 Conduits and Structures

Hydraulic data for culverts, storm sewers, and channel cross sections were obtained from existing site-specific survey, stormwater management system databases, and as-built drawings. Data collected include elevation, length, geometry, surface roughness, local loss characteristics, and other pertinent features. The infrastructure location, size, and length were input into the stormwater model in their equivalent form. Closed conduit and culvert characteristics include length, slope (upstream and downstream invert elevations), width and depth, Manning's roughness coefficient, and inlet and outlet loss coefficients.

Physical characteristics of the canals or other open channel conveyances in the study area include length, slope (upstream and downstream invert elevations), cross-sectional geometry and Manning's n roughness coefficient for channel and overbank. Overflow conduits were added along the roadway to account for open channel flow on the street gutter. Additional overland flow conduits were added to account for culvert related overflows, overflow from street directly to the ditch, and street/gutter overland flows into HUs outside of the study area.

The datum applied in the model is NAVD88. Because GIS data appeared approximately a foot higher than observed, the inverts derived from the GIS were assumed to be NGVD29 and were converted to NAVD88 by subtracting 1.06 feet. Inverts in nodes were set at or lower than the lowest connecting conduit invert, and initial depth was set based on the boundary condition of the model. For closed conduits, entry losses were 0.35 for pipes and 0.50 for culverts. Exit losses are 0.25 for pipes and 1.0 at outfalls. Average losses were 0.50 at locations where the pipe bends 90 degrees downstream.

2.3.3 Boundary Condition

Hydraulic boundary conditions are needed in order to simulate the tailwater effects on Coquina Ditch. Coastal evaluations consider stillwater conditions that account for surge conditions and represent cases with lower occurrence, such as the 10-, 25-, 50-, and 100-year (i.e., the 10-percent, 4-percent, 2-percent, and 1-percent annual chance) recurrence intervals. For the pilot model, the 1-year stillwater elevation was considered for all three rainfall events. In addition to the outfalls, initial depths within Coquina Ditch and the pipes junctions are also set based on the stillwater elevation.

CDM Smith considered these stillwater elevations for the areas along the Matanzas River, as published by FEMA in the 2016 Preliminary Flood Insurance Study (FIS). By using the predicted x-percent annual chance stillwater elevations and utilizing least square regression using a power curve, the present day 1-year (100-percent chance) stillwater elevation is estimated to be 2.9 ft NAVD88. The value is slightly higher than the mean higher-high water level (MHHW), which is 2.0 ft NAVD88 at St. Augustine Beach. The FEMA FIS stillwater elevation predictions are based on recent advances in storm surge modeling. Additional documentation regarding the 2016 Preliminary FEMA FIS are found on the FEMA Map Service Center website for St. Johns County, FL. Sea level rise is currently not considered for the pilot model; however the study evaluated a tidal flood protection barrier at 7 feet NAVD88 around the perimeter of the study area.

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Section 3

Existing Condition Model Results

The pilot model is applied to 24-hour duration design storms with return periods of 5-year, 25-year, and 100-year. These design storms were evaluated with the downstream boundary condition estimated at 1-year stillwater of 2.9 feet. The model is later adjusted for several combinations of potential improvement projects and compared to the inundation for the same design storms and boundary conditions.

3.1 Peak Stages

Design storm model results for junctions in the pilot model are summarized in **Table 3-1**. Detailed model results at every junctions and conduit can be found in **Appendix B**.

Table 3-1: Existing Condition Peak Stages

HU	Junction	5-Year Stage (ft NAVD88)	25-Year Stage (ft NAVD88)	100-Year Stage (ft NAVD88)
CD-01	OF-0116	3.4	3.9	4.1
CD-02	IB-1062	3.5	3.9	4.1
CD-03	MH-0373	3.9	4.5	4.8
CD-04	IB-1051	4.3	4.8	5.1
CD-05	IB-1048	3.8	4.5	4.8
CD-06	CD-0001	3.5	4.0	4.3
CD-07	ND-0001	4.8	5.0	5.1
CD-08	IB-1053A	4.3	4.9	5.1
FD-01	IB-1703	3.5	4.1	4.3
QC-01	IB-1066	3.3	3.8	4.1

3.2 Inundation Mapping

Figures 3-1 through 3-3 show inundation maps for the pilot area for the three precipitation-based design storms with the 1-year stillwater elevation and existing stormwater conveyance system. These maps show flooding driven primarily by limitations of capacity in the stormwater conveyance system.

Inundation maps were created in ArcGIS by assigning the event-specific peak stage to the spatial extent of a HU, converting the peak stage of the HU to a raster format, and subtracting the ground surface (LiDAR topography) to develop a new raster layer showing the flood depth above existing ground surface. The assumption with this flood depth visualization methodology is that the peak stage affects the entire HU uniformly, which in reality is not likely the case. However, this approach approximates the flooding extent given the level of detail and analysis. To improve the visualization of the rasters, the model HUs were subdivided and additional nodes in the models that were not associated with the model HU were associated with these subdivided HU.

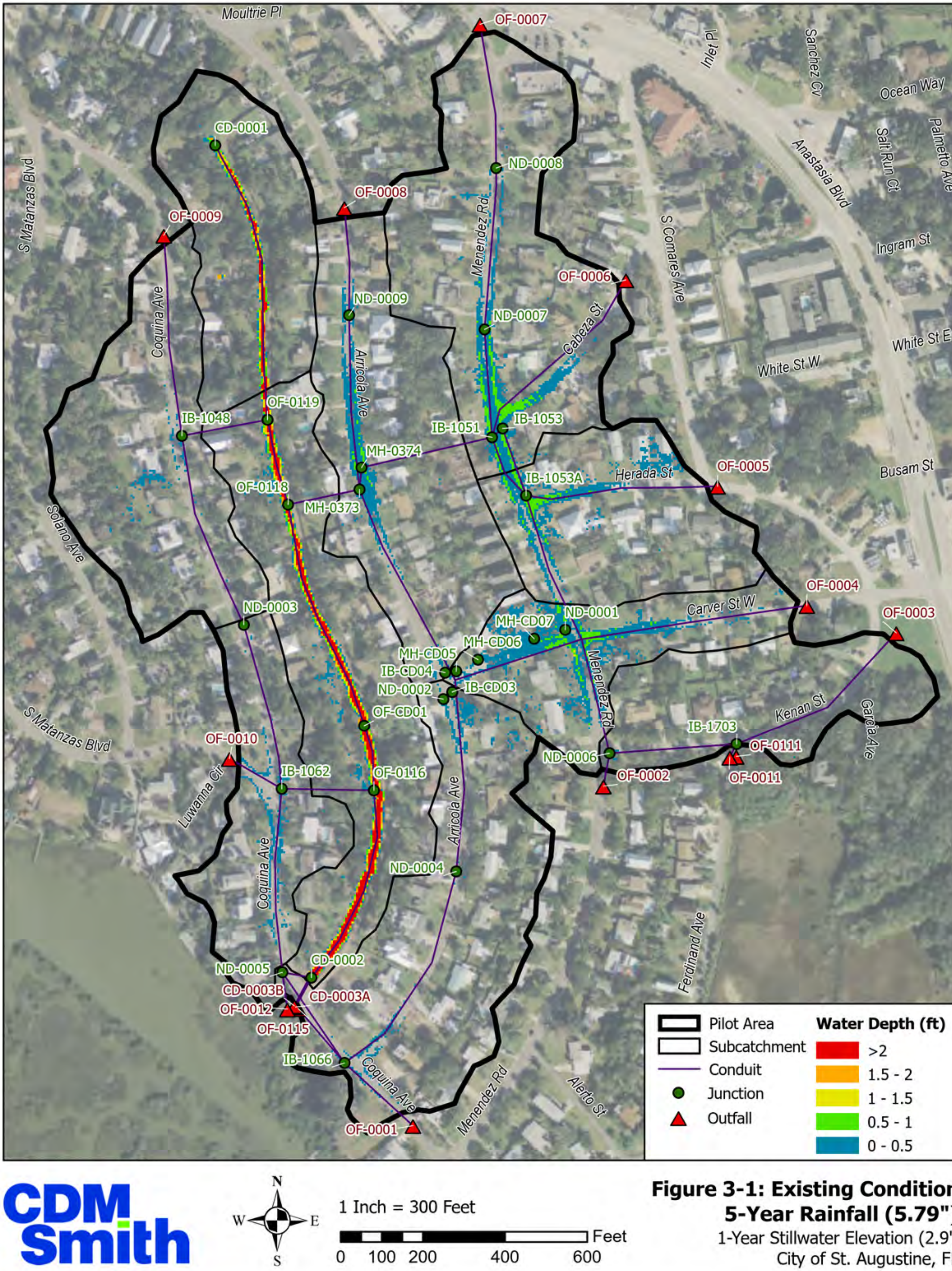

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Figure 3-1: Existing Condition
5-Year Rainfall (5.79")
1-Year Stillwater Elevation (2.9')
City of St. Augustine, FL

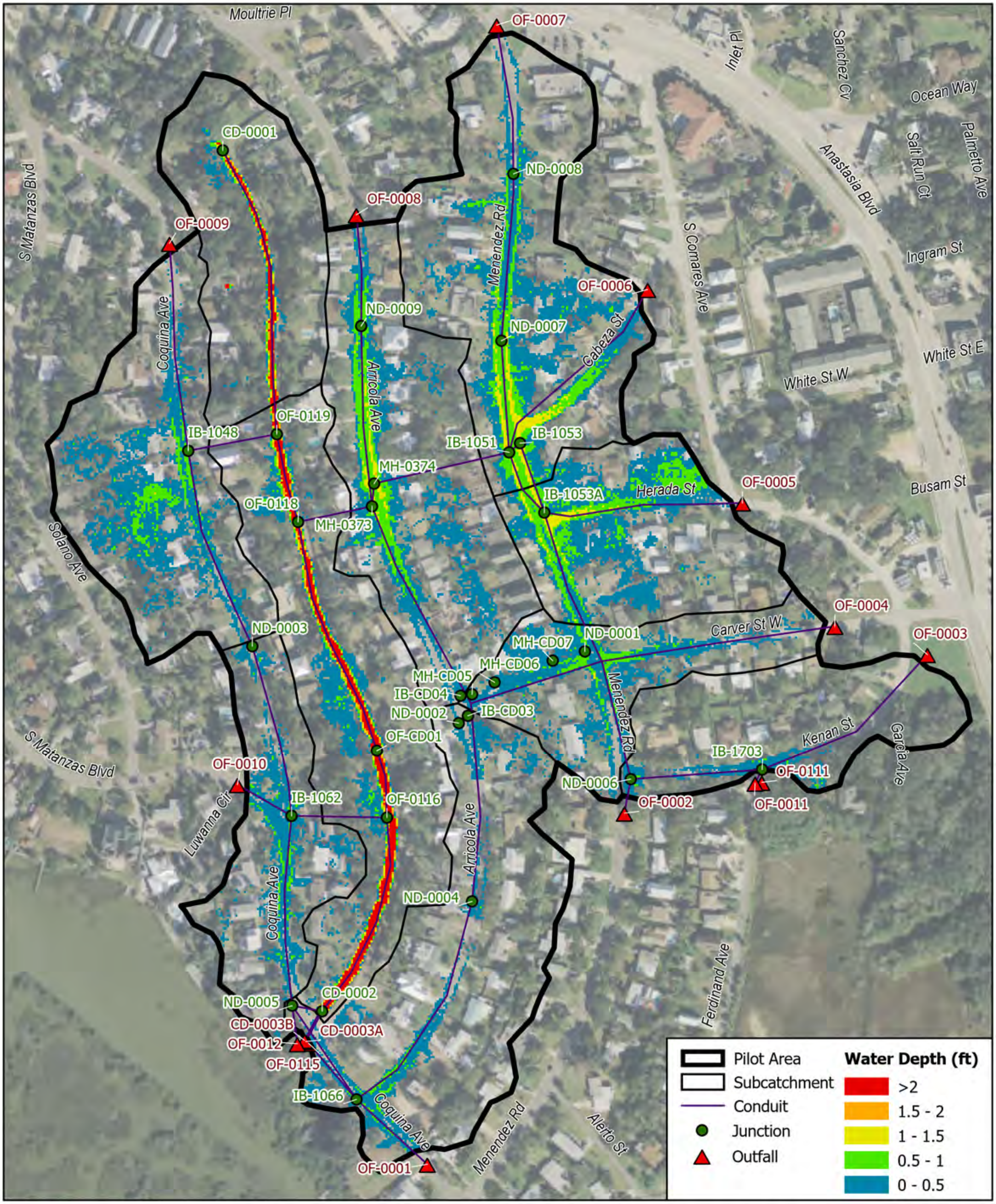

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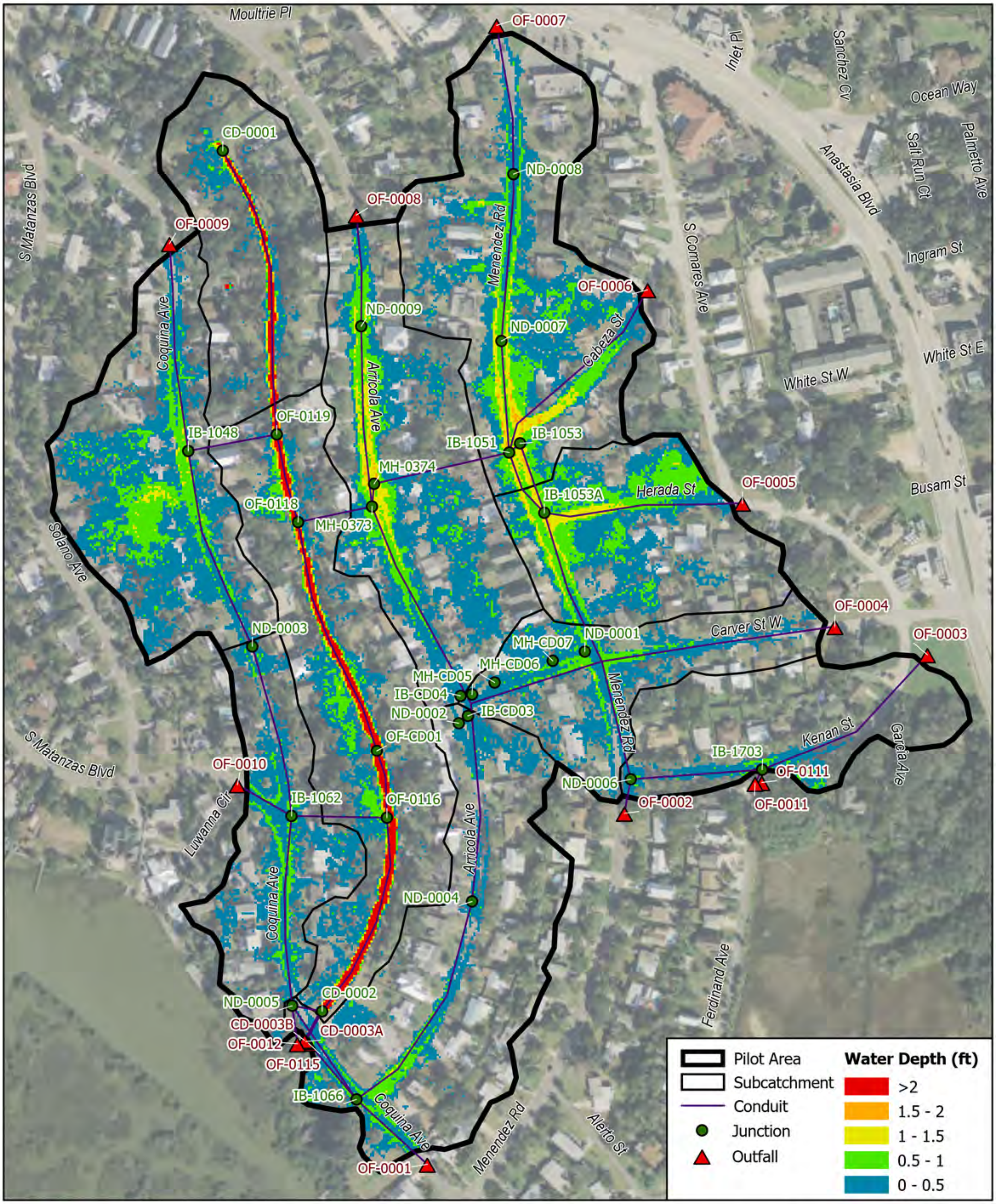
Figure 3-2: Existing Condition 25-Year Rainfall (8.90")

1-Year Stillwater Elevation (2.9')

City of St. Augustine, FL



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N W E S

1 Inch = 300 Feet

Feet
0 100 200 400 600

Figure 3-3: Existing Condition 100-Year Rainfall (12.40")

1-Year Stillwater Elevation (2.9')

City of St. Augustine, FL

Section 4

Mitigation Strategies

CDM Smith, in conjunction with the City, considered several different flood mitigation improvement projects that will meet the level of service (LOS) for the neighborhood. The level of service was developed based on the results of the pilot area and the current capacity of the stormwater infrastructure. CDM Smith proposes the following level of service goals:

- Local roads shall be passable for the 5-year/24-hour design storm (5.79 inches). Proposed future projects should aim to keep flood levels below the crown of the roadway to allow for vehicle travel. Crown elevation was estimated using the LiDAR topographic data.
- Structures shall not flood up to the 100-year/24-hour design storm (12.4 inches). In order to assess this goal, it is necessary to determine what the lowest floor elevation of each structure in the project area is. Because there is no comprehensive survey data done to measure actual finished floor elevation for every structure, an estimate was done based on the existing elevation certificate and LiDAR data, to measure the average grade adjacent to the structure. The assumption is very conservative since most structures are at least elevated 1-foot above grade instead of flush with grade.
- Future projects shall be assessed based on a design tidal condition of 2.9 ft NAVD88. This value corresponds to the 1-year still water elevation described previously. By considering this condition, the City can implement projects that will be designed to operate under normal conditions, but also conditions up to the 1-year tailwater.
- At higher tidal conditions, additional mitigation strategies will be required. These strategies are out of scope for the current pilot project but will be briefly mentioned.

Two alternatives were developed to meet the two level of service requirements. The alternative to meet the 100-year level of service builds upon the requirements for meeting the 5-year level of service.

The projects required to meet a 5-year level of service, known as Mitigation Alternative #1 are as follows:

- Upsize Coquina Ditch culvert outfall crossing Coquina Avenue from two-barrel 36-inch to two-barrel 48-inch and install two tidal check valves.
- Regrade Coquina Ditch to 10 feet wide bottom with 4:1 horizontal to vertical slope.
- Construct Coquina Ditch storm sewer improvements based on plan set developed by Applied Technology & Management, Inc., dated November 2016
- Upgrade 12 inlets to FDOT Type 2 inlets.

- Regrade intersections in neighborhood to raise crown elevation and remove gutter crossing the intersection where stormwater inlets exist or will be constructed.

The projects required to meet the 100-year level of service, known as Mitigation Alternative #2, include those for the 5-year LOS plus the following:

- Dredge Coquina Ditch 1 ft down with bottom width expanded to 20 feet with 4:1 horizontal to vertical slope.
- Upsize all pipes that enter the ditch, including those that are part of the Coquina Ditch storm sewer improvements.

The individual mitigation strategies will be further discussed in the following sections.

4.1 Mitigation Alternative #1

Mitigation Alternative #1 consists of strategies required to meet the 5-year level of service as discussed in the previous section. **Figure 4-2** summarizes the upgrades needed to meet the 5-year level of service. **Appendix A** summarizes the model input parameter values specified for the Mitigation Alternative #1 model. Additional junction and conduits are added for new pipe projects, while attributes associated with the existing conditions model were modified to reflect pipe upgrades and Coquina Ditch regrading.

4.1.1 Coquina Ditch Storm Sewer Improvements

The project is based on plans dated November 2016. One portion of the plan is already constructed: the pipe segment along Menendez Road from Herada Street to Cabeza Street. The remaining segment of pipe from the Carver Street and Menendez Road intersection to Coquina Ditch was not constructed but is proposed in the mitigation plan to alleviate flooding to the north and flooding at the Carver Street and Menendez Road intersection.

The proposed pipes along Carver Street from Menendez Road to Arricola Avenue is 357 linear feet (LF) of 14-inch tall by 23-inch wide reinforced concrete elliptical pipe. From Arricola Avenue to the Coquina Ditch, the pipes consist of 215 LF of 19-inch tall by 30-inch wide reinforced concrete elliptical pipe. The pipe utilizes a 15 feet proposed drainage easement to outfall to Coquina Ditch.

4.1.2 Coquina Ditch Regrading

To provide additional capacity for the ditch to convey flow, a slight regrading of the ditch is proposed for Mitigation Alternative #1. The ditch will be regraded to allow for a consistent bottom width of 10 feet with a side slope of 4 feet horizontal to 1 feet vertical. The side slope is the maximum allowed under St. Johns River Water Management District (SJRWMD) criteria. Assuming a 5-year maximum water depth for the ditch under existing conditions, regrading the ditch increases the storage volume from 87,000 cubic feet (2.0 acre-feet) to 119,000 cubic feet (2.7 acre-feet) The ditch bottom and slopes should be cleared to maintain a lower roughness coefficient. **Figure 4-1** shows the existing and proposed cross section of the ditch.

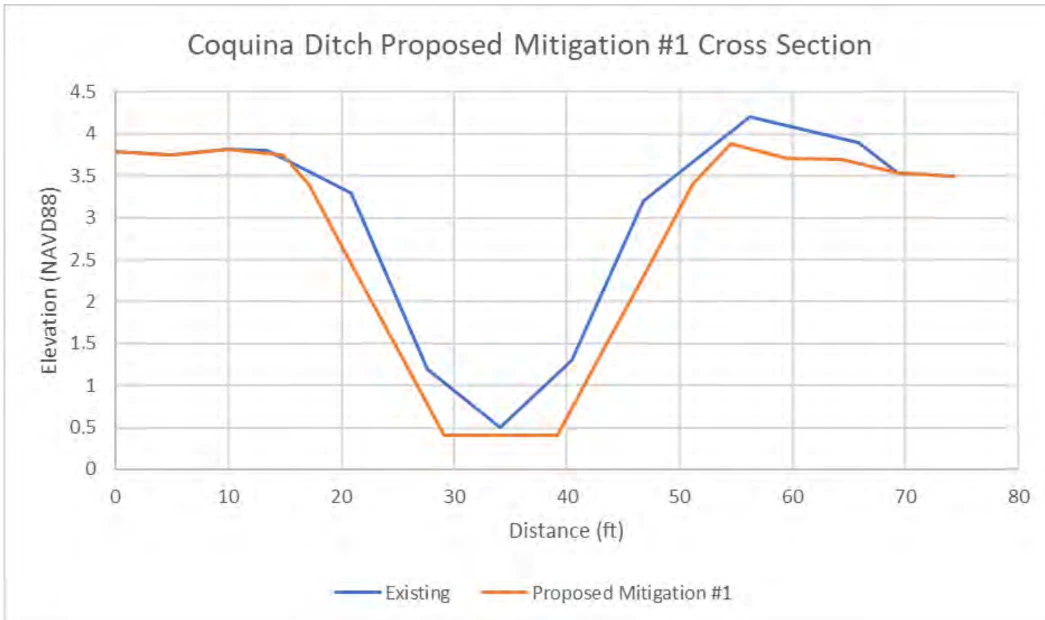


Figure 4-1: Coquina Ditch Mitigation #1 Cross Section

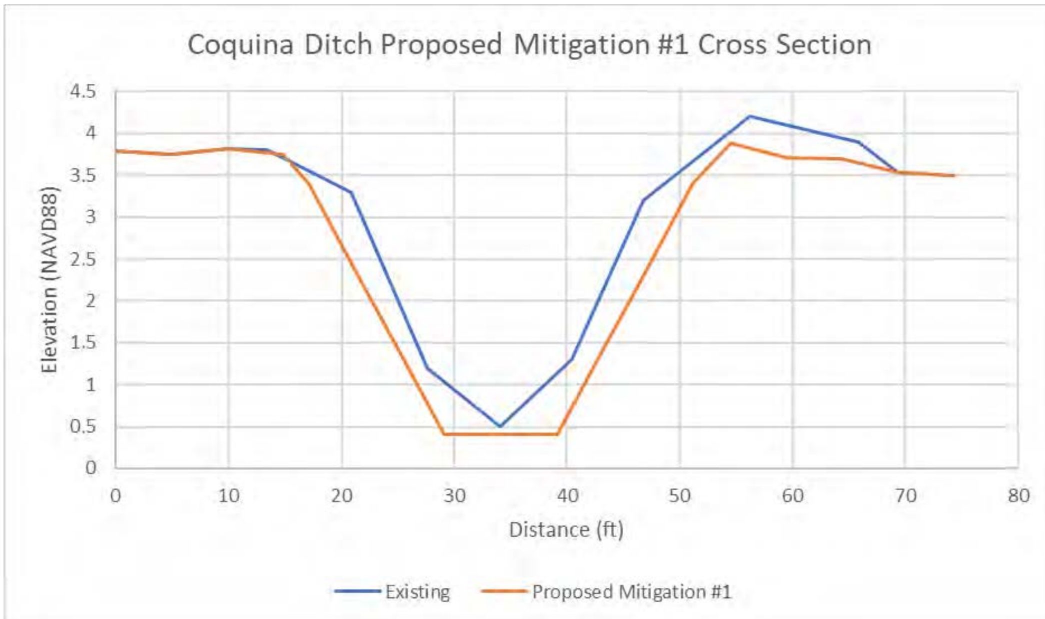
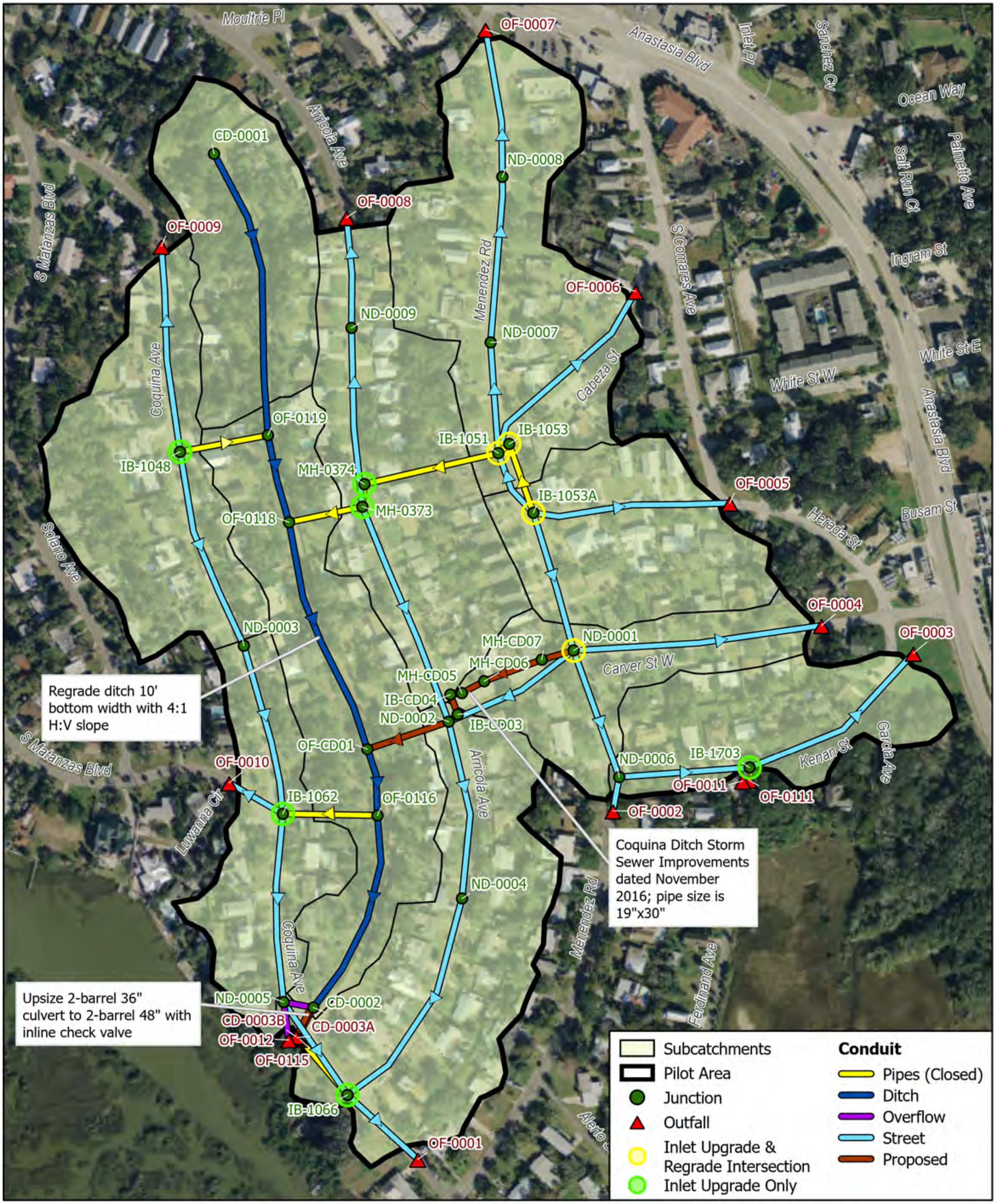


Figure 4-1: Coquina Ditch Mitigation #1 Cross Section



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N
W E
S

1 Inch = 300 Feet

0 100 200 400 600 Feet

Figure 4-2: Mitigation Alternative #1 Model Schematic

City of St. Augustine, FL

4.1.3 Coquina Ditch Culvert

During the 5-year existing event, the head loss at the culvert can exceed 0.4 feet. To reduce the head loss, the culverts should be upsized from a twin-barrel 36-inch pipe to a twin-barrel 48-inch pipe. In order to prevent tidal flow into Coquina Ditch and to provide additional storage in the ditch, two inline check valves are recommended. An inline check valve is designed to prevent backflow coming up into the pipeline; in this case being tidal flow. This type of check valve can be installed within the pipe and were evaluated to have minimal head loss (e.g., Tideflex Checkmate). At the beginning of the storm event, Coquina Ditch would function as a long linear wet detention basin. Once water surface elevation exceeds the 2.9 ft NAVD88 stillwater elevation, the tide check valves open and discharge stormwater to Quarry Creek. By freeing up some storage capacity, peak flooding levels can be lowered. For modeling purposes, initial elevation in Coquina Ditch and at connecting junctions were modeled at 0 ft NAVD88. This appears to be consistent with observed water levels in the ditch during normal conditions. In future sea level rise conditions, a pump station may be required.

4.1.4 Inlet Upgrades

The model does not explicitly consider capacity constraints due to inlets. Based on street observations in the neighborhood, an FDOT Type 9 inlet was evaluated for existing inlet flow capacity. Depending on the percentage of flow that enters the inlet, the inlet capacity is mostly less than 1 cfs. Based on the results of the inflow for a 5-year event with Mitigation Alternative #1 as shown in **Table 4-1**, the number of inlets required would be significantly more than would be realistic at an intersection. As a result, it is recommended that some of the inlets be upgraded to FDOT Type 2 inlets. A schematic of the Type 2 inlet is shown in **Figure 4-3**, and a photo of the concrete top is shown in **Figure 4-4** .

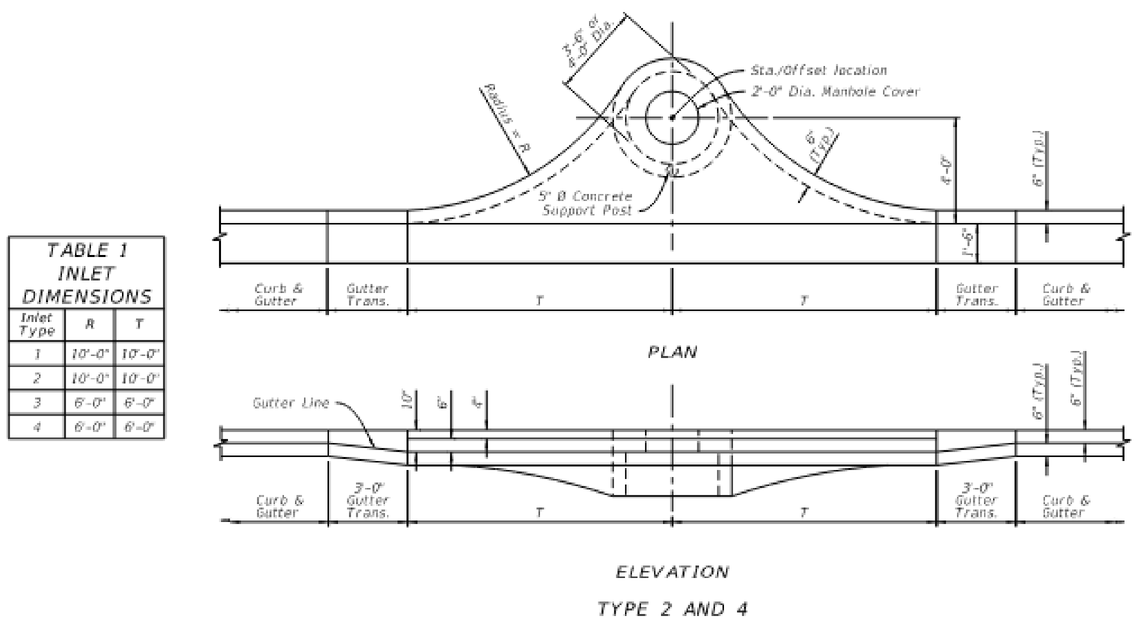

Figure 4-3: FDOT Type 2 Inlet Schematic

Figure 4-4: FDOT Curb Inlet Top (Source: U.S. Concrete Products)

Assuming a typical acceptable spread of 12 feet, and a cross slope of 2%, the total design inflow according to Figure I-17 of the FDOT Drainage Design Guide is 7.3 cfs. Table 4-1 lists for each intersection the minimum number of Type 2 inlets required for Mitigation Alternative #1. It should be noted that the calculation does not consider the capacity of the connecting pipe, many of which are branch lines that are not modeled. Type 2 inlets should first be placed connecting larger pipes or upgraded pipes. A more detailed model would be needed to determine the exact inlets to upgrade at an intersection and any upgrades to the connecting pipe.

Table 4-1: Type 2 Inlets Required for Mitigation Alternative #1

Location	HU	Max Inflow 5-year (cfs)	Number of Type 2 Inlets
Coquina Ave. & S. Matanzas Blvd.	CD-02	6.5	1
Arricola Ave. north of Carver St. W	CD-03	8.6	2
Menendez Rd. & Cabeza St.	CD-04	8.0	2
Coquina Ave. north of S. Matanzas Blvd.	CD-05	8.6	2
Menendez Rd. & Carver St.	CD-07	4.8	1
Menendez Rd. & Herada St.	CD-08	3.6	1
Kenan St. & Ferdinand Ave.	FD-01	6.6	1
Coquina Ave. & Arricola Ave.	QC-01	8.6	2

4.1.5 Regrade Intersections

With the Coquina Ditch storm sewer improvements incorporated, three intersections can be regraded to eliminate gutters that cross the side street. The intersections are Menendez Road and Cabeza Street; Menendez Road and Herada Street; and Menendez Road and Carver Street. The crown of the road along the side streets at the three intersections can be regraded to line up with the crown at Menendez Street, allowing for the side streets to remain passable during a 5-year rainfall event. Regrading only to remove the gutter on the side street will not increase the overall level of flooding in the neighborhood. **Figure 4-5** shows the topography of the Menendez Road and Carver Street intersection and the proposed changes.

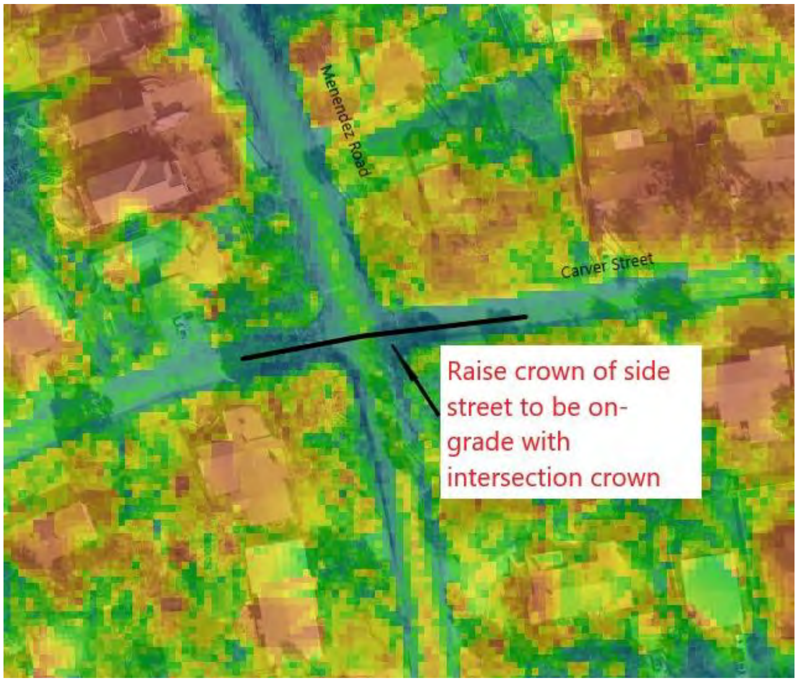

Figure 4-5: Proposed Intersection Regrading at Menendez Rd. and Carver St.

4.1.6 Comparison of Peak Stages

Table 4-2 compares the peak stage for 5-year existing and 5-year with Mitigation Alternative #1, and the crown of the roadway at the intersection (excluding crown at the side streets that are recommended for regrading).

Table 4-2: Peak Stage, 5-Year Existing and 5-Year with Mitigation Alternative #1

HU	Junction	Low Road Crown Elevation (ft NAVD88)	5-Year Existing Stage (ft NAVD88)	5-Year Mitigation #1 Stage (ft NAVD88)
CD-01	OF-0116	N/A	3.4	3.1
CD-02	IB-1062	3.6	3.5	3.3
CD-03	MH-0373	3.7	3.9	3.7
CD-04	IB-1051	4.0	4.3	3.9
CD-05	IB-1048	4.0	3.8	3.6
CD-06	CD-0001	N/A	3.5	3.2
CD-07	ND-0001	4.6	4.8	4.6
CD-08	IB-1053A	4.2	4.3	4.1
FD-01	IB-1703	3.8	3.5	3.5
QC-01	IB-1066	3.6	3.3	3.3

On average, Mitigation Alternative #1 reduces peak stage by 0.2 to 0.3 feet for all areas that drain directly to Coquina Ditch. The peak level of Coquina Ditch is reduced by increasing the size of the outfall culvert to reduce head loss. The flooding at Menendez Avenue and Arricola Avenue north of Carver Street is mitigated largely by the incorporation of the proposed Coquina Ditch storm sewer improvements.

Figure 4-6 summarizes the flood map result for a 5-year rainfall event with Mitigation Project #1. Detailed results for 5-year, 25-year and 100-year rainfall can be found in **Appendix B**, and flood map results for 25-year and 100-year rainfall can be found in **Appendix C**. The overview maps are intended to visually display the impacts of the proposed alternatives and are not used to determine flooding related to individual structures.

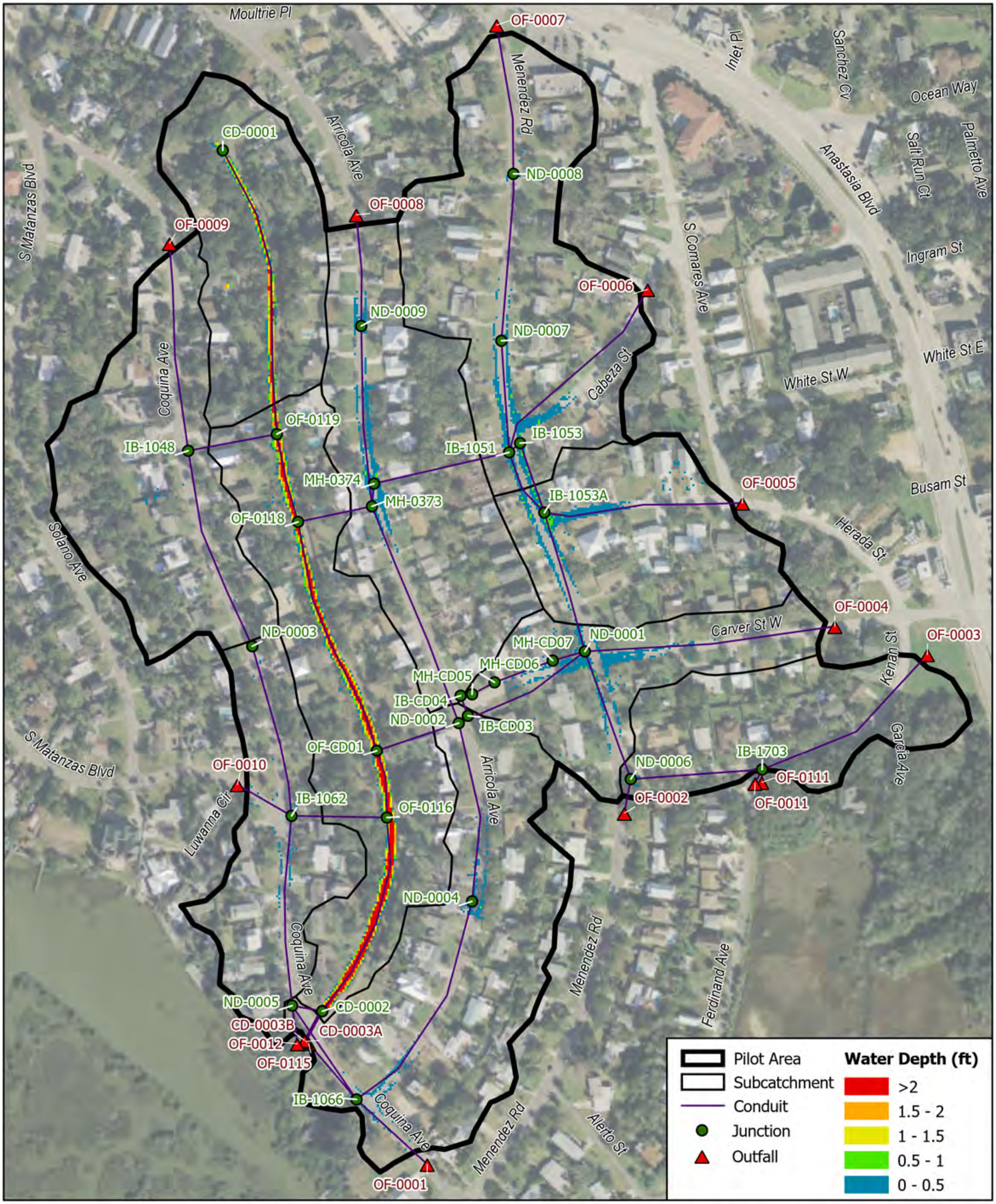

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Figure 4-6: Mitigation Alternative #1
5-Year Rainfall (5.79")
1-Year Stillwater Elevation (2.9')
City of St. Augustine, FL

4.2 Mitigation Alternative #2

Mitigation Alternative #2 consists of strategies required to meet the 100-year level of service as discussed in the previous section. **Figure 4-8** summarizes the upgrades needed to meet the 100-year level of service. **Appendix A** summarizes the model input parameter values specified for the Mitigation Alternative #2 model. The alternative consists of upgrades required under Mitigation Alternative #1 with expansions as discussed in the following sections.

4.2.1 Coquina Ditch Dredging

To increase the capacity for the 100-year event, Coquina Ditch is dredged 1 feet with bottom width expanded to 20 feet. Side slope will remain at design standards of 4 ft horizontal for every 1 ft vertical. The ditch bottom and slopes should be cleared to maintain a lower roughness coefficient. Dredging the ditch allows for the removal of sediments that may have accumulated at the bottom of the ditch, and allows the ditch bottom to align with the inverts of the culvert and outfall pipes that enter the ditch. **Figure 4-7** shows the cross section of the existing and proposed ditch.

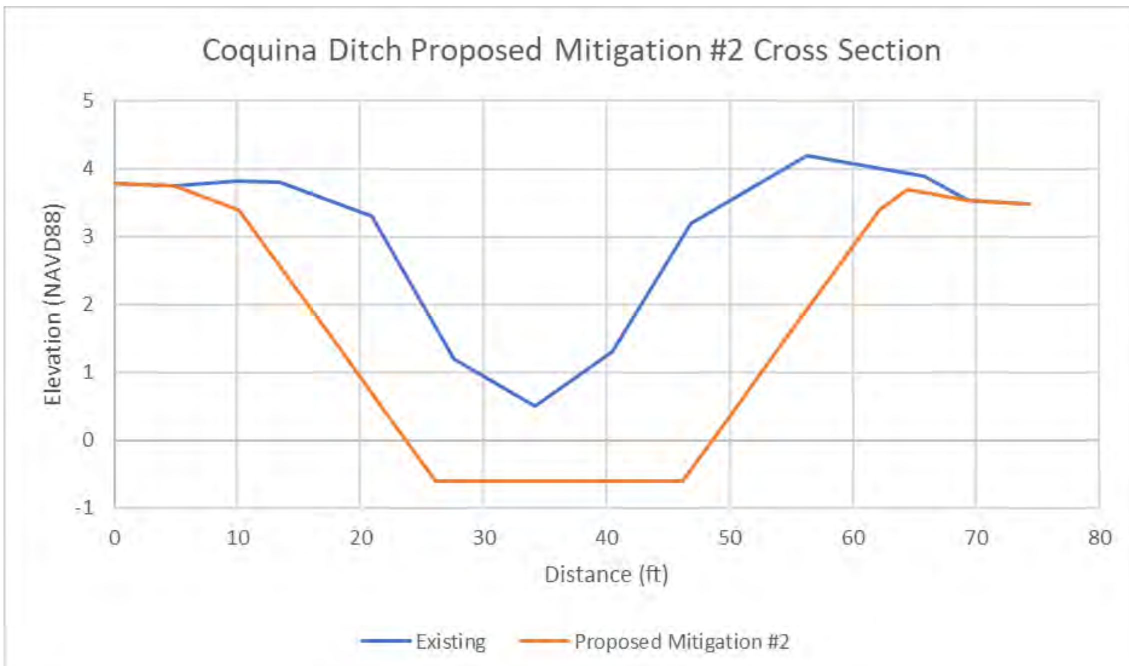

Figure 4-7: Coquina Ditch Mitigation #2 Cross Section

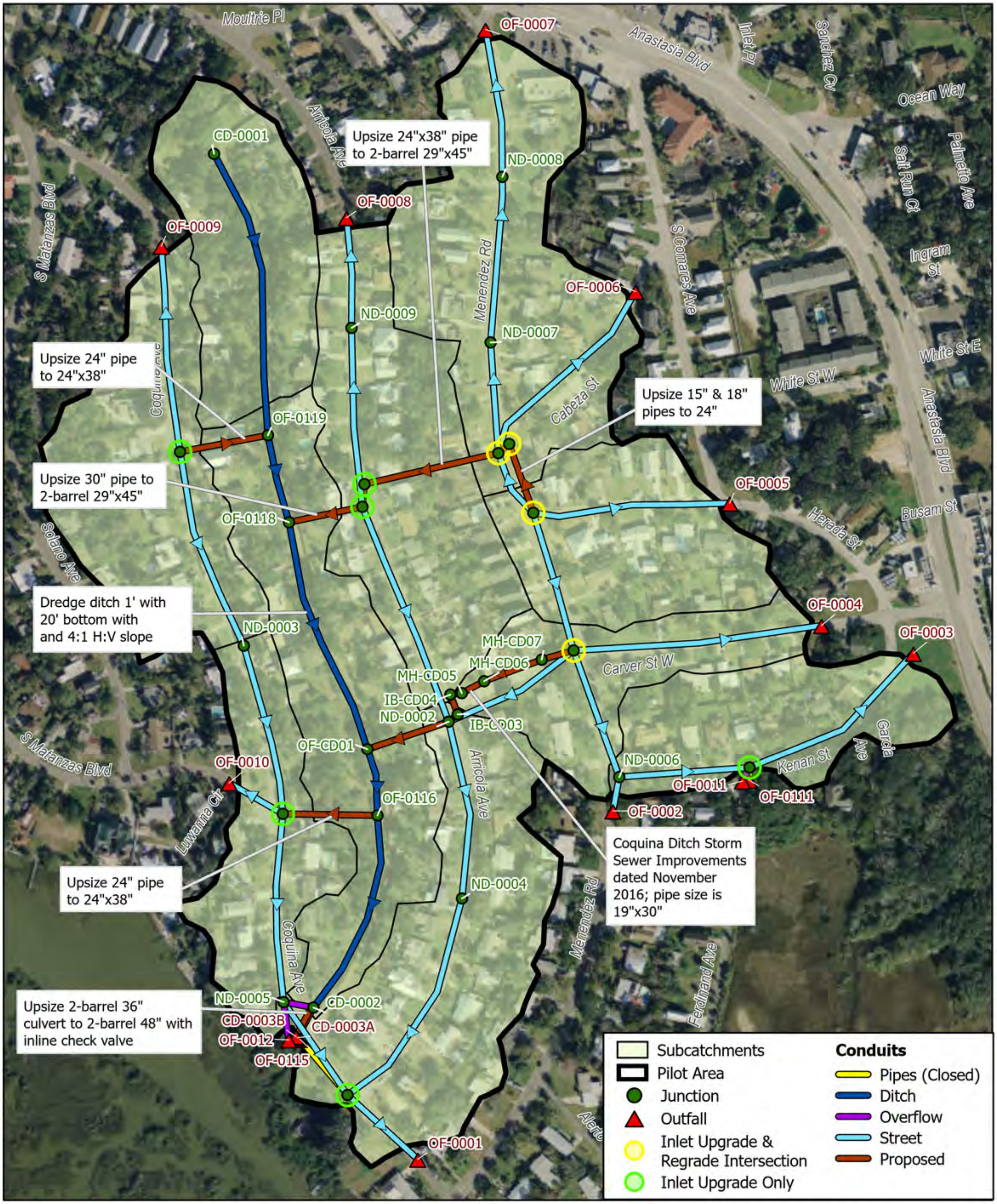

Figure 4-8: Mitigation Alternative #2 Model Schematic

City of St. Augustine, FL

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4.2.2 Pipe Upgrades

Dredging Coquina Ditch and expanding downstream capacity alone does not reduce peak flood stage significantly. Upsizing the pipes connecting to Coquina Ditch will reduce the flooding level at the streets and redirect flow to Coquina Ditch, which when dredged has more capacity to receive flow from the streets. The following is a detailed list of pipe upgrades required as part of Mitigation Alternative #2:

- Pipe connecting from Coquina Avenue and S. Matanzas Boulevard intersection to Coquina Ditch totaling 223 LF should be upsized from a 24-inch circular pipe to a 24-inch tall by 38-inch wide elliptical pipe to reduce potential structural flooding at the intersection.
- Pipe connecting from inlets north of Coquina Avenue and S. Matanzas Boulevard intersection to Coquina Ditch totaling 210 LF should be upsized from a 24-inch circular pipe to a 24-inch tall by 38-inch wide elliptical pipe to reduce flooding in the area.
- Pipe upgrades that are part of the Coquina Ditch Storm Sewer improvements need to be further upsized. The 357 LF of 14-inch tall by 23-inch wide elliptical pipe along Carver Street need to be upgraded to 19-inch tall by 30-inch wide elliptical pipe. The pipe that outfalls to Coquina Ditch remains the same size as under Mitigation Alternative #1.
- Pipes that were already constructed as part of the Coquina Ditch Storm Sewer improvements along Menendez Road from Herada St. to Cabeza Street, totaling 203 LF, need to be upsized to 24-inch circular.
- Existing pipes that connect from Menendez Road and Cabeza Street to Arricola Avenue, totaling 374 LF, need to be upsized from 24-inch high by 38-inch wide elliptical pipe to two-barrel 29-inch high by 45-inch wide elliptical pipes. The significant sizing is needed in part to meaningfully reduce flooding along Menendez Road.
- The pipe downstream of Arricola Avenue to Coquina Ditch, totaling 176 LF, also need to be upsized from 30-inch circular to two-barrel 29-inch tall by 45-inch wide elliptical pipes, to be consistent with upstream pipe sizes and to reduce flooding along both Arricola Avenue and Menendez Road.

4.2.3 Inlet Upgrades

Additional inlet upgrades will be required in some locations to allow the higher flows to reach the upsized pipes. Under a 100-year event, the acceptable depth of street flooding is higher since the level of service only requires the flood level to stay below structure elevation. As a result, the amount of flow for an FDOT Type 2 inlet is likely much higher than the 7.3 cfs assumed with 12 feet spread and cross slope of 2%. Nonetheless, the flow rate will be applied as a conservative estimate on the number of Type 2 inlets that will be necessary at various locations. **Table 4-3** summarizes the number of inlets required under a 100-year rainfall with Mitigation Alternative #2. The large number of inlets needed at Menendez Road and Arricola Avenue is likely acceptable given the connecting upsized pipes are twin-barrel elliptical pipes, each of which can have an inlet.

Table 4-3: Type 2 Inlets Required for Mitigation Alternative #2

Location	HU	Max Inflow (cfs)	Number of Type 2 Inlets
Coquina Ave. & S. Matanzas Blvd.	CD-02	13.6	2
Arricola Ave. north of Carver St. W	CD-03	22.5	4
Menendez Rd. & Cabeza St.	CD-04	34.8	5
Coquina Ave. north of S. Matanzas Blvd.	CD-05	19.0	3
Menendez Rd. & Carver St.	CD-07	9.0	2
Menendez Rd. & Herada St.	CD-08	10.3	2
Kenan St. & Ferdinand Ave.	FD-01	10.2	2
Coquina Ave. & Arricola Ave.	QC-01	14.5	2

4.2.4 Comparison of Peak Stages

Table 4-4 compares the peak stage for 100-year existing and 100-year with Mitigation Alternative #2, and the estimated minimum floor elevation of structures in the vicinity of the intersection (N/A in some locations due to Coquina Ditch HU).

Table 4-4: Peak Stage, 5-Year Existing and 5-Year with Mitigation Alternative #1

HU	Junction	Minimum Structure Elevation (ft NAVD88)	100-Year Existing Stage (ft NAVD88)	100-Year Mitigation #2 Stage (ft NAVD88)
CD-01	OF-0116	N/A	4.1	3.8
CD-02	IB-1062	4.0	4.1	4.0
CD-03	MH-0373	4.5	4.8	4.4
CD-04	IB-1051	4.8	5.1	4.7
CD-05	IB-1048	4.6	4.8	4.5
CD-06	CD-0001	N/A	4.3	3.9
CD-07	ND-0001	5.0	5.1	5.0
CD-08	IB-1053A	4.8	5.1	4.7
FD-01	IB-1703	4.8	4.3	4.3
QC-01	IB-1066	4.6	4.1	4.1

On average, Mitigation Alternative #2 reduces peak stage by 0.2 to 0.3 feet for all drainage area that drains to Coquina Ditch. Reduction of peak stage for subbasins west of the ditch is smaller than those on the subbasin east of the ditch since more pipe upgrades were needed to reduce peak stage below structure elevation. Peak stage along Coquina Ditch are within the top of bank elevations.

Figure 4-9 summarizes the flood map result for a 100-year rainfall event with Mitigation Project #2. Detailed results for 5-year, 25-year and 100-year rainfall can be found in the **Appendix B**, and figures for 5-year and 25-year rainfall can be found in **Appendix C**. The overview maps are intended to visually display the impacts of the proposed alternatives and are not used to determine flooding related to individual structures.

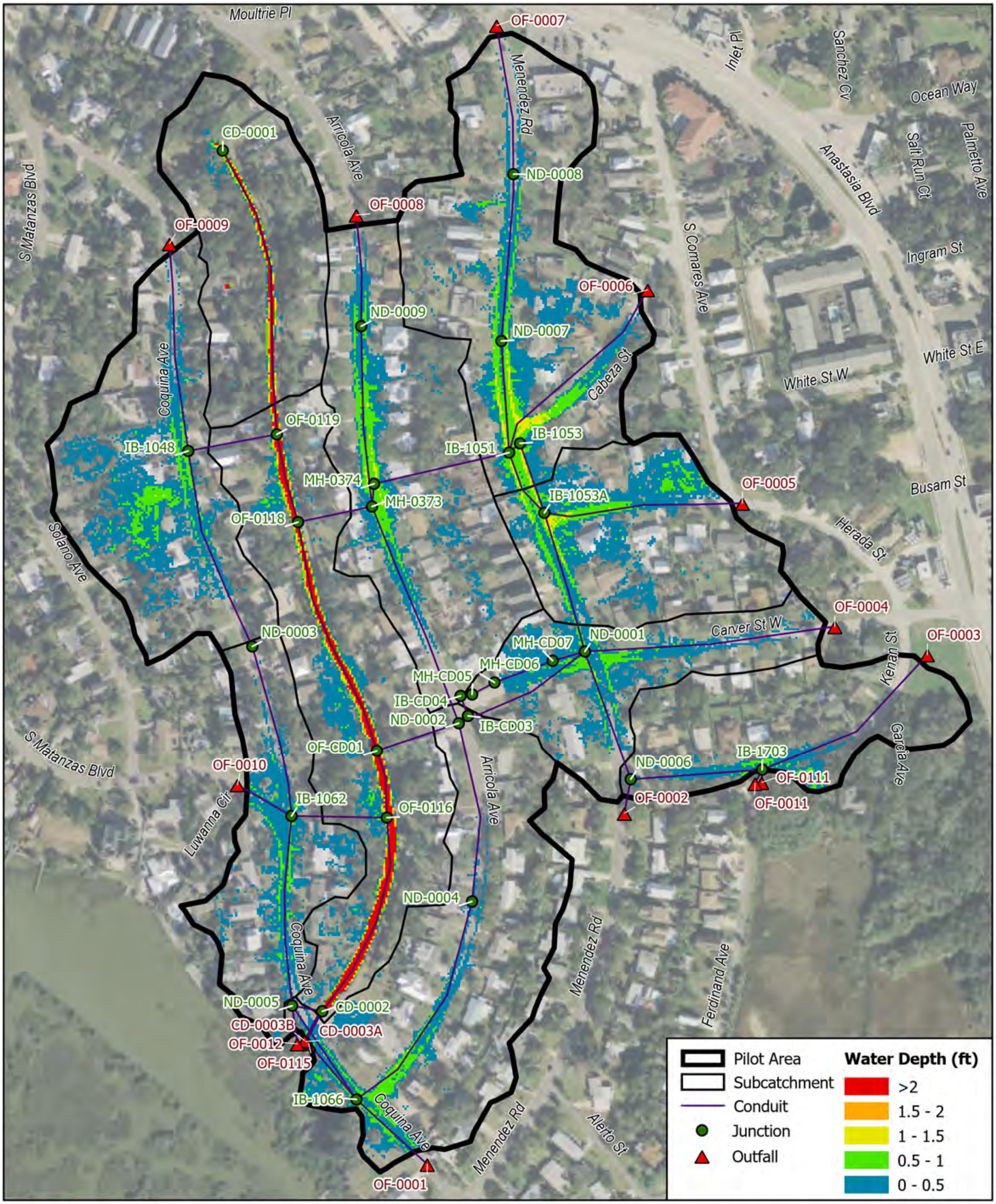

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Figure 4-9: Mitigation Alternative #2
100-Year Rainfall (12.40")
1-Year Stillwater Elevation (2.9')
City of St. Augustine, FL

4.3 Conceptual Capital Cost Estimates

The project capital cost depends on the alternative selected, with Mitigation Alternative #1 costing less because fewer upgrades are necessary to meet the 5-year level of service.

For Mitigation Alternative #1, the estimated cost breakdown is as follow:

- Coquina Ditch storm sewer improvements: $95,600
- Coquina Ditch regrading: $17,800
- Coquina Ditch culvert upsize: $111,100
- Inlet upgrades: $92,400
- Intersection regrading: $76,700
- Other costs, including mobilization, traffic, and dewatering: $54,800
- Contingencies (30% of above costs): $134,800
- Engineering, Permitting & Survey (20% of cost including contingencies): $116,600

Total Conceptual Capital Cost: $699,500

For Mitigation Alternative #2, the estimated cost breakdown is as follow:

- Coquina Ditch storm sewer improvements (including larger pipes): $102,100
- Pipe upsizes to existing pipes: $349,700
- Coquina Ditch dredging: $97,800
- Coquina Ditch culvert upsize: $111,100
- Inlet upgrades: $169,400
- Intersection regrading: $76,700
- Other costs, including mobilization, traffic, and dewatering: $124,500
- Contingencies (30% of above costs): $309,400
- Engineering, Permitting & Survey (20% of cost including contingencies): $268,100

Total Conceptual Capital Cost: $1,608,800

The cost is a conceptual level cost estimate with a 30% contingency to account for elements that are not accounted for yet in the cost estimate. An additional 20% is added to account for engineering, permitting, and survey. The cost estimate also does not account for additional proposals like pumps and seawall to handle tidal surges and sea level rise. A more detailed breakdown of the cost estimate can be found in **Appendix D**.

4.4 Additional Mitigation Strategies

The mitigation alternatives described manage rainfall related flooding for a 1-year stillwater tidal elevation of up to 2.9 ft NAVD88, but these improvements do not account for higher surge conditions or sea level rise. Under sea level rise conditions, the water level will begin to exceed the street level at Coquina Avenue and flooding will result from the higher boundary conditions. As a result, the mitigation alternatives alone will not be sufficient to meet the design level of service. Addition mitigation strategies are discussed in the sections below.

4.4.1 Seawalls

Current FEMA 100-year Base Flood Elevation (BFE) at South Davis Shores is 7 ft NAVD88. To prevent that level from flooding inland, a combination of raised perimeter roads, seawall, and/or berm would be necessary. A short concrete, or similar, wall or reinforced berm would need to reach at least 7 ft NAVD88 in top elevation and be continuous along the entire shoreline. As the wall or berm will be on private properties, it must tie in with adjacent properties to provide the same level of protection along the entire shoreline. Based on land elevations ranging from 1 to 3 ft NAVD88, the wall or equivalent would need to be approximately 4 to 6 feet tall depending on the location along the shoreline. A typical concrete seawall, as seen elsewhere in the City would be a likely option, as would a reinforced berm. The berm could be reinforced with earth, rock, or geomembrane, but it must be reasonably impermeable and resistant to significant wave actions. In the event the seawall is overtopped, additional infrastructure projects like pump station may be necessary to allow for faster recovery time and to minimize the amount of time streets and yards are flooded.

There is approximately 9,050 linear feet (LF) of shoreline to protect along the South Davis Shores neighborhood. The shoreline in question lies primarily on the east banks of Matanzas River and Quarry Creek, as shown in **Figure 4-10**. Construction estimates will vary, though based on seawall projects recently completed in Fort Lauderdale, the construction cost will range from $650 to $2,000 per linear foot depending on depth and location. Engineering and permitting would require another 20% of the cost, with each property potentially counting as a separate job, depending on permitting requirements. Utilizing these cost projections, the total estimated cost of an approximately 9,050 LF seawall or berm would range from $5.9 million to $18.1 million with engineering and permitting costing between $1.2 million and $3.6 million. Ordinances may be enacted to require property owners to implement a seawall and specify minimum standards for seawall dimensions to ensure the seawall is continuous and provides the desired level of protection.

4.4.2 Pump Station

Higher tailwater or sea level rise conditions exceeding 3.7 feet NAVD88 will prevent the proposed Coquina Ditch culvert tide check valves from opening since an upstream head gradient is required to open the valves. To allow for the Coquina Ditch to drain during a higher tailwater event, a pump station will be necessary in addition to the proposed seawall. Under Mitigation Alternative #2, the maximum combined flow from the two Coquina Ditch culverts is approximately 122 cfs during a 100-year rainfall event. In order to keep the peak flood stages the same under a higher tailwater condition, the pump station must have a capacity of at least 125 cfs. The pump station would also serve to quickly drain the neighborhood if overtopping of the seawall does occur. A pump station of this size would cost somewhere in the $1 million to $2 million range.

Figure 4-10: Proposed Extent of Seawall

City of St. Augustine, FL

4.4.3 Smart Valves

The current mitigation plan proposes an in-line check valve for the Coquina Ditch outfalls. An in-line check valve operates by opening when the upstream water level is higher than downstream. This allows flow from the ditch to reach the outfall but does not allow tidal flow into the ditch. As a result, the ditch will not experience tidal fluctuations, which could result in the conversion to a freshwater system. A smart tide valve would offer flood control benefits while allowing regular tidal flows during normal operation. A smart valve can be installed in one of the two culverts at Coquina Ditch outfall.

A smart valve would utilize a pinch valve or any compatible valve that can be operated pneumatically to open and close the valve. The valve would be connected to a telemetry system which would measure water levels at both ends of the culverts in real time. The telemetry system would offer remote access and control of the valve via a cloud-based system. Under normal conditions, the valve will remain open during both high tide and low tide scenarios. If storm surge conditions and/or major rainfall events are forecasted, the valve would be closed at low tide to prevent tidal flow from entering the ditch. The valve can then be reopened at the point the upstream water level exceeds the downstream water level.

4.4.4 Upgrades Outside of Pilot Area

The pilot model assumed that the downstream boundary condition of the outfall at Ferdinand Avenue and Kenan Street is the same as the Coquina Ditch culvert outfall. The model does not consider the impacts of the channel along Ferdinand Avenue, or the Hermosa outfall and the Coquina/Old Quarry Road outfall, which are culverts that cross Coquina Avenue further to the south. In addition, the model does not currently consider any pipe upgrades outside of the Coquina Ditch drainage area. Future modeling efforts will be necessary to determine infrastructure upgrades outside the pilot area, including upgrading pipes and the outfall culverts. A smart valve will likely apply for the Hermosa and Coquina/Old Quarry Road culverts since there are saltwater wetlands upstream of the culvert.

Section 5

Funding Options

CDM Smith was tasked as part of the resiliency study to determine funding options to implement the mitigation plans that were described in the previous sections. The following is a brief description of possible sources of funding, through various federal, state, and local agencies. CDM Smith recommends focusing on the Building Resilient Infrastructure and Communities (BRIC), the Hazard Mitigation Grant Program (HMGP), and the Florida Resilient Coastline Program (FRCP) for sources of funding.

1. **Army Corps of Engineers**

   Under the Continuing Authorities Program (CAP) the Army Corps of Engineers (USACE) can plan, design, and implement certain types of water resources projects. The purpose of the CAP is to plan and implement projects of limited size, cost, and scope. There are nine legislative authorities under the program which can be used for projects such as streambank and shoreline erosion protection of public works: flood control and removal of obstructions, clearing of channels for flood control. Project feasibility studies are federally funded up to $100,000 with remaining costs shared on a 50/50 basis. Costs beyond the feasibility phase are shared as specified in the authorizing legislation.

   https://www.nae.usace.army.mil/Missions/Public-Services/Continuing-Authorities-Program/

2. **Building Resilient Infrastructure and Communities (BRIC)**

   Building Resilient Infrastructure and Communities (BRIC) is a new FEMA program that replaces the existing Pre-Disaster Mitigation (PDM) program. BRIC support states, local communities, tribes and territories in reducing their risks from disasters and natural hazards as they undertake pre-disaster hazard mitigation projects designed to increase resilience and public safety; reduce injuries and loss of life; and reduce damage to property, critical services, facilities, and infrastructure. BRIC is funded on an annual basis based on 6% of FEMA disaster recovery expenditures and is a nationwide competitive grant program for mitigation funding. A cost share is required which is generally 75 percent federal / 25 percent non-federal.

   https://www.fema.gov/grants/mitigation/building-resilient-infrastructure-communities

3. **Community Development Block Grant – Disaster Recovery Program (CDBG-DR)**

   Following a Presidentially declared disaster, Congress may appropriate funds to Housing & Urban Development (HUD) for long-term recovery when there are significant unmet needs. The grants are to help cities, counties, and states recover, especially in low-income areas. Funds are used in impacted and distressed areas for disaster relief, long-term recovery, restoration of infrastructure, housing, and economic revitalization.

https://www.hudexchange.info/programs/cdbg-dr/

4. **Community Development Block Grant – Mitigation Program (CDBG-MIT)**

Assistance for areas impacted by recent disasters to carry out mitigation activities to reduce disaster and natural hazards risks and reduce future losses. The program identifies mitigation activities as those that increase resilience to disasters and reduce or eliminate the long-term risk of loss of life, injury, damage, and loss of property, and suffering and hardship by lessening the impact of future disasters.

https://www.hudexchange.info/programs/cdbg-mit/

5. **Community Disaster Loan (CDL) Program, FEMA**

Following a Presidentially declared disaster, the Community Disaster Loan provides financial support to local governments to provide essential community services when local revenue is sustained at least 5-percent lower than pre-disaster revenue in the current or future fiscal year, impacting the local government's ability to serve its citizens. The Community Disaster Loan Program allows the federal government to support the local government through its post-storm hardship with a loan to continue or expand essential municipal services to meet disaster-related needs, and cannot exceed 25 percent of the local government's annual operating budget or up to $5 million. The deadline to apply for a CDL is determined from the end of the incident period through the end of the following fiscal year. The term of the loan is 5 years but may be extended. The locality must be in a Presidentially declared disaster area and would need to request the loan through the Governor's Authorized Representative.

https://www.fema.gov/assistance/public/nonstate-nonprofit/community-disaster-loan

6. **Flood Mitigation Assistance (FMA) Program**

The Flood Mitigation Assistance (FMA) Program is a competitive grant program that provides funds that can be used for projects that reduce or eliminate the risk of repetitive flood damages to buildings insured under the National Flood Insurance Program. Priority under the program is given to projects that will mitigate flood damages of Severe Repetitive Loss (SRL) and Repetitive Loss (RL) properties. This is a cost share program where federal funding is available for up to 75 percent of the eligible activity costs. However, up to 100 percent of the costs may be provided for SRL properties and up to 90 percent for RL properties.

https://www.fema.gov/grants/mitigation/floods

7. **Hazard Mitigation Grant Program (HMGP)**

Following a Presidentially declared disaster, the Hazard Mitigation Grant Program (HMGP) provides financial support to states, local communities, tribal and territorial governments for rebuilding to reduce future disaster losses in their communities. This is a cost share program where FEMA provides up to 75 percent of the total amount of funds needed for mitigation projects with the remaining 25 percent coming from other sources.

https://www.fema.gov/grants/mitigation/hazard-mitigation

8. **Hurricane Loss Mitigation Program, State of Florida**

With funding provided by the Florida Hurricane Catastrophe Trust Fund, this program provides funding to support programs that improve hurricane preparedness, reduce potential losses in the event of a hurricane , and to provide research and education on how to reduce hurricane losses. Activities funded include promoting property resiliency through retrofits made to residential, commercial and mobile home properties; providing public education and information that assist in determining the best retrofitting options for properties; and the funding of research to support hurricane loss reduction. Projects that have been funded include retrofits, inspections, and construction or modification of building components designed to increase a structure's ability to withstand hurricane-force winds and flooding. The Retrofit Program utilizes the Florida Building Code as its standard for all retrofitting.

https://www.floridadisaster.org/dem/mitigation/hurricane-loss-mitigation-program/

9. **National Flood Insurance Program, Flood Insurance**

The NFIP provides federal flood insurance coverage in communities that participate in the NFIP. Flood insurance is a policy that is separate from other policies, such as a homeowner's policy, and covers buildings, the contents in a building, or both from damages caused by flooding. NFIP flood insurance is available for structures both within and outside of a special flood hazard areas. Structures located in low-to-moderate risk areas may be eligible for the low-cost Preferred Risk Policy. Flood insurance claims are only applicable for loss due to flood. If floods damage a home or business, the NFIP may require the owner to meet certain building requirements to reduce flood damage.

https://www.fema.gov/flood-insurance

10. **National Flood Insurance Program, Increased Cost of Compliance (ICC)**

Following substantial or repetitive damage from a flood, structures may be required to be brought into compliance with a community's floodplain management requirements for new construction. As part of the Standard Flood Insurance Policy, the Increased Cost of Compliance Coverage may be available to bring their structures into compliance with the community's floodplain management ordinance or regulations. Up to $30,000 may be available in instances where a building has damages by flood totaling 50 percent or more of the pre-damaged market value of the home, meeting FEMA's current definition of being Substantially Damaged; or where an NFIP-insured building incurred flood-related damage two or more times over a period of 10 years with the total repairs equaling at least 25 percent of the market value of the home before each event, meeting the current FEMA definition for a Repetitive Loss property. ICC funding is available for four types of post-storm mitigation activities: elevation, floodproofing (for nonresidential structures only), relocation, and demolition.

In some cases, policyholders eligible for ICC funding may also assign their ICC benefits to the local community as a nonfederal match for a community-wide mitigation grant. The community will then assist the individual, using the mitigation grant funding, in paying for the cost, or portion of the cost, to elevate, relocate, or demolish a structure. The mitigation grant funding does not have a $30,000 limit.

https://www.fema.gov/floodplain-management/financial-help/increased-cost-compliance

11. Florida Department of Environmental Protection (FDEP)

The Florida Department of Environmental Protection provides a variety of grants and loans for projects that provide a benefit to the environment and local communities. One of many grants available is the Coastal Partnership Initiative Grant Program (CPI). Projects supported under the CPI grant include those that improve a communities resiliency to coastal hazards.

https://floridadep.gov/sec/sec/content/funding-opportunities

12. Florida Resilient Coastline Program (FRCP)

The Florida Resilient Coastlines Program (FRCP) provides financial assistance to Florida communities for preparing for the current and future effects of rising sea levels, including coastal flooding, erosion and ecosystem changes. To be eligible communities must have a coastal management element in their comprehensive plan. Under the program, Resilience Planning Grants (RPG) and Resilience Implementation Grants (RIGs) are available. The RPG is to promote community resilience planning and the RIG is to assist coastal communities in implementing their adaptation/resilience plans. Grants up to $75,000 are available under the RPG and under the RIG up to $500,000 is made to communities for projects that can be completed in 10 months.

https://floridadep.gov/rcp/florida-resilient-coastlines-program/content/frcp-resilience-grants

13. St. Augustine Stormwater Utility Fee

The stormwater utility fee was established in 1993 to create a dedicated funding source for a long-term plan to reduce flooding and protect water resources within the City. Through the revenue the city has implemented numerous roadway and drainage projects to reduce the impacts of flooding.

https://www.citystaug.com/446/Stormwater-Utility-Fee

14. St. Johns River Water Management District

The St. Johns River Water Management District offers several cost-share programs for projects that provide flood protections and natural systems restoration. Projects must benefit one of the four core missions of the district and not be for operations and maintenance. The program is funded annually and is a cost-shared program.

https://www.sjrwmd.com/localgovernments/funding/

15. Special Assessments

Ad valorem and non-ad valorem assessments can be made on local property tax bills to meet specific public purposes. These may be in the form of a "capital project assessment." Policies which contemplate special assessment in designated areas could be used to help fund specific improvements that aid in adaptation and protection of targeted locations.

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Section 6

Potential Ordinance Policy

The current floodplain management and building code requirements for the City of St. Augustine, are contained in Chapter 8 – Buildings and Building Regulations of the Code of the City of St. Augustine, Florida. These regulations include:

- Adoption of the latest edition of the Florida Building Code, which includes a 1-foot freeboard requirements. The Florida Building Code, 7th Edition became effective December 31, 2020.
- Adoption of the flood load and flood resistant construction requirements of ASCE 24, Flood Resistant Design and Construction, to regulate buildings and structures exempt from the requirements of the Florida Building Code. ASCE 24 also requires freeboard based on the Flood Design Class of a structure.
- Adoption of floodplain management provisions for other development such as fences, walls, sidewalks, driveways, slabs and other development for which specific provisions are not elsewhere specified in Chapter 8 or the Florida Building Code.
- Adoption of a 5-year cumulative provision for determining if a structure is a Substantial Improvement.
- Adopts the latest Flood Insurance Study (FIS) and accompanying Flood Insurance Rate Maps (FIRMs) prepared by FEMA. Extends the applicability of the floodplain management regulations to areas that are near special flood hazard areas shown on the FIRMs but that are below the base flood elevation shown on FIRMs.
- Adopts a requirement that new buildings and structures located in areas outside of special flood hazard areas (Zone X) as shown on the FIRMs have the lowest habitable floor elevated at least 12-inches above the crown of road.

The Building Code Task Force has included recommendations to the City Commission for changes to the code. The recommendations, dated March 8, 2021, are currently being considered for approval by the Planning and Zoning Board. The Task Force was given three specific goals:

1. Goal #1: Protect older homes from the flooding impacts of new home construction.
2. Goal #2: Provide incentives for property owners to use building techniques which do not require land filling for new home construction.
3. Goal #3: Limit the amount of impervious surface that is allowed on residential lots.

The full task force recommendations are found in **Appendix E**. The following are some potential ordinance and policy options for consideration to increase resiliency in the South Davis Shores neighborhood, some of which incorporate the task force recommendations. These options can be considered on top of the Mitigation Alternatives.

1. **Regulation Applicability**. Consider applying the floodplain management regulations in the 0.2%-annual-flood-hazard area.

2. **Development Incentives**. Explore the feasibility of offering density credits, transfers of development rights, or other similar types of strategy in order to guide development from the Special Flood Hazard Area. This would reduce the allowed development density within a flood prone area and result in land preservation. This would provide incentives to landowners to relocate outside of the flood hazard area. The transfer of any impact fees associated with the property could also be considered.

3. **Fill Limitations**. Consider setting limitations on the use of fill to elevate structures. In considering limitations on fill, consider allowing the use of fill in areas where the fill can be at or above the required elevation and extend no more than a set distance beyond the structure in all directions. The Building Code Task Force recommends requiring a lot grading plan as part of the permitting process for new infill residential developments, with fill only allowed if there is sufficient means to direct rainwater to the street without flooding neighboring properties.

4. **100-Year Floodplain Compensating Volume**. Consider requiring compensating storage volume to offset the impacts of the use of fill. This should be on a 1:1 basis.

   Example language: No net loss of 100 year (1% annual probability) floodplain storage is allowed. Any fill placement would require an offsetting excavation for no net loss, and compensating storage shall be equivalently provided between the seasonal high-water level and the 100-year flood level to allow storage function during all lesser flood events.

5. **Encroachment Analysis**. Considering requiring an encroachment analysis for all permit applications. Deny any permits that will cause an increase of more than 0.00 feet to the base flood elevation in both the floodway and the special flood hazard area outside of the floodway.

6. **Limit Lot Coverage**. Consider reductions to allowed lot impervious coverage (e.g. 50%). Consider increasing allowed heights in exchange for smaller building footprints. Also consider prohibiting or limiting the footprint of accessory structures, such as storage structures or detached buildings. The Building Code Task Force recommends a maximum percentage of impervious area of 70% and requiring lot grading plans when any new impervious surface exceeding 400 square feet is proposed. In addition, the Task Force propose allowing additional lot coverage when certain mitigation measures are taken by property owner.

7. **Limit/Reduce Impervious Surfaces (Public properties)**. Explore the reductions in roadway widths to reduce impervious surfaces as roadways are maintained, reconstructed, or built. Consider, where feasible, creating one-way streets with greenways.

8. **Limit Impervious Surfaces (Private properties)**. Explore providing information and support to private property owners to reduce impervious services. Consider offering reductions to stormwater utility fees for reduction in impervious surfaces or other incentives. The Building Code Task Force recommend utilizing incentive programs to implement porous materials for driveways and patios, and to cap the maximum impervious surface ratio at 70%.

9. **Low Impact Development / Green Infrastructure**. Consider the installation of green infrastructure on public property to store and infiltrate runoff onsite from new impervious surfaces.

10. **Neighborhood Passive Parks / Stormwater Management Areas**. Explore buy-outs of repetitively flooded structures and create areas that serve as passive neighborhood parks that can also be used as stormwater management areas.

11. **Freeboard**. Consider requiring building elevations above the minimum required by the NFIP and Florida Building Code (e.g., 2 ft vs 1 ft). Buildings at higher elevations have reduced occurrences of flood frequency and reduced flood damage. Elevation of building utility systems would also be included.

12. **Foundation Limitations**. Consider requiring residential structures be elevated using pilings or columns. This would eliminate the use of fill or stem-wall construction. This would essentially be applying Zone V standards in Zone A and the Coastal A Zones. To incentivize the use of pier foundations, the Building Code Task Force recommends giving an additional 5% lot coverage for structures that are built on pier foundation and meet other conditions relating to impervious coverages.

13. **Floodproofing**. Consider prohibiting the floodproofing of non-residential structures and require structures to be elevated on pilings or columns.

14. **Stem-wall in Coastal A Zones**. Consider eliminating the exception in Section R322.3.3 Foundations of the Florida Building Code, Residential allowing filled stem-wall construction in Coastal A Zones (CAZ).

15. **Enclosure Limitations**. Consider prohibiting or limiting the size of enclosures below the lowest floor / lowest horizontal structure member. The construction method could also be limited to require breakaway walls in lieu of walls of enclosures with flood openings.

16. **Lower Threshold for Substantial Damage / Substantial Improvement**. Consider a lower threshold than the 50% for both Substantial Damage and Substantial Improvement. This will have the effect of requiring more structures to come into compliance.

17. **Mitigation Prioritization**. Prioritize pursuit of funding for mitigation of structures.

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Section 7

Conclusions and Recommendations

This study presents the data and evaluations for flood risk resiliency for the South Davis Shores area with consideration of potential future sea level rise. A pilot stormwater model was developed to evaluate mitigative measures to manage flooding in coordination with tidal outfall backflow prevention and ultimately for a 7 ft-NAVD88 flood resilience barrier around the area.

The main purpose of the pilot area model is to evaluate flooding at three intersections of interest: Arricola Avenue and Carver Street, Menendez Road and Carver Street, and Ferdinand Avenue and Kenan Street. Based on the pilot area modeling analysis, recommendations include the following:

- Dredging Coquina Ditch and increasing ditch width to provide more storage.
- Upsizing the Coquina Ditch culvert and adding low head loss check valves to prevent tidal flow from entering the ditch.
- Implementing storm sewer projects including pipe upsizes.
- Replacing inlets with higher-capacity inlets.
- Regrading intersections to remove gutter flow on side streets and allow side streets to remain passable at 5-year level of service.

Since the analysis covers a small extent and a 1-year stillwater elevation, it does not account for downstream impacts in the ditch along Ferdinand Avenue, sea level rise, or higher tailwater elevations. It also does not account for pipe upgrades needed in other portions of the South Davis Shores area. Additional analysis will be required to determine if any additional mitigation measures may be required to account for these factors. Possible projects include:

- Pump station at Coquina Ditch culvert to pump out the ditch during higher tailwater and future sea level rise conditions.
- Seawall or berm along Mantanzas River and Quarry Creek.
- Culvert upgrades for Hermosa Outfall across Coquina Avenue, downstream of Ferdinand Avenue ditch.
- Pipe upgrades outside of the Coquina Ditch drainage area.
- Installation of a smart valve, which is controlled by instrumentations measuring water levels upstream and downstream of the Coquina Ditch culvert. Additional locations for smart valves include the Hermosa and Coquina/Old Quarry Road culverts.

It is further recommended that the City extend the stormwater model to the full study area in the next phase to identify additional stormwater management needs (inlets, piping, storage and treatment, and potential pumping).

Various federal, state, and local funding sources are available to implement the mitigation alternatives. In addition to the infrastructure upgrades, proposed ordinances and policies as previously listed are also an effective tool in the mitigation strategy.

Additional model results, figures, cost estimates, Building Code Task Force recommendations, and report comments can be found in the Appendix A through F.

Appendix A

Model Elements

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Table A-1: Existing Condition Model- Junctions

Name	Invert Elev. (ft)	Rim Elev. (ft)	Initial Depth (ft)
CD-0001	1.10	16.10	1.80
CD-0002	-2.14	12.86	5.04
IB-1048	0.45	15.45	2.45
IB-1051	0.57	15.57	2.33
IB-1053	0.57	15.57	2.33
IB-1053A	0.87	15.87	2.03
IB-1062	0.21	15.21	2.69
IB-1066	-2.39	12.61	5.29
IB-1703	1.41	16.41	1.49
MH-0373	-0.05	14.95	2.95
MH-0374	0.07	15.07	2.83
ND-0001	3.90	18.90	0
ND-0002	4.20	19.20	0
ND-0003	4.10	19.10	0
ND-0004	3.80	18.80	0
ND-0005	3.40	18.40	0
ND-0006	4.50	19.50	0
ND-0007	3.90	18.90	0
ND-0008	4.30	19.30	0
ND-0009	3.90	18.90	0
OF-0116	-0.04	14.96	2.94
OF-0118	-0.59	14.41	3.49
OF-0119	-0.37	14.63	3.27

Table A-2: Existing Condition Model- Outfalls

Name	Invert Elev. (ft)	Type	Fixed Stage (ft)
CD-0003A	-2.22	FIXED	2.90
CD-0003B	-2.24	FIXED	2.90
OF-0001	3.60	FREE	0
OF-0002	4.90	FREE	0
OF-0003	5.00	FREE	0
OF-0004	5.20	FREE	0
OF-0005	5.00	FREE	0
OF-0006	4.60	FREE	0
OF-0007	5.00	FREE	0
OF-0008	4.30	FREE	0
OF-0009	4.80	FREE	0
OF-0010	3.50	FREE	0
OF-0011	3.70	FREE	0
OF-0012	3.30	FREE	0
OF-0111	1.13	FIXED	2.90
OF-0115	-3.33	FIXED	2.90

Table A-3: Existing Condition Model- Conduits

Name	Tag	Length (ft)	Roughness*	Inlet Elev. (ft)	Outlet Elev. (ft)
CD-0002:CD-0003A		80.2	0.022	-2.14	-2.22
CD-0002:CD-0003B		80.2	0.022	-1.66	-2.24
D-CD-0001:OF-0119	DITCH	685.8	0	1.10	0.80
D-OF-0116:CD-0002	DITCH	492.4	0	0.40	-0.20
D-OF-0118:OF-0116	DITCH	727.5	0	0.70	0.40
D-OF-0119:OF-0118	DITCH	210.7	0	0.80	0.70
IB-1048:OF-0119		210.1	0.013	0.45	-0.37
IB-1051:MH-0374		320.7	0.013	0.57	0.07
IB-1053:IB-1051		33.0	0.013	0.57	0.73
IB-1053A:IB-1053		170.0	0.013	0.87	0.61
IB-1062:OF-0116		222.5	0.013	0.21	-0.04
IB-1066:OF-0115		172.1	0.013	-2.39	-3.33
IB-1703:OF-0111		29.9	0.013	1.41	1.13
MH-0373:OF-0118		176.3	0.013	-0.05	-0.59
MH-0374:MH-0373		53.2	0.013	0.07	0.11
O_CD-0002:ND-0005	OVERFLOW	37.0	0	3.70	3.60
O_IB-1048:ND-0003	STREET_FLOW	484.2	0	3.80	4.60
O_IB-1048:OF-0009	STREET_FLOW	466.3	0	3.80	4.80
O_IB-1051:ND-0007	STREET_FLOW	261.2	0	3.60	3.90
O_IB-1051:OF-0006	STREET_FLOW	329.9	0	3.60	4.60
O_IB-1053A:IB-1051	STREET_FLOW	164.4	0	3.80	3.60
O_IB-1053A:ND-0001	STREET_FLOW	372.5	0	3.80	4.40
O_IB-1053A:OF-0005	STREET_FLOW	324.3	0	3.60	5.00
O_IB-1062:ND-0005	STREET_FLOW	445.8	0	3.40	4.10
O_IB-1062:OF-0010	STREET_FLOW	120.7	0	3.40	3.50
O_IB-1066:OF-0001	STREET_FLOW	181.5	0	3.30	3.60
O_IB-1703:OF-0003	STREET_FLOW	458.8	0	3.60	5.00
O_IB-1703:OF-0011	OVERFLOW	15.0	0	3.80	3.70
O_MH-0373:ND-0002	STREET_FLOW	433.4	0	3.60	4.80
O_MH-0373:ND-0009	STREET_FLOW	421.5	0	3.60	3.90
O_ND-0001:ND-0006	STREET_FLOW	287.1	0	4.40	5.00
O_ND-0001:OF-0004	STREET_FLOW	428.7	0	4.40	5.20
O_ND-0002:ND-0001	STREET_FLOW	236.5	0	4.80	4.40
O_ND-0002:ND-0004	STREET_FLOW	407.9	0	4.80	4.30
O_ND-0003:IB-1062	STREET_FLOW	401.6	0	4.60	3.40
O_ND-0004:IB-1066	STREET_FLOW	462.2	0	4.30	3.30
O_ND-0005:IB-1066	STREET_FLOW	153.3	0	4.10	3.30
O_ND-0005:OF-0012	OVERFLOW	35.0	0	3.40	3.30
O_ND-0006:IB-1703	STREET_FLOW	225.9	0	5.00	3.60

Name	Tag	Length (ft)	Roughness*	Inlet Elev. (ft)	Outlet Elev. (ft)
O_ND-0006:OF-0002	STREET_FLOW	44.6	0	5.00	4.90
O_ND-0007:ND-0008	STREET_FLOW	390.1	0	3.90	4.30
O_ND-0008:OF-0007	STREET_FLOW	349.9	0	4.30	5.00
O_ND-0009:OF-0008	STREET_FLOW	235.4	0	3.90	4.30

* Roughness for tagged features are specified within the transect properties. Roughness based on tag:

- Street Flow: 0.05 along right/left bank, 0.02 for center channel
- Overflow: 0.05 along entire transect
- Ditch: 0.08 to 0.10 along right/left bank, 0.04 to 0.05 for center channel

Name	Entry Loss Coeff.	Exit Loss Coeff.	Avg. Loss Coeff.	Flap Gate
CD-0002:CD-0003A	0.5	1	0	NO
CD-0002:CD-0003B	0.5	1	0	NO
D-CD-0001:OF-0119	0	0	0	NO
D-OF-0116:CD-0002	0	0	0	NO
D-OF-0118:OF-0116	0	0	0	NO
D-OF-0119:OF-0118	0	0	0	NO
IB-1048:OF-0119	0.35	1	0	NO
IB-1051:MH-0374	0.35	0.25	0.5	NO
IB-1053:IB-1051	0.35	0.25	0	NO
IB-1053A:IB-1053	0.35	0.25	0.5	NO
IB-1062:OF-0116	0.35	1	0	NO
IB-1066:OF-0115	0.35	1	0	NO
IB-1703:OF-0111	0.35	0.25	0	NO
MH-0373:OF-0118	0.35	1	0	NO
MH-0374:MH-0373	0.35	0.25	0.5	NO
O_CD-0002:ND-0005	0	0	0	NO
O_IB-1048:ND-0003	0	0	0	NO
O_IB-1048:OF-0009	0	0	0	NO
O_IB-1051:ND-0007	0	0	0	NO
O_IB-1051:OF-0006	0	0	0	NO
O_IB-1053A:IB-1051	0	0	0	NO
O_IB-1053A:ND-0001	0	0	0	NO
O_IB-1053A:OF-0005	0	0	0	NO
O_IB-1062:ND-0005	0	0	0	NO
O_IB-1062:OF-0010	0	0	0	NO
O_IB-1066:OF-0001	0	0	0	NO
O_IB-1703:OF-0003	0	0	0	NO
O_IB-1703:OF-0011	0	0	0	NO
O_MH-0373:ND-0002	0	0	0	NO
O_MH-0373:ND-0009	0	0	0	NO
O_ND-0001:ND-0006	0	0	0	NO

Name	Entry Loss Coeff.	Exit Loss Coeff.	Avg. Loss Coeff.	Flap Gate
O_ND-0001:OF-0004	0	0	0	NO
O_ND-0002:ND-0001	0	0	0	NO
O_ND-0002:ND-0004	0	0	0	NO
O_ND-0003:IB-1062	0	0	0	NO
O_ND-0004:IB-1066	0	0	0	NO
O_ND-0005:IB-1066	0	0	0	NO
O_ND-0005:OF-0012	0	0	0	NO
O_ND-0006:IB-1703	0	0	0	NO
O_ND-0006:OF-0002	0	0	0	NO
O_ND-0007:ND-0008	0	0	0	NO
O_ND-0008:OF-0007	0	0	0	NO
O_ND-0009:OF-0008	0	0	0	NO

Name	Cross-Section	Geom1 (ft)	Geom2 (ft)	Barrels	Transect
CD-0002:CD-0003A	CIRCULAR	3	0	1	
CD-0002:CD-0003B	CIRCULAR	3	0	1	
D-CD-0001:OF-0119	IRREGULAR	0	0	1	CD-4
D-OF-0116:CD-0002	IRREGULAR	0	0	1	CD-1
D-OF-0118:OF-0116	IRREGULAR	0	0	1	CD-2
D-OF-0119:OF-0118	IRREGULAR	0	0	1	CD-3
IB-1048:OF-0119	CIRCULAR	2	0	1	
IB-1051:MH-0374	HORIZ_ELLIPSE	2	3.167	1	
IB-1053:IB-1051	CIRCULAR	1.5	0	1	
IB-1053A:IB-1053	CIRCULAR	1.25	0	1	
IB-1062:OF-0116	CIRCULAR	2	0	1	
IB-1066:OF-0115	CIRCULAR	2	0	1	
IB-1703:OF-0111	CIRCULAR	1.25	0	1	
MH-0373:OF-0118	CIRCULAR	2.5	0	1	
MH-0374:MH-0373	HORIZ_ELLIPSE	2	3.167	1	
O_CD-0002:ND-0005	IRREGULAR	0	0	1	O_CD-0002:ND-0005
O_IB-1048:ND-0003	IRREGULAR	0	0	1	O_IB-1048:ND-0003
O_IB-1048:OF-0009	IRREGULAR	0	0	1	O_IB-1048:OF-0009
O_IB-1051:ND-0007	IRREGULAR	0	0	1	O_IB-1051:ND-0007
O_IB-1051:OF-0006	IRREGULAR	0	0	1	O_IB-1051:OF-0006
O_IB-1053A:IB-1051	IRREGULAR	0	0	1	O_IB-1053A:IB-1051
O_IB-1053A:ND-0001	IRREGULAR	0	0	1	O_IB-1053A:ND-0001
O_IB-1053A:OF-0005	IRREGULAR	0	0	1	O_IB-1051:OF-0005
O_IB-1062:ND-0005	IRREGULAR	0	0	1	O_IB-1062:ND-0005
O_IB-1062:OF-0010	IRREGULAR	0	0	1	O_IB-1062:OF-0010
O_IB-1066:OF-0001	IRREGULAR	0	0	1	O_IB-1066:OF-0001

Name	Cross-Section	Geom1 (ft)	Geom2 (ft)	Barrels	Transect
O_IB-1703:OF-0003	IRREGULAR	0	0	1	O_IB-1703:OF-0003
O_IB-1703:OF-0011	IRREGULAR	0	0	1	O_IB-1703:OF-0011
O_MH-0373:ND-0002	IRREGULAR	0	0	1	O_MH-0373:ND-0002
O_MH-0373:ND-0009	IRREGULAR	0	0	1	O_MH-0373:ND-0009
O_ND-0001:ND-0006	IRREGULAR	0	0	1	O_ND-0001:ND-0006
O_ND-0001:OF-0004	IRREGULAR	0	0	1	O_ND-0001:OF-0004
O_ND-0002:ND-0001	IRREGULAR	0	0	1	O_ND-0002:ND-0001
O_ND-0002:ND-0004	IRREGULAR	0	0	1	O_ND-0002:ND-0004
O_ND-0003:IB-1062	IRREGULAR	0	0	1	O_ND-0003:IB-1062
O_ND-0004:IB-1066	IRREGULAR	0	0	1	O_ND-0004:IB-1066
O_ND-0005:IB-1066	IRREGULAR	0	0	1	O_ND-0005:IB-1066
O_ND-0005:OF-0012	IRREGULAR	0	0	1	O_ND-0005:OF-0012
O_ND-0006:IB-1703	IRREGULAR	0	0	1	O_ND-0006:IB-1703
O_ND-0006:OF-0002	IRREGULAR	0	0	1	O_ND-0006:OF-0002
O_ND-0007:ND-0008	IRREGULAR	0	0	1	O_ND-0007:ND-0008
O_ND-0008:OF-0007	IRREGULAR	0	0	1	O_ND-0008:OF-0007
O_ND-0009:OF-0008	IRREGULAR	0	0	1	O_ND-0009:OF-0008

Table A-4: Existing Condition Model- HU

Name	Rain Gage	Outlet	Area (ac)	Width (ft)	Slope (%)	Imperv. (%)
CD-01	Gage1	OF-0116	8.0	2286	2.21	22.4
CD-02	Gage1	IB-1062	4.2	461	0.43	34.7
CD-03	Gage1	MH-0373	7.3	547	0.45	32.9
CD-04	Gage1	IB-1051	8.5	521	0.40	30.7
CD-05	Gage1	IB-1048	6.4	629	0.36	31.2
CD-06	Gage1	CD-0001	5.0	1436	2.08	22.4
CD-07	Gage1	ND-0001	3.9	441	0.40	37.3
CD-08	Gage1	IB-1053A	4.8	490	0.75	33.7
FD-01	Gage1	IB-1703	4.3	461	0.54	32.4
QC-01	Gage1	IB-1066	7.9	439	0.27	33.7

Name	N Imperv	N Perv	Dstore Imperv (in)	Dstore Perv (in)	Zero Imperv (%)	Subarea Routing	Percent Routed (%)
CD-01	0.015	0.250	0.10	0.25	25	PERVIOUS	34.3
CD-02	0.015	0.252	0.10	0.25	25	PERVIOUS	35.0
CD-03	0.015	0.250	0.10	0.25	25	PERVIOUS	34.3
CD-04	0.015	0.250	0.10	0.25	25	PERVIOUS	32.5
CD-05	0.015	0.250	0.10	0.25	25	PERVIOUS	34.3
CD-06	0.015	0.250	0.10	0.25	25	PERVIOUS	34.3
CD-07	0.015	0.250	0.10	0.25	25	PERVIOUS	34.3
CD-08	0.015	0.250	0.10	0.25	25	PERVIOUS	34.3
FD-01	0.017	0.250	0.11	0.25	25	PERVIOUS	30.5
QC-01	0.015	0.254	0.10	0.25	25	PERVIOUS	35.5

Name	Infiltration Method	Max. Infil. Rate (in/hr)	Min. Infil. Rate (in/hr)	Decay Constant (1/hr)	Drying Time (days)	Max. Volume (in)
CD-01	HORTON	5	0.5	2.002	2.1	4
CD-02	HORTON	5	0.5	2.002	2.1	4
CD-03	HORTON	5	0.5	2.002	2.1	4
CD-04	HORTON	5	0.5	2.002	2.1	4
CD-05	HORTON	5	0.5	2.002	2.1	4
CD-06	HORTON	5	0.5	2.002	2.1	4
CD-07	HORTON	5	0.5	2.002	2.1	4
CD-08	HORTON	5	0.5	2.002	2.1	4
FD-01	HORTON	5	0.5	2.002	2.1	4
QC-01	HORTON	5	0.5	2.002	2.1	4

Table A-5: Mitigation Alternative #1- Junctions

Name	Invert Elev. (ft)	Rim Elev. (ft)	Initial Depth (ft)
CD-0001	1.10	16.10	0
CD-0002	-2.14	12.86	2.14
IB-1048	0.45	15.45	0
IB-1051	0.57	15.57	0
IB-1053	0.57	15.57	0
IB-1053A	0.87	15.87	0
IB-1062	0.21	15.21	0
IB-1066	-2.39	12.61	5.29
IB-1703	1.41	16.41	1.49
IB-CD03	1.42	16.42	0
IB-CD04	1.45	16.45	0
MH-0373	-0.05	14.95	0.05
MH-0374	0.07	15.07	0
MH-CD05	1.46	16.46	0
MH-CD06	1.50	16.50	0
MH-CD07	1.58	16.58	0
ND-0001	1.63	16.63	0
ND-0002	1.41	16.41	0
ND-0003	4.10	19.10	0
ND-0004	4.30	19.30	0
ND-0005	3.40	18.40	0
ND-0006	4.50	19.50	0
ND-0007	3.90	18.90	0
ND-0008	4.30	19.30	0
ND-0009	3.90	18.90	0
OF-0116	-0.04	14.96	0.04
OF-0118	-0.59	14.41	0.59
OF-0119	-0.37	14.63	0.37
OF-CD01	0.50	15.50	0

Table A-6: Mitigation Alternative #1- Outfalls

Name	Invert Elev. (ft)	Type	Fixed Stage (ft)
CD-0003A	-2.22	FIXED	2.90
CD-0003B	-2.24	FIXED	2.90
OF-0001	3.60	FREE	0
OF-0002	4.90	FREE	0
OF-0003	5.00	FREE	0
OF-0004	5.20	FREE	0
OF-0005	5.00	FREE	0
OF-0006	4.60	FREE	0
OF-0007	5.00	FREE	0
OF-0008	4.30	FREE	0
OF-0009	4.80	FREE	0
OF-0010	3.50	FREE	0
OF-0011	3.70	FREE	0
OF-0012	3.30	FREE	0
OF-0111	1.13	FIXED	2.90
OF-0115	-3.33	FIXED	2.90

Table A-7: Mitigation Alternative #1- Conduits

Name	Tag	Length (ft)	Roughness*	Inlet Elev. (ft)	Outlet Elev. (ft)
CD-0002:CD-0003A	UPSIZE	80.2	0.022	-2.14	-2.22
CD-0002:CD-0003B	UPSIZE	80.2	0.022	-1.66	-2.24
D-CD-0001:OF-0119	DITCH_DREDGED	685.8	0	1.10	0.80
D-OF-0116:CD-0002	DITCH_DREDGED	492.4	0	0.40	-0.20
D-OF-0118:OF-CD01	DITCH_DREDGED	567.8	0	0.70	0.50
D-OF-0119:OF-0118	DITCH_DREDGED	210.7	0	0.80	0.70
D-OF-CD01:OF-0116	DITCH_DREDGED	159.7	0	0.50	0.40
IB-1048:OF-0119		210.1	0.013	0.45	-0.37
IB-1051:MH-0374		320.7	0.013	0.57	0.07
IB-1053:IB-1051		33.0	0.013	0.57	0.73
IB-1053A:IB-1053		170.0	0.013	0.87	0.61
IB-1062:OF-0116		222.5	0.013	0.21	-0.04
IB-1066:OF-0115		172.1	0.013	-2.39	-3.33
IB-1703:OF-0111		29.9	0.013	1.41	1.13
IB-CD02:OF-CD01	MITIGATION	190.0	0.013	1.41	1.30
IB-CD03:IB-CD02	MITIGATION	25.0	0.013	1.42	1.41
IB-CD04:IB-CD03	MITIGATION	50.0	0.013	1.45	1.42
IB-CD08:MH-CD07	MITIGATION	76.0	0.013	1.63	1.58
MH-0373:OF-0118		176.3	0.013	-0.05	-0.59
MH-0374:MH-0373		53.2	0.013	0.07	0.11
MH-CD05:IB-CD04	MITIGATION	26.0	0.013	1.46	1.45
MH-CD06:MH-CD05	MITIGATION	68.0	0.013	1.50	1.46
MH-CD07:MH-CD06	MITIGATION	137.0	0.013	1.58	1.50
O_CD-0002:ND-0005	OVERFLOW	37.0	0	3.70	3.60
O_IB-1048:ND-0003	STREET_FLOW	484.2	0	3.80	4.60
O_IB-1048:OF-0009	STREET_FLOW	466.3	0	3.80	4.80
O_IB-1051:ND-0007	STREET_FLOW	261.2	0	3.60	3.90
O_IB-1051:OF-0006	STREET_FLOW	329.9	0	3.60	4.60
O_IB-1053A:IB-1051	STREET_FLOW	164.4	0	3.80	3.60
O_IB-1053A:IB-CD08	STREET_FLOW	372.5	0	3.80	4.40
O_IB-1053A:OF-0005	STREET_FLOW	324.3	0	3.60	5.00
O_IB-1062:ND-0005	STREET_FLOW	445.8	0	3.40	4.10
O_IB-1062:OF-0010	STREET_FLOW	120.7	0	3.40	3.50
O_IB-1066:OF-0001	STREET_FLOW	181.5	0	3.30	3.60
O_IB-1703:OF-0003	STREET_FLOW	458.8	0	3.60	5.00
O_IB-1703:OF-0011	OVERFLOW	15.0	0	3.80	3.70
O_IB-CD02:ND-0004	STREET_FLOW	407.9	0	4.80	4.30

Name	Tag	Length (ft)	Roughness*	Inlet Elev. (ft)	Outlet Elev. (ft)
O_IB-CD08:IB-CD02	STREET_FLOW	236.5	0	4.80	4.40
O_IB-CD08:ND-0006	STREET_FLOW	287.1	0	4.40	5.00
O_IB-CD08:OF-0004	STREET_FLOW	428.7	0	4.40	5.20
O_MH-0373:IB-CD02	STREET_FLOW	433.4	0	3.60	4.80
O_MH-0373:ND-0009	STREET_FLOW	421.5	0	3.60	3.90
O_ND-0003:IB-1062	STREET_FLOW	401.6	0	4.60	3.40
O_ND-0004:IB-1066	STREET_FLOW	462.2	0	4.30	3.30
O_ND-0005:IB-1066	STREET_FLOW	153.3	0	4.10	3.30
O_ND-0005:OF-0012	OVERFLOW	35.0	0	3.40	3.30
O_ND-0006:IB-1703	STREET_FLOW	225.9	0	5.00	3.60
O_ND-0006:OF-0002	STREET_FLOW	44.6	0	5.00	4.90
O_ND-0007:ND-0008	STREET_FLOW	390.1	0	3.90	4.30
O_ND-0008:OF-0007	STREET_FLOW	349.9	0	4.30	5.00
O_ND-0009:OF-0008	STREET_FLOW	235.4	0	3.90	4.30

* Roughness for tagged features are specified within the transect properties. Roughness based on tag:

- Street Flow: 0.05 along right/left bank, 0.02 for center channel
- Overflow: 0.05 along entire transect
- Ditch Dredged: 0.08 along right/left bank, 0.03 for center channel

Name	Entry Loss Coeff.	Exit Loss Coeff.	Avg. Loss Coeff.	Flap Gate
CD-0002:CD-0003A	0.5	1	0	YES
CD-0002:CD-0003B	0.5	1	0	YES
D-CD-0001:OF-0119	0	0	0	NO
D-OF-0116:CD-0002	0	0	0	NO
D-OF-0118:OF-CD01	0	0	0	NO
D-OF-0119:OF-0118	0	0	0	NO
D-OF-CD01:OF-0116	0	0	0	NO
IB-1048:OF-0119	0.35	1	0	NO
IB-1051:MH-0374	0.35	0.25	0.5	NO
IB-1053:IB-1051	0.35	0.25	0	NO
IB-1053A:IB-1053	0.35	0.25	0.5	NO
IB-1062:OF-0116	0.35	1	0	NO
IB-1066:OF-0115	0.35	1	0	NO
IB-1703:OF-0111	0.35	0.25	0	NO
IB-CD02:OF-CD01	0.35	1	0	NO
IB-CD03:IB-CD02	0.35	0.25	0	NO
IB-CD04:IB-CD03	0.35	0.25	0.5	NO
IB-CD08:MH-CD07	0.35	0.25	0	NO
MH-0373:OF-0118	0.35	1	0	NO
MH-0374:MH-0373	0.35	0.25	0.5	NO
MH-CD05:IB-CD04	0.35	0.25	0.5	NO
MH-CD06:MH-CD05	0.35	0.25	0	NO
MH-CD07:MH-CD06	0.35	0.25	0	NO
O_CD-0002:ND-0005	0	0	0	NO
O_IB-1048:ND-0003	0	0	0	NO
O_IB-1048:OF-0009	0	0	0	NO
O_IB-1051:ND-0007	0	0	0	NO
O_IB-1051:OF-0006	0	0	0	NO
O_IB-1053A:IB-1051	0	0	0	NO
O_IB-1053A:IB-CD08	0	0	0	NO
O_IB-1053A:OF-0005	0	0	0	NO
O_IB-1062:ND-0005	0	0	0	NO
O_IB-1062:OF-0010	0	0	0	NO
O_IB-1066:OF-0001	0	0	0	NO
O_IB-1703:OF-0003	0	0	0	NO
O_IB-1703:OF-0011	0	0	0	NO
O_IB-CD02:ND-0004	0	0	0	NO
O_IB-CD08:IB-CD02	0	0	0	NO
O_IB-CD08:ND-0006	0	0	0	NO
O_IB-CD08:OF-0004	0	0	0	NO

Name	Entry Loss Coeff.	Exit Loss Coeff.	Avg. Loss Coeff.	Flap Gate
O_MH-0373:IB-CD02	0	0	0	NO
O_MH-0373:ND-0009	0	0	0	NO
O_ND-0003:IB-1062	0	0	0	NO
O_ND-0004:IB-1066	0	0	0	NO
O_ND-0005:IB-1066	0	0	0	NO
O_ND-0005:OF-0012	0	0	0	NO
O_ND-0006:IB-1703	0	0	0	NO
O_ND-0006:OF-0002	0	0	0	NO
O_ND-0007:ND-0008	0	0	0	NO
O_ND-0008:OF-0007	0	0	0	NO
O_ND-0009:OF-0008	0	0	0	NO

Name	Cross-Section	Geom1 (ft)	Geom2 (ft)	Barrels	Transect
CD-0002:CD-0003A	CIRCULAR	4	0	1	
CD-0002:CD-0003B	CIRCULAR	4	0	1	
D-CD-0001:OF-0119	IRREGULAR	0	0	1	CD-4_5yr
D-OF-0116:CD-0002	IRREGULAR	0	0	1	CD-1_5yr
D-OF-0118:OF-CD01	IRREGULAR	0	0	1	CD-2_5yr
D-OF-0119:OF-0118	IRREGULAR	0	0	1	CD-3_5yr
D-OF-CD01:OF-0116	IRREGULAR	0	0	1	CD-2_5yr
IB-1048:OF-0119	CIRCULAR	2	0	1	
IB-1051:MH-0374	HORIZ_ELLIPSE	2	3.167	1	
IB-1053:IB-1051	CIRCULAR	1.5	0	1	
IB-1053A:IB-1053	CIRCULAR	1.25	0	1	
IB-1062:OF-0116	CIRCULAR	2	0	1	
IB-1066:OF-0115	CIRCULAR	2	0	1	
IB-1703:OF-0111	CIRCULAR	1.25	0	1	
IB-CD02:OF-CD01	HORIZ_ELLIPSE	1.583	2.5	1	
IB-CD03:IB-CD02	HORIZ_ELLIPSE	1.583	2.5	1	
IB-CD04:IB-CD03	HORIZ_ELLIPSE	1.167	1.917	1	
IB-CD08:MH-CD07	HORIZ_ELLIPSE	1.167	1.917	1	
MH-0373:OF-0118	CIRCULAR	2.5	0	1	
MH-0374:MH-0373	HORIZ_ELLIPSE	2	3.167	1	
MH-CD05:IB-CD04	HORIZ_ELLIPSE	1.167	1.917	1	
MH-CD06:MH-CD05	HORIZ_ELLIPSE	1.167	1.917	1	
MH-CD07:MH-CD06	HORIZ_ELLIPSE	1.167	1.917	1	
O_CD-0002:ND-0005	IRREGULAR	0	0	1	O_CD-0002:ND-0005
O_IB-1048:ND-0003	IRREGULAR	0	0	1	O_IB-1048:ND-0003
O_IB-1048:OF-0009	IRREGULAR	0	0	1	O_IB-1048:OF-0009
O_IB-1051:ND-0007	IRREGULAR	0	0	1	O_IB-1051:ND-0007
O_IB-1051:OF-0006	IRREGULAR	0	0	1	O_IB-1051:OF-0006
O_IB-1053A:IB-1051	IRREGULAR	0	0	1	O_IB-1053A:IB-1051
O_IB-1053A:IB-CD08	IRREGULAR	0	0	1	O_IB-1053A:IB-CD08
O_IB-1053A:OF-0005	IRREGULAR	0	0	1	O_IB-1053A:OF-0005
O_IB-1062:ND-0005	IRREGULAR	0	0	1	O_IB-1062:ND-0005
O_IB-1062:OF-0010	IRREGULAR	0	0	1	O_IB-1062:OF-0010
O_IB-1066:OF-0001	IRREGULAR	0	0	1	O_IB-1066:OF-0001
O_IB-1703:OF-0003	IRREGULAR	0	0	1	O_IB-1703:OF-0003
O_IB-1703:OF-0011	IRREGULAR	0	0	1	O_IB-1703:OF-0011
O_IB-CD02:ND-0004	IRREGULAR	0	0	1	O_IB-CD02:ND-0004
O_IB-CD08:IB-CD02	IRREGULAR	0	0	1	O_IB-CD08:IB-CD02
O_IB-CD08:ND-0006	IRREGULAR	0	0	1	O_IB-CD08:ND-0006
O_IB-CD08:OF-0004	IRREGULAR	0	0	1	O_IB-CD08:OF-0004

Name	Cross-Section	Geom1 (ft)	Geom2 (ft)	Barrels	Transect
O_MH-0373:IB-CD02	IRREGULAR	0	0	1	O_MH-0373:IB-CD02
O_MH-0373:ND-0009	IRREGULAR	0	0	1	O_MH-0373:ND-0009
O_ND-0003:IB-1062	IRREGULAR	0	0	1	O_ND-0003:IB-1062
O_ND-0004:IB-1066	IRREGULAR	0	0	1	O_ND-0004:IB-1066
O_ND-0005:IB-1066	IRREGULAR	0	0	1	O_ND-0005:IB-1066
O_ND-0005:OF-0012	IRREGULAR	0	0	1	O_ND-0005:OF-0012
O_ND-0006:IB-1703	IRREGULAR	0	0	1	O_ND-0006:IB-1703
O_ND-0006:OF-0002	IRREGULAR	0	0	1	O_ND-0006:OF-0002
O_ND-0007:ND-0008	IRREGULAR	0	0	1	O_ND-0007:ND-0008
O_ND-0008:OF-0007	IRREGULAR	0	0	1	O_ND-0008:OF-0007
O_ND-0009:OF-0008	IRREGULAR	0	0	1	O_ND-0009:OF-0008

Table A-8: Mitigation Alternative #1- HU

Name	Rain Gage	Outlet	Area (ac)	Width (ft)	Slope (%)	Imperv. (%)
CD-01	Gage1	OF-0116	8.1	2286	2.21	22.4
CD-02	Gage1	IB-1062	4.2	461	0.43	34.7
CD-03	Gage1	MH-0373	7.1	530	0.45	32.3
CD-04	Gage1	IB-1051	8.5	521	0.40	30.7
CD-05	Gage1	IB-1048	6.4	629	0.36	31.2
CD-06	Gage1	CD-0001	5.0	1436	2.08	22.4
CD-07	Gage1	ND-0001	3.8	423	0.40	37.2
CD-08	Gage1	IB-1053A	4.8	490	0.75	33.7
CD-09	Gage1	ND-0002	0.7	266	0.81	45.5
FD-01	Gage1	IB-1703	4.3	461	0.54	32.4
QC-01	Gage1	IB-1066	7.6	424	0.27	33.4

Name	N Imperv	N Perv	Dstore Imperv (in)	Dstore Perv (in)	Zero Imperv (%)	Subarea Routing	Percent Routed (%)
CD-01	0.015	0.250	0.10	0.25	25	PERVIOUS	34.3
CD-02	0.015	0.252	0.10	0.25	25	PERVIOUS	35.0
CD-03	0.015	0.250	0.10	0.25	25	PERVIOUS	34.3
CD-04	0.015	0.250	0.10	0.25	25	PERVIOUS	32.5
CD-05	0.015	0.250	0.10	0.25	25	PERVIOUS	34.3
CD-06	0.015	0.250	0.10	0.25	25	PERVIOUS	34.3
CD-07	0.015	0.250	0.10	0.25	25	PERVIOUS	34.3
CD-08	0.015	0.250	0.10	0.25	25	PERVIOUS	34.3
FD-01	0.017	0.250	0.11	0.25	25	PERVIOUS	30.5
QC-01	0.015	0.254	0.10	0.25	25	PERVIOUS	35.5

Name	Infiltration Method	Max. Infil. Rate (in/hr)	Min. Infil. Rate (in/hr)	Decay Constant (1/hr)	Drying Time (days)	Max. Volume (in)
CD-01	HORTON	5	0.5	2.002	2.1	4
CD-02	HORTON	5	0.5	2.002	2.1	4
CD-03	HORTON	5	0.5	2.002	2.1	4
CD-04	HORTON	5	0.5	2.002	2.1	4
CD-05	HORTON	5	0.5	2.002	2.1	4
CD-06	HORTON	5	0.5	2.002	2.1	4
CD-07	HORTON	5	0.5	2.002	2.1	4
CD-08	HORTON	5	0.5	2.002	2.1	4
CD-09	HORTON	5	0.5	2.002	2.1	4

Name	Infiltration Method	Max. Infil. Rate (in/hr)	Min. Infil. Rate (in/hr)	Decay Constant (1/hr)	Drying Time (days)	Max. Volume (in)
FD-01	HORTON	5	0.5	2.002	2.1	4
QC-01	HORTON	5	0.5	2.002	2.1	4

Table A-9: Mitigation Alternative #2- Junctions

Name	Invert Elev. (ft)	Rim Elev. (ft)	Initial Depth (ft)
CD-0001	0.10	16.10	0
CD-0002	-2.14	12.86	2.14
IB-1048	0.45	15.45	0
IB-1051	0.57	15.57	0
IB-1053	0.57	15.57	0
IB-1053A	0.87	15.87	0
IB-1062	0.21	15.21	0
IB-1066	-2.39	12.61	5.29
IB-1703	1.41	16.41	1.49
IB-CD03	1.42	16.42	0
IB-CD04	1.45	16.45	0
MH-0373	-0.05	14.95	0.05
MH-0374	0.07	15.07	0
MH-CD05	1.46	16.46	0
MH-CD06	1.50	16.50	0
MH-CD07	1.58	16.58	0
ND-0001	1.63	16.63	0
ND-0002	1.41	16.41	0
ND-0003	4.10	19.10	0
ND-0004	4.30	19.30	0
ND-0005	3.40	18.40	0
ND-0006	4.50	19.50	0
ND-0007	3.90	18.90	0
ND-0008	4.30	19.30	0
ND-0009	3.90	18.90	0
OF-0116	-0.60	14.96	0.60
OF-0118	-0.59	14.41	0.59
OF-0119	-0.37	14.63	0.37
OF-CD01	-0.50	15.50	0.50

Table A-10: Mitigation Alternative #2- Outfalls

Name	Invert Elev. (ft)	Type	Fixed Stage (ft)
CD-0003A	-2.22	FIXED	2.90
CD-0003B	-2.24	FIXED	2.90
OF-0001	3.60	FREE	0
OF-0002	4.90	FREE	0
OF-0003	5.00	FREE	0
OF-0004	5.20	FREE	0
OF-0005	5.00	FREE	0
OF-0006	4.60	FREE	0
OF-0007	5.00	FREE	0
OF-0008	4.30	FREE	0
OF-0009	4.80	FREE	0
OF-0010	3.50	FREE	0
OF-0011	3.70	FREE	0
OF-0012	3.30	FREE	0
OF-0111	1.13	FIXED	2.90
OF-0115	-3.33	FIXED	2.90

Table A-11: Mitigation Alternative #2- Conduits

Name	Tag	Length (ft)	Roughness*	Inlet Elev. (ft)	Outlet Elev. (ft)
CD-0002:CD-0003A	UPSIZE	80.2	0.022	-2.14	-2.22
CD-0002:CD-0003B	UPSIZE	80.2	0.022	-1.66	-2.24
D-CD-0001:OF-0119	DITCH_DREDGED	685.8	0	0.10	-0.20
D-OF-0116:CD-0002	DITCH_DREDGED	492.4	0	-0.60	-1.20
D-OF-0118:OF-CD01	DITCH_DREDGED	567.8	0	-0.30	-0.50
D-OF-0119:OF-0118	DITCH_DREDGED	210.7	0	-0.20	-0.30
D-OF-CD01:OF-0116	DITCH_DREDGED	159.7	0	-0.50	-0.60
IB-1048:OF-0119	UPSIZE	210.1	0.013	0.45	-0.37
IB-1051:MH-0374	UPSIZE	320.7	0.013	0.57	0.07
IB-1053:IB-1051	UPSIZE	33.0	0.013	0.57	0.73
IB-1053A:IB-1053	UPSIZE	170.0	0.013	0.87	0.61
IB-1062:OF-0116	UPSIZE	222.5	0.013	0.21	-0.04
IB-1066:OF-0115		172.1	0.013	-2.39	-3.33
IB-1703:OF-0111		29.9	0.013	1.41	1.13
IB-CD02:OF-CD01	MITIGATION	190.0	0.013	1.41	1.30
IB-CD03:IB-CD02	MITIGATION	25.0	0.013	1.42	1.41
IB-CD04:IB-CD03	MITIGATION	50.0	0.013	1.45	1.42
IB-CD08:MH-CD07	MITIGATION	76.0	0.013	1.63	1.58
MH-0373:OF-0118	UPSIZE	176.3	0.013	-0.05	-0.59
MH-0374:MH-0373	UPSIZE	53.2	0.013	0.07	-0.05
MH-CD05:IB-CD04	MITIGATION	26.0	0.013	1.46	1.45
MH-CD06:MH-CD05	MITIGATION	68.0	0.013	1.50	1.46
MH-CD07:MH-CD06	MITIGATION	137.0	0.013	1.58	1.50
O_CD-0002:ND-0005	OVERFLOW	37.0	0	3.70	3.60
O_IB-1048:ND-0003	STREET_FLOW	484.2	0	3.80	4.60
O_IB-1048:OF-0009	STREET_FLOW	466.3	0	3.80	4.80
O_IB-1051:ND-0007	STREET_FLOW	261.2	0	3.60	3.90
O_IB-1051:OF-0006	STREET_FLOW	329.9	0	3.60	4.60
O_IB-1053A:IB-1051	STREET_FLOW	164.4	0	3.80	3.60
O_IB-1053A:IB-CD08	STREET_FLOW	372.5	0	3.80	4.40
O_IB-1053A:OF-0005	STREET_FLOW	324.3	0	3.60	5.00
O_IB-1062:ND-0005	STREET_FLOW	445.8	0	3.40	4.10
O_IB-1062:OF-0010	STREET_FLOW	120.7	0	3.40	3.50
O_IB-1066:OF-0001	STREET_FLOW	181.5	0	3.30	3.60
O_IB-1703:OF-0003	STREET_FLOW	458.8	0	3.60	5.00
O_IB-1703:OF-0011	OVERFLOW	15.0	0	3.80	3.70
O_IB-CD02:ND-0004	STREET_FLOW	407.9	0	4.80	4.30

Name	Tag	Length (ft)	Roughness*	Inlet Elev. (ft)	Outlet Elev. (ft)
O_IB-CD08:IB-CD02	STREET_FLOW	236.5	0	4.80	4.40
O_IB-CD08:ND-0006	STREET_FLOW	287.1	0	4.40	5.00
O_IB-CD08:OF-0004	STREET_FLOW	428.7	0	4.40	5.20
O_MH-0373:IB-CD02	STREET_FLOW	433.4	0	3.60	4.80
O_MH-0373:ND-0009	STREET_FLOW	421.5	0	3.60	3.90
O_ND-0003:IB-1062	STREET_FLOW	401.6	0	4.60	3.40
O_ND-0004:IB-1066	STREET_FLOW	462.2	0	4.30	3.30
O_ND-0005:IB-1066	STREET_FLOW	153.3	0	4.10	3.30
O_ND-0005:OF-0012	OVERFLOW	35.0	0	3.40	3.30
O_ND-0006:IB-1703	STREET_FLOW	225.9	0	5.00	3.60
O_ND-0006:OF-0002	STREET_FLOW	44.6	0	5.00	4.90
O_ND-0007:ND-0008	STREET_FLOW	390.1	0	3.90	4.30
O_ND-0008:OF-0007	STREET_FLOW	349.9	0	4.30	5.00
O_ND-0009:OF-0008	STREET_FLOW	235.4	0	3.90	4.30

* Roughness for tagged features are specified within the transect properties. Roughness based on tag:

- Street Flow: 0.05 along right/left bank, 0.02 for center channel
- Overflow: 0.05 along entire transect
- Ditch Dredged: 0.08 along right/left bank, 0.03 for center channel

Name	Entry Loss Coeff.	Exit Loss Coeff.	Avg. Loss Coeff.	Flap Gate
CD-0002:CD-0003A	0.5	1	0	YES
CD-0002:CD-0003B	0.5	1	0	YES
D-CD-0001:OF-0119	0	0	0	NO
D-OF-0116:CD-0002	0	0	0	NO
D-OF-0118:OF-CD01	0	0	0	NO
D-OF-0119:OF-0118	0	0	0	NO
D-OF-CD01:OF-0116	0	0	0	NO
IB-1048:OF-0119	0.35	1	0	NO
IB-1051:MH-0374	0.35	0.25	0.5	NO
IB-1053:IB-1051	0.35	0.25	0	NO
IB-1053A:IB-1053	0.35	0.25	0.5	NO
IB-1062:OF-0116	0.35	1	0	NO
IB-1066:OF-0115	0.35	1	0	NO
IB-1703:OF-0111	0.35	0.25	0	NO
IB-CD02:OF-CD01	0.35	1	0	NO
IB-CD03:IB-CD02	0.35	0.25	0	NO
IB-CD04:IB-CD03	0.35	0.25	0.5	NO
IB-CD08:MH-CD07	0.35	0.25	0	NO
MH-0373:OF-0118	0.35	1	0	NO
MH-0374:MH-0373	0.35	0.25	0.5	NO
MH-CD05:IB-CD04	0.35	0.25	0.5	NO
MH-CD06:MH-CD05	0.35	0.25	0	NO
MH-CD07:MH-CD06	0.35	0.25	0	NO
O_CD-0002:ND-0005	0	0	0	NO
O_IB-1048:ND-0003	0	0	0	NO
O_IB-1048:OF-0009	0	0	0	NO
O_IB-1051:ND-0007	0	0	0	NO
O_IB-1051:OF-0006	0	0	0	NO
O_IB-1053A:IB-1051	0	0	0	NO
O_IB-1053A:IB-CD08	0	0	0	NO
O_IB-1053A:OF-0005	0	0	0	NO
O_IB-1062:ND-0005	0	0	0	NO
O_IB-1062:OF-0010	0	0	0	NO
O_IB-1066:OF-0001	0	0	0	NO
O_IB-1703:OF-0003	0	0	0	NO
O_IB-1703:OF-0011	0	0	0	NO
O_IB-CD02:ND-0004	0	0	0	NO
O_IB-CD08:IB-CD02	0	0	0	NO
O_IB-CD08:ND-0006	0	0	0	NO
O_IB-CD08:OF-0004	0	0	0	NO

Name	Entry Loss Coeff.	Exit Loss Coeff.	Avg. Loss Coeff.	Flap Gate
O_MH-0373:IB-CD02	0	0	0	NO
O_MH-0373:ND-0009	0	0	0	NO
O_ND-0003:IB-1062	0	0	0	NO
O_ND-0004:IB-1066	0	0	0	NO
O_ND-0005:IB-1066	0	0	0	NO
O_ND-0005:OF-0012	0	0	0	NO
O_ND-0006:IB-1703	0	0	0	NO
O_ND-0006:OF-0002	0	0	0	NO
O_ND-0007:ND-0008	0	0	0	NO
O_ND-0008:OF-0007	0	0	0	NO
O_ND-0009:OF-0008	0	0	0	NO

Name	Cross-Section	Geom1 (ft)	Geom2 (ft)	Barrels	Transect
CD-0002:CD-0003A	CIRCULAR	4	0	1	
CD-0002:CD-0003B	CIRCULAR	4	0	1	
D-CD-0001:OF-0119	IRREGULAR	0	0	1	CD-4_100yr
D-OF-0116:CD-0002	IRREGULAR	0	0	1	CD-1_100yr
D-OF-0118:OF-CD01	IRREGULAR	0	0	1	CD-2_100yr
D-OF-0119:OF-0118	IRREGULAR	0	0	1	CD-3_100yr
D-OF-CD01:OF-0116	IRREGULAR	0	0	1	CD-2_100yr
IB-1048:OF-0119	HORIZ_ELLIPSE	4	0	1	
IB-1051:MH-0374	HORIZ_ELLIPSE	6	0	2	
IB-1053:IB-1051	CIRCULAR	2	0	1	
IB-1053A:IB-1053	CIRCULAR	2	0	1	
IB-1062:OF-0116	HORIZ_ELLIPSE	4	0	1	
IB-1066:OF-0115	CIRCULAR	2	0	1	
IB-1703:OF-0111	CIRCULAR	1.25	0	1	
IB-CD02:OF-CD01	HORIZ_ELLIPSE	2	0	1	
IB-CD03:IB-CD02	HORIZ_ELLIPSE	2	0	1	
IB-CD04:IB-CD03	HORIZ_ELLIPSE	2	0	1	
IB-CD08:MH-CD07	HORIZ_ELLIPSE	2	0	1	
MH-0373:OF-0118	HORIZ_ELLIPSE	6	0	2	
MH-0374:MH-0373	HORIZ_ELLIPSE	6	0	2	
MH-CD05:IB-CD04	HORIZ_ELLIPSE	2	0	1	
MH-CD06:MH-CD05	HORIZ_ELLIPSE	2	0	1	
MH-CD07:MH-CD06	HORIZ_ELLIPSE	2	0	1	
O_CD-0002:ND-0005	IRREGULAR	0	0	1	O_CD-0002:ND-0005
O_IB-1048:ND-0003	IRREGULAR	0	0	1	O_IB-1048:ND-0003
O_IB-1048:OF-0009	IRREGULAR	0	0	1	O_IB-1048:OF-0009
O_IB-1051:ND-0007	IRREGULAR	0	0	1	O_IB-1051:ND-0007
O_IB-1051:OF-0006	IRREGULAR	0	0	1	O_IB-1051:OF-0006
O_IB-1053A:IB-1051	IRREGULAR	0	0	1	O_IB-1053A:IB-1051
O_IB-1053A:IB-CD08	IRREGULAR	0	0	1	O_IB-1053A:IB-CD08
O_IB-1053A:OF-0005	IRREGULAR	0	0	1	O_IB-1053A:OF-0005
O_IB-1062:ND-0005	IRREGULAR	0	0	1	O_IB-1062:ND-0005
O_IB-1062:OF-0010	IRREGULAR	0	0	1	O_IB-1062:OF-0010
O_IB-1066:OF-0001	IRREGULAR	0	0	1	O_IB-1066:OF-0001
O_IB-1703:OF-0003	IRREGULAR	0	0	1	O_IB-1703:OF-0003
O_IB-1703:OF-0011	IRREGULAR	0	0	1	O_IB-1703:OF-0011
O_IB-CD02:ND-0004	IRREGULAR	0	0	1	O_IB-CD02:ND-0004
O_IB-CD08:IB-CD02	IRREGULAR	0	0	1	O_IB-CD08:IB-CD02
O_IB-CD08:ND-0006	IRREGULAR	0	0	1	O_IB-CD08:ND-0006
O_IB-CD08:OF-0004	IRREGULAR	0	0	1	O_IB-CD08:OF-0004

Name	Cross-Section	Geom1 (ft)	Geom2 (ft)	Barrels	Transect
O_MH-0373:IB-CD02	IRREGULAR	0	0	1	O_MH-0373:IB-CD02
O_MH-0373:ND-0009	IRREGULAR	0	0	1	O_MH-0373:ND-0009
O_ND-0003:IB-1062	IRREGULAR	0	0	1	O_ND-0003:IB-1062
O_ND-0004:IB-1066	IRREGULAR	0	0	1	O_ND-0004:IB-1066
O_ND-0005:IB-1066	IRREGULAR	0	0	1	O_ND-0005:IB-1066
O_ND-0005:OF-0012	IRREGULAR	0	0	1	O_ND-0005:OF-0012
O_ND-0006:IB-1703	IRREGULAR	0	0	1	O_ND-0006:IB-1703
O_ND-0006:OF-0002	IRREGULAR	0	0	1	O_ND-0006:OF-0002
O_ND-0007:ND-0008	IRREGULAR	0	0	1	O_ND-0007:ND-0008
O_ND-0008:OF-0007	IRREGULAR	0	0	1	O_ND-0008:OF-0007
O_ND-0009:OF-0008	IRREGULAR	0	0	1	O_ND-0009:OF-0008

Table A-12: Mitigation Alternative #2- HU

Name	Rain Gage	Outlet	Area (ac)	Width (ft)	Slope (%)	Imperv. (%)
CD-01	Gage1	OF-0116	8.1	2286	2.21	22.4
CD-02	Gage1	IB-1062	4.2	461	0.43	34.7
CD-03	Gage1	MH-0373	7.1	530	0.45	32.3
CD-04	Gage1	IB-1051	8.5	521	0.40	30.7
CD-05	Gage1	IB-1048	6.4	629	0.36	31.2
CD-06	Gage1	CD-0001	5.0	1436	2.08	22.4
CD-07	Gage1	ND-0001	3.8	423	0.40	37.2
CD-08	Gage1	IB-1053A	4.8	490	0.75	33.7
CD-09	Gage1	ND-0002	0.7	266	0.81	45.5
FD-01	Gage1	IB-1703	4.3	461	0.54	32.4
QC-01	Gage1	IB-1066	7.6	424	0.27	33.4

Name	N Imperv	N Perv	Dstore Imperv (in)	Dstore Perv (in)	Zero Imperv (%)	Subarea Routing	Percent Routed (%)
CD-01	0.015	0.250	0.10	0.25	25	PERVIOUS	34.3
CD-02	0.015	0.252	0.10	0.25	25	PERVIOUS	35.0
CD-03	0.015	0.250	0.10	0.25	25	PERVIOUS	34.3
CD-04	0.015	0.250	0.10	0.25	25	PERVIOUS	32.5
CD-05	0.015	0.250	0.10	0.25	25	PERVIOUS	34.3
CD-06	0.015	0.250	0.10	0.25	25	PERVIOUS	34.3
CD-07	0.015	0.250	0.10	0.25	25	PERVIOUS	34.3
CD-08	0.015	0.250	0.10	0.25	25	PERVIOUS	34.3
CD-09	0.015	0.250	0.10	0.25	25	PERVIOUS	34.3
FD-01	0.017	0.250	0.11	0.25	25	PERVIOUS	30.5

Name	Infiltration Method	Max. Infil. Rate (in/hr)	Min. Infil. Rate (in/hr)	Decay Constant (1/hr)	Drying Time (days)	Max. Volume (in)
CD-01	HORTON	5	0.5	2.002	2.1	4
CD-02	HORTON	5	0.5	2.002	2.1	4
CD-03	HORTON	5	0.5	2.002	2.1	4
CD-04	HORTON	5	0.5	2.002	2.1	4
CD-05	HORTON	5	0.5	2.002	2.1	4
CD-06	HORTON	5	0.5	2.002	2.1	4
CD-07	HORTON	5	0.5	2.002	2.1	4
CD-08	HORTON	5	0.5	2.002	2.1	4
CD-09	HORTON	5	0.5	2.002	2.1	4
FD-01	HORTON	5	0.5	2.002	2.1	4
QC-01	HORTON	5	0.5	2.002	2.1	4

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Appendix B

Detailed Model Results

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Table B-1: Existing Condition Model Peak Levels

Junction attributes	St. Augustine Existing Condition 5 Yr	St. Augustine Existing Condition 25 Yr	St. Augustine Existing Condition 100 Yr
IB-1051 - Max. HGL (ft)	4.3	4.8	5.1
MH-0374 - Max. HGL (ft)	4.0	4.6	4.9
MH-0373 - Max. HGL (ft)	3.9	4.5	4.8
OF-0119 - Max. HGL (ft)	3.5	3.9	4.2
OF-0118 - Max. HGL (ft)	3.5	3.9	4.2
OF-0116 - Max. HGL (ft)	3.4	3.9	4.1
IB-1048 - Max. HGL (ft)	3.8	4.5	4.8
IB-1703 - Max. HGL (ft)	3.5	4.1	4.3
IB-1062 - Max. HGL (ft)	3.5	3.9	4.1
IB-1066 - Max. HGL (ft)	3.3	3.8	4.1
CD-0002 - Max. HGL (ft)	3.3	3.7	4.0
CD-0001 - Max. HGL (ft)	3.5	4.0	4.3
ND-0001 - Max. HGL (ft)	4.8	5.0	5.1
ND-0002 - Max. HGL (ft)	4.8	4.9	5.0
ND-0006 - Max. HGL (ft)	4.5	4.5	5.0
ND-0004 - Max. HGL (ft)	3.9	4.4	4.5
ND-0003 - Max. HGL (ft)	4.1	4.1	4.8
ND-0005 - Max. HGL (ft)	3.4	3.4	3.7
ND-0007 - Max. HGL (ft)	4.3	4.8	5.1
ND-0008 - Max. HGL (ft)	4.3	4.9	5.1
ND-0009 - Max. HGL (ft)	3.9	4.5	4.8
IB-1053 - Max. HGL (ft)	4.3	4.8	5.1
IB-1053A - Max. HGL (ft)	4.3	4.9	5.1

Table B-2: Existing Condition Model Conduit Flow Rate

Conduit attributes	St. Augustine Existing Condition 5 Yr	St. Augustine Existing Condition 25 Yr	St. Augustine Existing Condition 100 Yr
IB-1066:OF-0115 - Max. |Flow| (cfs)	8.8	12.9	14.6
MH-0374:MH-0373 - Max. |Flow| (cfs)	12.4	14.6	14.6
MH-0373:OF-0118 - Max. |Flow| (cfs)	16.0	20.6	20.4
IB-1051:MH-0374 - Max. |Flow| (cfs)	12.4	14.6	14.6
IB-1703:OF-0111 - Max. |Flow| (cfs)	6.6	9.4	10.2
IB-1048:OF-0119 - Max. |Flow| (cfs)	8.3	10.3	12.1
IB-1062:OF-0116 - Max. |Flow| (cfs)	5.5	5.6	6.3
CD-0002:CD-0003A - Max. |Flow| (cfs)	20.4	29.1	33.3
D-CD-0001:OF-0119 - Max. |Flow| (cfs)	9.4	24.5	32.9
D-OF-0119:OF-0118 - Max. |Flow| (cfs)	13.6	27.2	32.2
D-OF-0118:OF-0116 - Max. |Flow| (cfs)	26.4	38.8	45.6
D-OF-0116:CD-0002 - Max. |Flow| (cfs)	40.9	58.5	69.8
CD-0002:CD-0003B - Max. |Flow| (cfs)	20.4	29.1	33.3
O_ND-0002:ND-0001 - Max. |Flow| (cfs)	0.1	1.2	3.8
O_IB-1053A:ND-0001 - Max. |Flow| (cfs)	5.2	10.2	16.0
O_MH-0373:ND-0002 - Max. |Flow| (cfs)	0.0	0.6	2.6
O_ND-0001:ND-0006 - Max. |Flow| (cfs)	0.0	0.0	0.1
O_ND-0006:IB-1703 - Max. |Flow| (cfs)	0.0	0.0	0.0
O_IB-1703:OF-0003 - Max. |Flow| (cfs)	0.0	0.0	0.0
O_ND-0002:ND-0004 - Max. |Flow| (cfs)	0.0	0.1	0.9
O_ND-0004:IB-1066 - Max. |Flow| (cfs)	0.0	0.1	0.9
O_ND-0007:ND-0008 - Max. |Flow| (cfs)	0.0	4.3	12.2
O_IB-1048:OF-0009 - Max. |Flow| (cfs)	0.0	0.0	0.0
O_IB-1048:ND-0003 - Max. |Flow| (cfs)	0.0	0.0	1.1
O_ND-0003:IB-1062 - Max. |Flow| (cfs)	0.0	0.0	1.0
O_ND-0005:IB-1066 - Max. |Flow| (cfs)	0.0	0.0	0.0
O_IB-1062:ND-0005 - Max. |Flow| (cfs)	0.0	0.0	0.0
O_ND-0001:OF-0004 - Max. |Flow| (cfs)	0.0	0.0	0.0
O_IB-1053A:OF-0005 - Max. |Flow| (cfs)	0.0	0.0	1.4
O_MH-0373:ND-0009 - Max. |Flow| (cfs)	0.0	6.1	11.0
O_IB-1066:OF-0001 - Max. |Flow| (cfs)	0.0	2.0	11.6
O_ND-0006:OF-0002 - Max. |Flow| (cfs)	0.0	0.0	0.0
O_IB-1062:OF-0010 - Max. |Flow| (cfs)	0.0	6.8	17.7
O_IB-1051:OF-0006 - Max. |Flow| (cfs)	0.0	6.3	19.8
O_ND-0008:OF-0007 - Max. |Flow| (cfs)	0.0	0.0	0.1

Conduit attributes	St. Augustine Existing Condition 5 Yr	St. Augustine Existing Condition 25 Yr	St. Augustine Existing Condition 100 Yr
O_IB-1051:ND-0007 - Max. |Flow| (cfs)	1.1	10.0	24.8
O_ND-0009:OF-0008 - Max. |Flow| (cfs)	0.0	1.7	10.7
O_IB-1703:OF-0011 - Max. |Flow| (cfs)	0.0	1.8	12.1
O_CD-0002:ND-0005 - Max. |Flow| (cfs)	0.0	0.0	1.2
O_ND-0005:OF-0012 - Max. |Flow| (cfs)	0.0	0.0	1.2
IB-1053:IB-1051 - Max. |Flow| (cfs)	3.8	3.5	3.3
O_IB-1053A:IB-1051 - Max. |Flow| (cfs)	5.9	11.2	22.4
IB-1053A:IB-1053 - Max. |Flow| (cfs)	3.8	3.5	3.3

Table B-3: Mitigation Alternative #1 Peak Levels

Junction attributes	St. Augustine Mitigation #1- 5 Yr	St. Augustine Mitigation #1- 25 Yr	St. Augustine Mitigation #1- 100 Yr
IB-1051 - Max. HGL (ft)	3.9	4.8	5.0
MH-0374 - Max. HGL (ft)	3.7	4.4	4.8
MH-0373 - Max. HGL (ft)	3.7	4.3	4.7
OF-0119 - Max. HGL (ft)	3.2	3.6	3.8
OF-0118 - Max. HGL (ft)	3.2	3.6	3.8
OF-0116 - Max. HGL (ft)	3.1	3.5	3.8
IB-1048 - Max. HGL (ft)	3.6	4.4	4.7
IB-1703 - Max. HGL (ft)	3.5	4.1	4.3
IB-1062 - Max. HGL (ft)	3.3	3.8	4.0
IB-1066 - Max. HGL (ft)	3.3	3.8	4.0
CD-0002 - Max. HGL (ft)	3.1	3.4	3.7
CD-0001 - Max. HGL (ft)	3.2	3.6	3.9
ND-0001 - Max. HGL (ft)	4.6	4.9	5.0
ND-0002 - Max. HGL (ft)	3.4	3.9	4.2
ND-0006 - Max. HGL (ft)	4.5	4.5	4.5
ND-0004 - Max. HGL (ft)	4.3	4.3	4.3
ND-0003 - Max. HGL (ft)	4.1	4.1	4.7
ND-0005 - Max. HGL (ft)	3.4	3.4	3.4
ND-0007 - Max. HGL (ft)	3.9	4.8	5.0
ND-0008 - Max. HGL (ft)	4.3	4.8	5.0
ND-0009 - Max. HGL (ft)	3.9	4.3	4.7
IB-1053 - Max. HGL (ft)	4.0	4.8	5.0
IB-1053A - Max. HGL (ft)	4.1	4.8	5.0
IB-CD03 - Max. HGL (ft)	3.4	3.9	4.3
IB-CD04 - Max. HGL (ft)	3.6	4.1	4.4
MH-CD05 - Max. HGL (ft)	3.8	4.2	4.5
MH-CD06 - Max. HGL (ft)	4.0	4.8	4.9
MH-CD07 - Max. HGL (ft)	4.3	6.3	5.5
OF-CD01 - Max. HGL (ft)	3.2	3.5	3.8

Table B-4: Mitigation Alternative #1 Conduit Flow Rate

Conduit attributes	St. Augustine Mitigation #1- 5 Yr	St. Augustine Mitigation #1- 25 Yr	St. Augustine Mitigation #1- 100 Yr
IB-1066:OF-0115 - Max. |Flow| (cfs)	8.6	12.7	14.5
MH-0374:MH-0373 - Max. |Flow| (cfs)	9.9	15.1	15.6
MH-0373:OF-0118 - Max. |Flow| (cfs)	16.7	22.8	24.7
IB-1051:MH-0374 - Max. |Flow| (cfs)	9.9	15.1	15.6
IB-1703:OF-0111 - Max. |Flow| (cfs)	6.6	9.4	10.2
IB-1048:OF-0119 - Max. |Flow| (cfs)	8.6	12.3	14.5
IB-1062:OF-0116 - Max. |Flow| (cfs)	6.5	7.7	7.8
CD-0002:CD-0003A - Max. |Flow| (cfs)	26.9	44.8	54.6
D-CD-0001:OF-0119 - Max. |Flow| (cfs)	12.3	23.2	34.0
D-OF-0119:OF-0118 - Max. |Flow| (cfs)	17.4	28.3	38.8
D-OF-0116:CD-0002 - Max. |Flow| (cfs)	53.9	89.9	111.1
CD-0002:CD-0003B - Max. |Flow| (cfs)	26.9	44.8	54.6
O_ND-0006:IB-1703 - Max. |Flow| (cfs)	0.0	0.0	0.0
O_IB-1703:OF-0003 - Max. |Flow| (cfs)	0.0	0.0	0.0
O_ND-0004:IB-1066 - Max. |Flow| (cfs)	0.0	0.0	0.0
O_ND-0007:ND-0008 - Max. |Flow| (cfs)	0.0	3.0	11.0
O_IB-1048:OF-0009 - Max. |Flow| (cfs)	0.0	0.0	0.0
O_IB-1048:ND-0003 - Max. |Flow| (cfs)	0.0	0.0	0.4
O_ND-0003:IB-1062 - Max. |Flow| (cfs)	0.0	0.0	0.3
O_ND-0005:IB-1066 - Max. |Flow| (cfs)	0.0	0.0	0.0
O_IB-1062:ND-0005 - Max. |Flow| (cfs)	0.0	0.0	0.0
O_IB-1053A:OF-0005 - Max. |Flow| (cfs)	0.0	0.0	0.1
O_MH-0373:ND-0009 - Max. |Flow| (cfs)	0.0	3.8	9.9
O_IB-1066:OF-0001 - Max. |Flow| (cfs)	0.0	1.5	10.6
O_ND-0006:OF-0002 - Max. |Flow| (cfs)	0.0	0.0	0.0
O_IB-1062:OF-0010 - Max. |Flow| (cfs)	0.0	4.1	13.8
O_IB-1051:OF-0006 - Max. |Flow| (cfs)	0.0	1.9	17.0
O_ND-0008:OF-0007 - Max. |Flow| (cfs)	0.0	0.0	0.0
O_IB-1051:ND-0007 - Max. |Flow| (cfs)	0.1	7.9	22.5
O_ND-0009:OF-0008 - Max. |Flow| (cfs)	0.0	0.0	6.0
O_IB-1703:OF-0011 - Max. |Flow| (cfs)	0.0	1.8	12.1
O_CD-0002:ND-0005 - Max. |Flow| (cfs)	0.0	0.0	0.0
O_ND-0005:OF-0012 - Max. |Flow| (cfs)	0.0	0.0	0.0
IB-1053:IB-1051 - Max. |Flow| (cfs)	3.6	3.7	3.4
O_IB-1053A:IB-1051 - Max. |Flow| (cfs)	2.1	8.6	19.7
IB-1053A:IB-1053 - Max. |Flow| (cfs)	3.6	3.7	3.4
D-OF-0118:OF-CD01 - Max. |Flow| (cfs)	31.7	48.5	56.8

Conduit attributes	St. Augustine Mitigation #1- 5 Yr	St. Augustine Mitigation #1- 25 Yr	St. Augustine Mitigation #1- 100 Yr
O_IB-CD08:IB-CD02 - Max. |Flow| (cfs)	0.0	0.0	0.8
O_IB-1053A:IB-CD08 - Max. |Flow| (cfs)	0.3	6.4	14.1
O_MH-0373:IB-CD02 - Max. |Flow| (cfs)	0.0	0.0	0.0
O_IB-CD08:ND-0006 - Max. |Flow| (cfs)	0.0	0.0	0.0
O_IB-CD02:ND-0004 - Max. |Flow| (cfs)	0.0	0.0	0.0
O_IB-CD08:OF-0004 - Max. |Flow| (cfs)	0.0	0.0	0.0
D-OF-CD01:OF-0116 - Max. |Flow| (cfs)	37.2	56.3	67.2
MH-CD07:MH-CD06 - Max. |Flow| (cfs)	4.8	5.0	5.1
MH-CD06:MH-CD05 - Max. |Flow| (cfs)	4.8	5.0	5.1
MH-CD05:IB-CD04 - Max. |Flow| (cfs)	4.8	5.0	5.1
IB-CD04:IB-CD03 - Max. |Flow| (cfs)	4.8	5.0	5.1
IB-CD03:IB-CD02 - Max. |Flow| (cfs)	4.8	5.0	5.1
IB-CD02:OF-CD01 - Max. |Flow| (cfs)	6.6	8.0	9.2
IB-CD08:MH-CD07 - Max. |Flow| (cfs)	4.8	5.0	5.1

Table B-5: Mitigation Alternative #2 Peak Levels

Junction attributes	St. Augustine Mitigation #2-5 Yr	St. Augustine Mitigation #2-25 Yr	St. Augustine Mitigation #2-100 Yr
IB-1051 - Max. HGL (ft)	3.0	3.9	4.7
MH-0374 - Max. HGL (ft)	3.0	3.8	4.5
MH-0373 - Max. HGL (ft)	3.0	3.7	4.4
OF-0119 - Max. HGL (ft)	2.9	3.4	3.9
OF-0118 - Max. HGL (ft)	2.9	3.4	3.9
OF-0116 - Max. HGL (ft)	2.9	3.4	3.8
IB-1048 - Max. HGL (ft)	3.0	3.8	4.5
IB-1703 - Max. HGL (ft)	3.5	4.1	4.3
IB-1062 - Max. HGL (ft)	2.9	3.6	4.0
IB-1066 - Max. HGL (ft)	3.3	3.8	4.1
CD-0002 - Max. HGL (ft)	2.9	3.4	3.8
CD-0001 - Max. HGL (ft)	2.9	3.4	3.9
ND-0001 - Max. HGL (ft)	3.3	4.7	5.0
ND-0002 - Max. HGL (ft)	3.0	3.9	4.4
ND-0006 - Max. HGL (ft)	4.5	4.5	4.5
ND-0004 - Max. HGL (ft)	4.3	4.3	4.3
ND-0003 - Max. HGL (ft)	4.1	4.1	4.1
ND-0005 - Max. HGL (ft)	3.4	3.4	3.5
ND-0007 - Max. HGL (ft)	3.9	3.9	4.7
ND-0008 - Max. HGL (ft)	4.3	4.3	4.7
ND-0009 - Max. HGL (ft)	3.9	3.9	4.4
IB-1053 - Max. HGL (ft)	3.0	4.0	4.7
IB-1053A - Max. HGL (ft)	3.0	4.2	4.7
IB-CD03 - Max. HGL (ft)	3.0	3.9	4.4
IB-CD04 - Max. HGL (ft)	3.0	4.1	4.5
MH-CD05 - Max. HGL (ft)	3.0	4.2	4.6
MH-CD06 - Max. HGL (ft)	3.1	4.4	4.7
MH-CD07 - Max. HGL (ft)	3.3	4.6	4.9
OF-CD01 - Max. HGL (ft)	2.9	3.4	3.9

Table B-6: Mitigation Alternative #2 Conduit Flow Rate

Conduit attributes	St. Augustine Mitigation #2- 5 Yr	St. Augustine Mitigation #2- 25 Yr	St. Augustine Mitigation #2- 100 Yr
IB-1066:OF-0115 - Max. |Flow| (cfs)	8.6	12.7	14.5
MH-0374:MH-0373 - Max. |Flow| (cfs)	15.8	27.6	36.2
MH-0373:OF-0118 - Max. |Flow| (cfs)	24.0	47.3	52.0
IB-1051:MH-0374 - Max. |Flow| (cfs)	16.7	27.6	36.1
IB-1703:OF-0111 - Max. |Flow| (cfs)	6.6	9.4	10.2
IB-1048:OF-0119 - Max. |Flow| (cfs)	8.3	19.6	19.0
IB-1062:OF-0116 - Max. |Flow| (cfs)	6.3	14.4	13.6
CD-0002:CD-0003A - Max. |Flow| (cfs)	10.3	44.4	59.8
D-CD-0001:OF-0119 - Max. |Flow| (cfs)	3.4	22.3	31.8
D-OF-0119:OF-0118 - Max. |Flow| (cfs)	7.3	27.8	36.4
D-OF-0116:CD-0002 - Max. |Flow| (cfs)	20.3	90.2	122.4
CD-0002:CD-0003B - Max. |Flow| (cfs)	10.3	44.4	59.8
O_ND-0006:IB-1703 - Max. |Flow| (cfs)	0.0	0.0	0.0
O_IB-1703:OF-0003 - Max. |Flow| (cfs)	0.0	0.0	0.0
O_ND-0004:IB-1066 - Max. |Flow| (cfs)	0.0	0.0	0.0
O_ND-0007:ND-0008 - Max. |Flow| (cfs)	0.0	0.0	3.6
O_IB-1048:OF-0009 - Max. |Flow| (cfs)	0.0	0.0	0.0
O_IB-1048:ND-0003 - Max. |Flow| (cfs)	0.0	0.0	0.0
O_ND-0003:IB-1062 - Max. |Flow| (cfs)	0.0	0.0	0.0
O_ND-0005:IB-1066 - Max. |Flow| (cfs)	0.0	0.0	0.0
O_IB-1062:ND-0005 - Max. |Flow| (cfs)	0.0	0.0	0.0
O_IB-1053A:OF-0005 - Max. |Flow| (cfs)	0.0	0.0	0.0
O_MH-0373:ND-0009 - Max. |Flow| (cfs)	0.0	0.0	4.2
O_IB-1066:OF-0001 - Max. |Flow| (cfs)	0.0	1.5	10.6
O_ND-0006:OF-0002 - Max. |Flow| (cfs)	0.0	0.0	0.0
O_IB-1062:OF-0010 - Max. |Flow| (cfs)	0.0	0.1	8.3
O_IB-1051:OF-0006 - Max. |Flow| (cfs)	0.0	0.0	1.3
O_ND-0008:OF-0007 - Max. |Flow| (cfs)	0.0	0.0	0.0
O_IB-1051:ND-0007 - Max. |Flow| (cfs)	0.0	0.0	10.1
O_ND-0009:OF-0008 - Max. |Flow| (cfs)	0.0	0.0	0.1
O_IB-1703:OF-0011 - Max. |Flow| (cfs)	0.0	1.8	12.1
O_CD-0002:ND-0005 - Max. |Flow| (cfs)	0.0	0.0	0.1
O_ND-0005:OF-0012 - Max. |Flow| (cfs)	0.0	0.0	0.1
IB-1053:IB-1051 - Max. |Flow| (cfs)	7.8	12.0	10.3
O_IB-1053A:IB-1051 - Max. |Flow| (cfs)	0.0	4.7	18.8
IB-1053A:IB-1053 - Max. |Flow| (cfs)	7.9	12.0	10.3
D-OF-0118:OF-CD01 - Max. |Flow| (cfs)	15.4	61.5	84.1

Conduit attributes	St. Augustine Mitigation #2- 5 Yr	St. Augustine Mitigation #2- 25 Yr	St. Augustine Mitigation #2- 100 Yr
O_IB-CD08:IB-CD02 - Max. |Flow| (cfs)	0.0	0.0	0.4
O_IB-1053A:IB-CD08 - Max. |Flow| (cfs)	0.0	2.4	10.8
O_MH-0373:IB-CD02 - Max. |Flow| (cfs)	0.0	0.0	0.0
O_IB-CD08:ND-0006 - Max. |Flow| (cfs)	0.0	0.0	0.0
O_IB-CD02:ND-0004 - Max. |Flow| (cfs)	0.0	0.0	0.0
O_IB-CD08:OF-0004 - Max. |Flow| (cfs)	0.0	0.0	0.0
D-OF-CD01:OF-0116 - Max. |Flow| (cfs)	17.4	69.0	95.0
MH-CD07:MH-CD06 - Max. |Flow| (cfs)	6.2	9.1	8.9
MH-CD06:MH-CD05 - Max. |Flow| (cfs)	6.2	9.1	8.9
MH-CD05:IB-CD04 - Max. |Flow| (cfs)	6.2	9.1	8.9
IB-CD04:IB-CD03 - Max. |Flow| (cfs)	6.2	9.1	8.8
IB-CD03:IB-CD02 - Max. |Flow| (cfs)	6.1	9.1	8.7
IB-CD02:OF-CD01 - Max. |Flow| (cfs)	8.1	12.6	11.7
IB-CD08:MH-CD07 - Max. |Flow| (cfs)	6.2	9.1	9.0

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Appendix C

Additional Flood Maps

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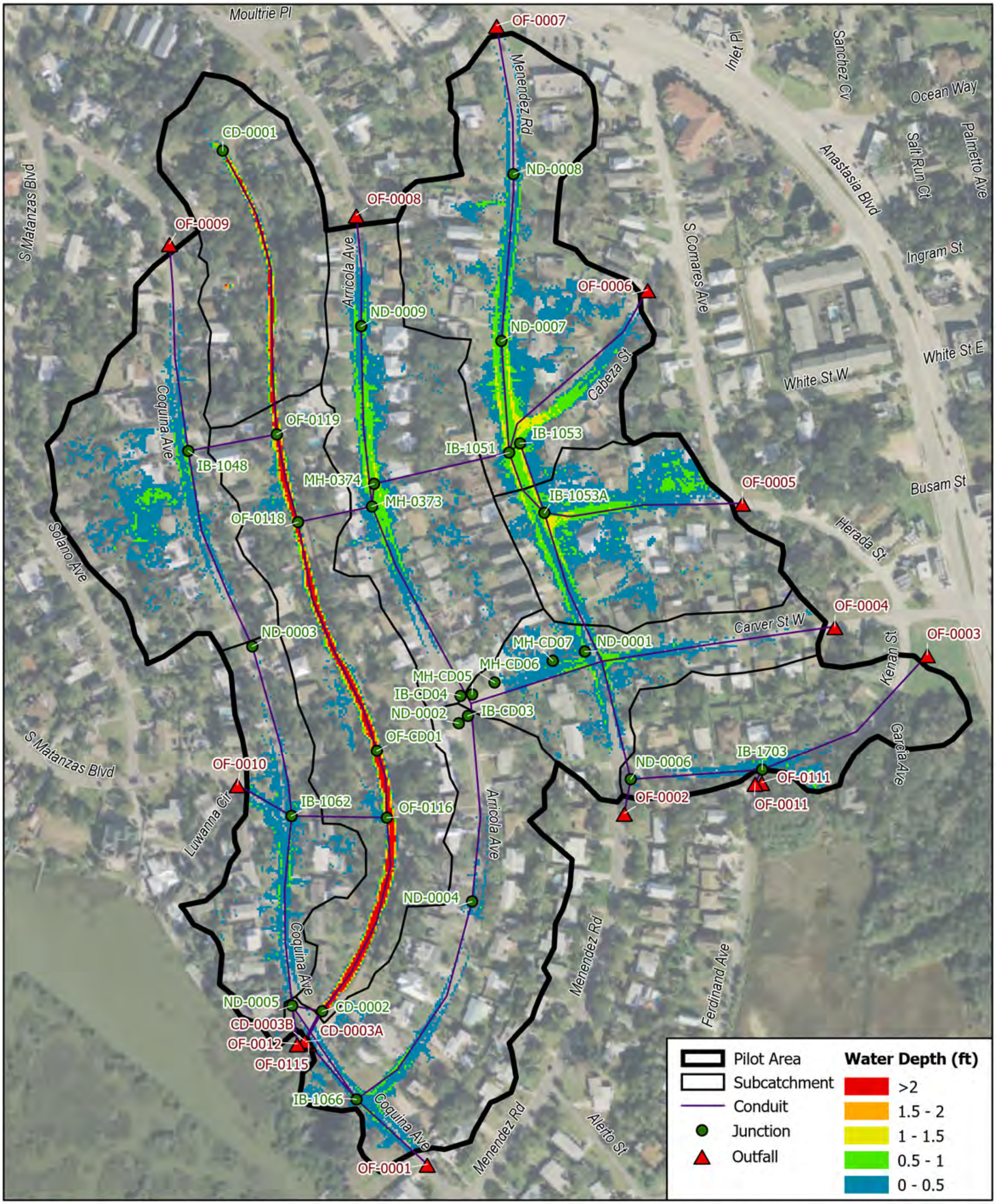
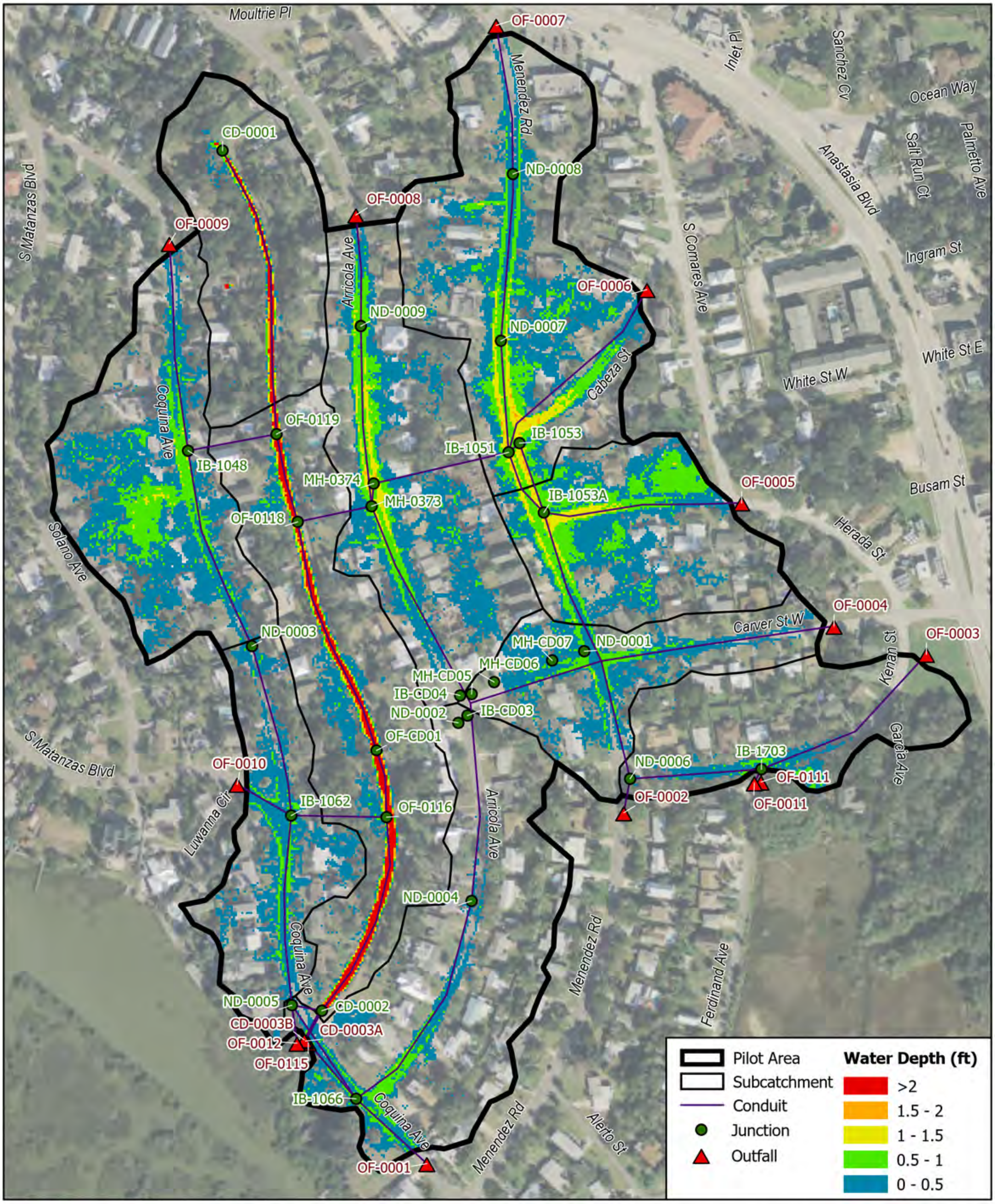


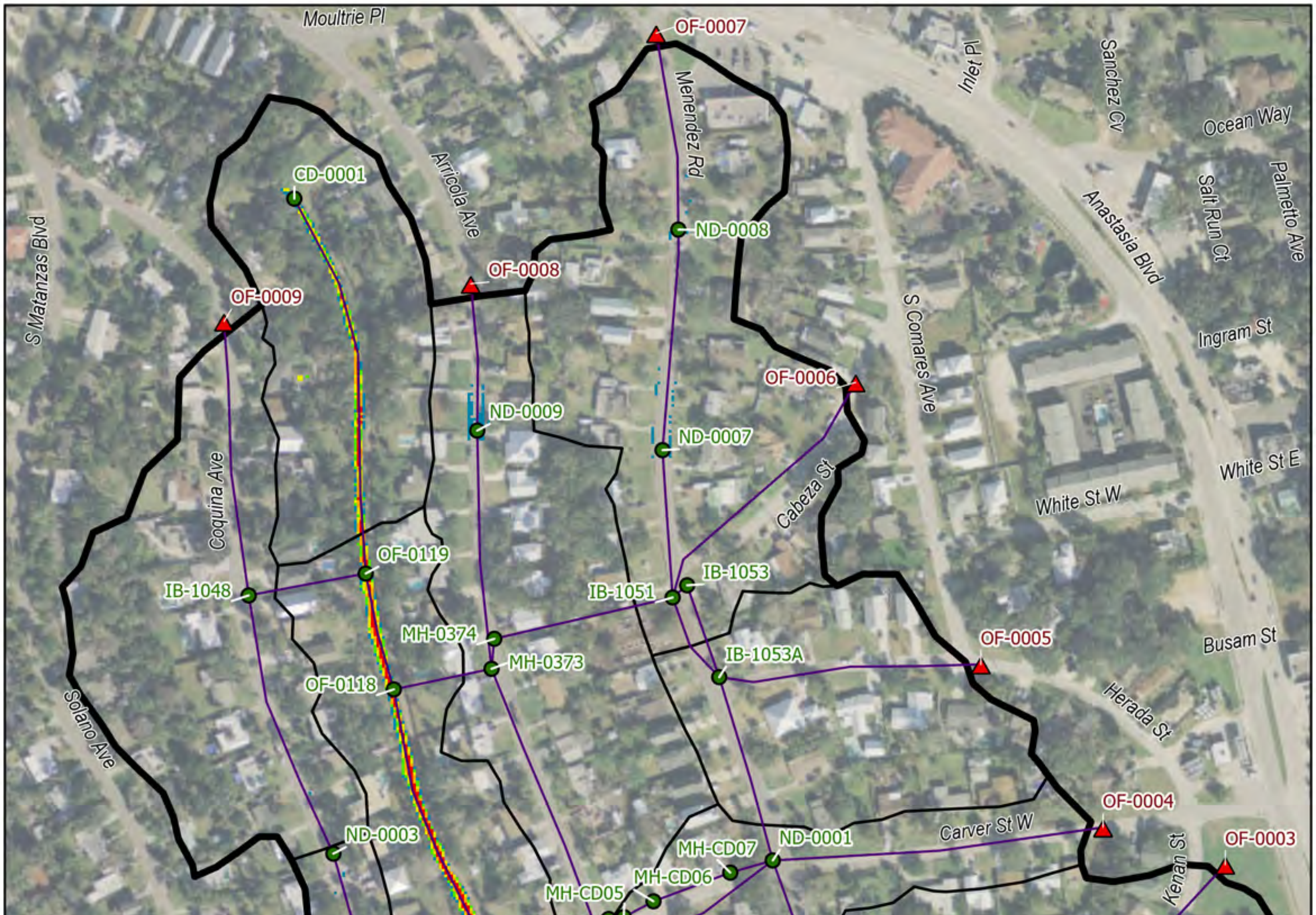
CDM Smith

Figure C-1: Mitigation Alternative #1
25-Year Rainfall (8.90")
1-Year Stillwater Elevation (2.9')
City of St. Augustine, FL



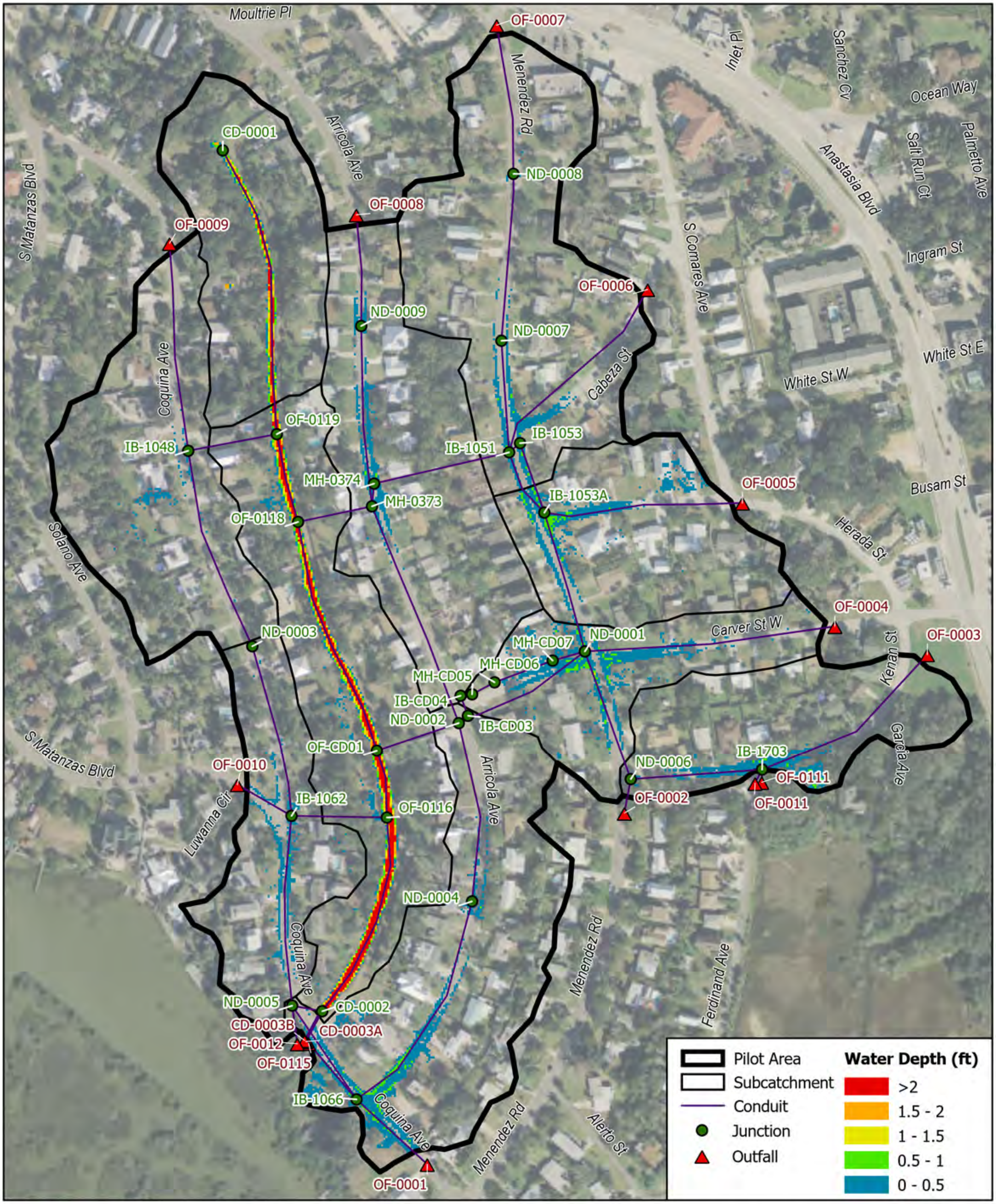
CDM Smith

Figure C-2: Mitigation Alternative #1
100-Year Rainfall (12.40")
1-Year Stillwater Elevation (2.9')
City of St. Augustine, FL



CDM Smith

Figure C-3: Mitigation Alternative #2
5-Year Rainfall (5.79")
1-Year Stillwater Elevation (2.9')
City of St. Augustine, FL



CDM Smith

Figure C-4: Mitigation Alternative #2
25-Year Rainfall (8.90")
1-Year Stillwater Elevation (2.9')
City of St. Augustine, FL

Appendix D

Conceptual Capital Cost Estimates

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Table D-1: Mitigation Alternative #1 Conceptual Capital Cost Estimates

Project	Upgrades	Sizing	Quantity	Unit	Unit Cost	Project Cost	Comments
Coquina Ditch Storm Sewer Improvements	Pipes along Carver St. (Coquina Ditch storm sewer plan)	14"x23"	357	LF	$77.63	$27,700	
	Pipes from Arricola Ave. to Coquina Ditch (Coquina Ditch storm sewer plan)	19"x30"	215	LF	$105.29	$22,600	
	FDOT Type 9 Inlet	< 10'	6	EA	$4,700.00	$28,200	
	Inline Manhole	< 8'	3	EA	$5,000.00	$15,000	
	General Excavation and Backfill for Pipe Trench	General Exc.	212	CY	$10.00	$2,100	Excavation and Backfill ($6 excavation/$4 backfill). Based on (footage of pipe)*(cross sectional area for excavation).
Coquina Ditch Regrade	Coquina Ditch Regrading 10 ft bottom width and 4:1 slope	General Exc.	1185	CY	$15.00	$17,800	Expansion of storage capacity. Excavation only $6/CY $6.00/CY grading $1.50/CY Haul off cost. Grass Seed for erosion control = $1.50/CY
Coquina Ditch Culvert Upsize	Coquina Ditch culvert	48"	160	LF	$224.00	$35,800	
	Coquina Ditch Culvert Endwall		20.8	CY	$1,210.00	$25,200	Class II Concrete Endwall @ 10.4 CY per endwall. 2 endwalls for project.
	Inline check valve	48"	2	EA	$24,025.00	$48,000	Red Valve CheckMate Inline Check Valve. Phone quote from Red Valve.
	General Excavation and Backfill for Pipe Trench	General Exc.	213	CY	$10.00	$2,100	Excavation and Backfill ($6 excavation/$4 backfill). Based on (footage of pipe)*(cross sectional area for excavation).
Inlet Upgrades	FDOT Type 2 Inlet	<10'	12	EA	$7,700.00	$92,400	

Project	Upgrades	Sizing	Quantity	Unit	Unit Cost	Project Cost	Comments
Intersection Improvements	Intersection Milling		3600	SY	$2.65	$9,500	Three intersections @ .25 AC Each. 2" Mill.
	Intersection Resurfacing		405	TN	$166.00	$67,200	Three intersections @ .25 AC Each. Miscellaneous asphalt pavement. Tonnage developed from calculator at http://www.csgnetwork.com/asphaltmixcalc.html
Miscellaneous	Mobilization		1	LS	$25,000.00	$25,000	
	Maintenance of Traffic		30	Day	$643.00	$19,300	
	Dewatering Allowance		30	Day	$350.00	$10,500	$35/hr X 10hr/day
			Subtotal			$448,400	
			Contingency			$134,500	30% of Subtotal
			Subtotal with Contingency			$582,900	
			Engineering, Permitting, and Surveying			$116,600	20% of Subtotal with Contingency
			Total Conceptual Capital Cost			$699,500	

Table D-2: Mitigation Alternative #2 Conceptual Capital Cost Estimates

Project	Upgrades	Sizing	Quantity	Unit	Unit Cost	Project Cost	Comments
Coquina Ditch Storm Sewer Improvements	Pipes along Carver St. (Coquina Ditch storm sewer plan)	19"x30"	357	LF	$105.29	$37,600	
	Pipes from Arricola Ave. to Coquina Ditch (Coquina Ditch storm sewer plan)	19"x30"	215	LF	$105.29	$22,600	
	FDOT Type 9 Inlets	< 10'	5	EA	$4,700.00	$23,500	
	Inline Manhole	< 8'	3	EA	$5,000.00	$15,000	
	General Excavation and Backfill for Pipe Trench	General Exc.	339	CY	$10.00	$3,400	Excavation and Backfill ($6 excavation/$4 backfill). Based on (footage of pipe)*(cross sectional area for excavation).
Pipe Upsizes to Existing Pipes	Pipe from S Matanzas Blvd and Coquina Ave intersection to Coquina Ditch	24"x38"	223	LF	$162.00	$36,100	
	Pipe from Coquina Ave to Coquina Ditch	24"x38"	210	LF	$162.00	$34,000	
	Pipe along Menendez Rd from Herada St to Cabeza St	24"	203	LF	$77.00	$15,600	
	Pipe from Menendez Rd & Cabeza St to Arricola Ave	29"x45"	748	LF	$219.00	$163,800	Each barrel counted separately
	Pipe from Arricola Ave to Coquina Ditch	29"x45"	352	LF	$219.00	$77,100	Each barrel counted separately
	Excavation and Backfill	General Exc.	2315	CY	$10.00	$23,100	Excavation and Backfill ($6 excavation/$4 backfill). Based on (footage of pipe)*(cross sectional area for excavation).
Coquina Ditch Regrade	Coquina Ditch 1 ft dredge 20 ft bottom width and 4:1 slope	General Exc.	6111	CY	$16.00	$97,800	Expansion of storage capacity. Excavation only $6/CY $6.00/CY grading $1.50/CY Haul off cost. Grass Seed for erosion control = $1.50/CY Clearing and Grubbing addition: $1/CY

Project	Upgrades	Sizing	Quantity	Unit	Unit Cost	Project Cost	Comments
Coquina Ditch Culvert Upsize	Coquina Ditch culvert	48"	160	LF	$224.00	$35,800	
	Coquina Ditch Culvert Endwall		20.8	CY	$1,210.00	$25,200	Class II Concrete Endwall @ 10.4 CY per endwall. 2 endwalls for project.
	Inline check valve	48"	2	EA	$24,025.00	$48,000	Red Valve CheckMate Inline Check Valve
	Excavation and Backfill	General Exc.	213	CY	$10.00	$2,100	Excavation and Backfill ($6 excavation/$4 backfill). Based on (footage of pipe)*(cross sectional area for excavation).
Inlet Upgrades	FDOT Type 2 Inlets	<10'	22	EA	$7,700.00	$169,400	
Intersection Improvements	Intersection Milling		3600	SY	$2.65	$9,500	Three intersections @ .25 AC Each. 2" Mill
	Intersection Asphalt		405	TN	$166.00	$67,200	Three intersections @ .25 AC Each. Miscellaneous asphalt pavement. Tonnage developed from calculator at http://www.csgnetwork.com/asphaltmixcalc.html.
Miscellaneous	Mobilization		1	LS	$50,000.00	$50,000	
	Maintenance of Traffic		75	Day	$643.00	$48,200	
	Dewatering Allowance		75	Day	$350.00	$26,300	
			Subtotal			$1,031,300	
			Contingency			$309,400	30% of Subtotal
			Subtotal with Contingency			$1,340,700	
			Engineering, Permitting, and Surveying			$268,100	20% of Subtotal with Contingency
			Total Conceptual Capital Cost			$1,608,800	

Appendix E

Building Code Task Force Report

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CITY OF ST. AUGUSTINE

MEMORANDUM

TO: John Regan, P.E.
City Manager

DATE: March 8, 2021

RE: Building Code Task Force for Existing Properties – Final Report

The City Commission created the Building Code Task Force to explore ways to update the city code related to flood protection and resiliency. To focus the scope of the project even further, the Task Force was given three specific goals.

Goal #1 – Protect older homes from the flooding impacts of new home construction.

Goal #2 – Provide incentives for property owners to use building techniques which do not require land filling for new home construction.

Goal #3 – Limit the amount of impervious surface that is allowed on residential lots.

The Task Force held four public meetings and produced a final report to the City Commission with their findings and recommendations.

If the City Commission accepts the final report and chooses to move forward with the recommendations of the Task Force, city staff will forward the land development code changes to the Planning and Zoning Board for their review. The Planning and Zoning Board will have at least one public hearing and will make formal recommendations to the City Commission concerning any land development code changes.

Please place the Final Report of the Building Code Task Force on the March 8, 2021 City Commission agenda.

If you have any questions, please let me know.

David Birchim

David Birchim, AICP
Director, Planning and Building

Building Code Task Force for Existing Properties
Final Report and Recommendations

The City Commission created the Building Code Task Force for Existing Properties to explore amendments to the city's land development code. Specifically, the intent of this project is to increase stormwater resiliency within the city's older, established neighborhoods.

The City Commission instructed the Building Code Task Force to focus on three goals.

1. Protecting older homes from the drainage impacts of new homes that are required to be built at higher elevations.
2. Providing incentives for property owners to use building techniques which do not require land filling for new home construction.
3. Limiting the amount of impervious surface that is allowed on residential lots.

GOAL #1 – PROTECTING OLDER HOMES FROM DRAINAGE IMPACTS OF ADJACENT DEVELOPMENT

RECOMMENDATION

A. An approved lot grading plan will be required for building and site development for all infill residential single-family development, except those private communities with master stormwater plans, according to the following rules. The intent of this section is to safeguard residential properties from the drainage impacts of new development. These regulations will not apply to private communities with approved master stormwater infrastructure.

1. Before a building permit is issued, a survey will be submitted to include spot elevations of the property, the location and size of all roofed areas and impervious surfaces of the property and the elevations of all neighboring properties 10 feet outside of the boundaries of the subject property. The survey will be produced by a licensed surveyor and will be used to design a lot grading plan.
2. The property owner, builder or general contractor will submit the proposed lot grading plan with the building permit submittal. The lot grading plan will demonstrate the following;
    a. The lot grading plan will show that no stormwater drainage will occur on adjacent private properties as a result of site grading and new construction. Lot grading will direct stormwater into the public right of way or onto adjacent public properties, as approved by the city.

b. The lot grading plan will maintain existing drainage patterns and will not disrupt or "dam" the natural flow of water from neighboring properties.
c. The lot grading plan can incorporate the use of gutters (downspouts and leaders), swales, retaining walls and similar methods to achieve stormwater drainage without adverse impacts, as approved by the city.

3. The lot grading plan is reviewed and approved by the city Public Works Department. If grading is not sufficient or feasible, then the use of gutters, swales, retaining walls or similar methods, may be required to divert or manage stormwater on the site and this must be approved by the city Building Official (Floodplain Manager) and the city Public Works Department.
4. A lot grading inspection will be done by the city. The grading inspection can be done at the rough grading phase of the project. The inspection will be done prior to closing out of the building permit and prior to a Certificate of Occupancy or Certificate of Completion being issued by the city, if applicable. A self-certification of grading improvements can be conducted by a Florida licensed surveyor or a Florida licensed engineer and submitted to the city Planning and Building Department prior to final closing of the building permit, in lieu of an inspection by the city.
5. Any new increase of 400 square feet or more of impervious surface on a residential lot, measured cumulatively within a 5 year period, will require an approved lot grading plan.

B. A variance process will be created to allow relief from the above rules if it can be demonstrated that application of these rules is technically infeasible and if a property contains a unique physical characteristic in which deviance from the strict application of these rules will not create any off-site drainage impacts and will not intensify any existing drainage problems.

GOAL #2 – PROVIDE INCENTIVES FOR PROPERTY OWNERS TO USE CONSTRUCTION TECHNIQUES WHICH DO NOT REQUIRE LAND FILLING

RECOMMENDATION

A. Property owners in residential single-family districts RS-1 and RS-2 are eligible for an additional 5% lot coverage if they comply with all of the required conditions listed below.

1. Pier foundation construction (open crawl space, without a slab under the structure) is the only allowable foundation type on the lot for all buildings, existing and proposed, to be eligible for this lot coverage bonus.

2. The installation of gutters, downspouts and leaders directing rainwater into the property and away from adjacent private properties is required to be installed and maintained on all structures with roofs or a lot grading plan must be approved by the city.
3. The only materials allowed for driveways, walkways and patios are pervious or semi-pervious in nature.
4. The property owner must maintain a minimum of 1 shade tree on the property.
5. The maximum impervious surface ratio for the property is 70%.
6. A natural bufferyard at least 5 feet in width must be maintained adjacent to all property lines. This bufferyard can contain utilities, driveway openings, walkway openings and fences, walls and gates but can not contain any other type of structure. If a fence or wall is proposed in the bufferyard, it must be demonstrated that the fence or wall will not alter any existing drainage patterns.

GOAL #3 – LIMIT THE AMOUNT OF IMPERVIOUS SURFACE THAT IS ALLOWED IN RESIDENTIAL DISTRICTS

RECOMMENDATION

A. The maximum impervious surface ratio allowed for single family residential development in all residential districts, including accessory structures and uses is 70%. This regulation does not apply to residential communities with private master stormwater systems.

B. Add the definitions of "Imperious Surface" and "Impervious Surface Ratio" in the City Code.

EDUCATION AND PUBLIC OUTREACH – A program to inform property owners and builders of any new rules and regulations shall accompany these city code changes. Additional promotion efforts including information and techniques for homeowners to become more resilient should also be done by the City.

Appendix F

Resiliency Report Comments

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Below list are comments from the City of St. Augustine and residents of South Davis Shores. Responses are in *italics*. Follow up comments and responses are mentioned if applicable.

1) How is the model accounting for the new wall around the Coquina Ditch? Overflow lines look like it is going through it? Maybe misunderstanding, possibly provide zoomed in figure of this area if accounted for.

Overflow of the ditch across Coquina Avenue occurs if the water level is high enough (exceeding 3.7 ft); we added overflow across the culvert to account for that. For mitigation models, we did not account for the proposed wall as it is not needed to meet the 10-year or 100-year level of service.

Client response: After reading the responses, I wanted to clarify in the first comment that the wall I was asking about is existing. See attached photos. Was this accounted for in the model?

No, we didn't account for this wall in the model. Our overflow elevation across Coquina Avenue was based on Lidar data on the eastern side of the road near the upstream end of the culvert. The overflow elevation may be lower than the top of the wall, but we will need survey information to confirm.

2) OF 0010 looks like it is flowing into the next basin?

Correct, there are some flow that goes into the next basin when the street floods high enough; that basin drains directly to Quarry Creek.

3) What design storm does this basin flow into the next basin(s)? If less than the 25-year or 100-year storm even, can they really be looked at as individual basins?

Flow does occur during a 5-year event. In smaller storms, flow would not occur. Given the modeling scope, we restricted the size of the catchment to areas that drain mostly to

Coquina Ditch but agree that neighboring basins should be modeled in future scope to examine impacts of cross-basin flows.

4) How were basins delineated? OF-0010 and OF-0001 are much lower than the others and next basins don't show higher contours for some distance.

Basins were delineated based on area that would flow to Coquina Ditch or its outfall (excluding FD-01 to include the additional point of interest) if a drop of rain falls there. If street flooding is high enough, flow would exit via other outfalls.

5) How was the model validated/calibrated/verified? Many of the streets showing flooding were not flooded during last floods and some more flooded…

Calibration and validation were not done since no flood data was provided and is not within current scope. In addition there are no calibration gages in the study area. The model simulated design storms are larger and more intense than the recent historic storms, with the St. Augustine rain gage recording no days with more daily rainfall than a 24-hour, 25-year volume of 8.9 inches since 2015. Parameters used were based on experience form the previous City of St Augustine SWMP Phase 1 (2013) and model by CDM Smith and similar northeast Florida study area experience. The model could be validated based to historic storm using available highwater marks and/or photographic accounts of flooding in a future phase.

6) OF-0009, OF-0010, and OF-0001 are all very flooded in any storm event, just having trouble seeing how these low locations are basin boundaries.

They are basin boundaries in part based on how runoff would travel when rain falls (with no flooding). Given that it doesn't take much rain to result in flooding, there is a lot of cross-boundary flow. Overland flow channels provide connections across basin boundaries as needed for flows.

7) Why are the rim elevations in existing/proposed models so high?

A constant depth of 15 feet was set for each node to keep water in the model. The rim elevation is not a real elevation since we want to account for all flooding volume, which is stored within the street flow conduits.

8) What elevation is the downtown seawall (for reference). Is this study proposing higher or same, lower level of service?

The seawall would be set to 7 feet NAVD based on scope to protect neighborhood up to the level, which is the 100-year BFE.

9) If LIDAR data is +/- 0.23' accurate and improvements range from 0-0.4' and assuming there are other assumed accuracy limitations in the model and other input data, don't these improvements seem negligible?

The 10-year improvements would be quite negligible. Greater benefits would be seen for the 5-year event and similar storms. We are trying to show the minimum needed for roads to be passable at that storm event. For both Lidar and traditional survey there is some tolerance and accuracy issues.

Client response: Table 4-2 Peak Stage 5 yr Existing and 5 year with Mit Alt #1 has the comparison. Does this mean that the difference (delta) between 5-year existing stage and 5-year mitigation #1 stage has already taken into account the LiDAR tolerance? If so, then the difference between the two would be actual realized improvements taking into account LiDAR accuracy, correct? If that is the case, let's include that clarification in the response

Correct, both models take into account the Lidar tolerance, so the difference between the two would be actual realized improvements.

10) How will raising the gutters and crown of the road improve drainage when many of the properties are draining towards the street? Will this make flooding worse within the properties?

We only propose raising crown of side street at intersections where gutters cross side street. In this case, the crown of the side street will be at grade with crown of main street, instead of dipping to accommodate a gutter. This allows the side streets to be passable. Part of the reason this could be done is because there will be inlets at all corners to accept flow. The scope of change is fairly small, but further surveys should be done to confirm the grade change does not result in more flooding overall.

11) If a seawall is constructed, report should state what the recovery time would be in a flood event that overtops the seawall. In current conditions, it is a relatively short duration, in and out, and I assume if it needs to be pumped out or run through stormwater system expectations will need to be adjusted.

Recovery time will largely depend on how quickly the tides recede, and what projects are implemented. A pump station/gate can speed up recovery times. Recovery time will be calculated during the design process.

12) And how will yards drain that currently drain to the water?

With seawalls in place, there will need to be provisions for collection or overland flow through yards to the stormwater system for discharge (and ultimately pumping). We added mentions of yards in discussions relating to seawall constructions and recovery time in Section 4.

13) Funding options are very vague. Suggest that once an option is selected these are refined with the viable options and application deadlines.

Added a sentence in Section 5 indicating CDM Smith recommends BRIC, HMGP, and FRCP as priority options to consider.

14) Section 6 – Items 3 and 12 – Apologies in advance but these comments are more to communicate how a resident feels when they have repeatedly dealt with a problem and had to invest over $100,000 of their own money to fix a problem or decide to sell the property knowing the next resident is going to then go through the same thing… I think an ordinance change like this needs to have more detailed and accurate modeling and drainage plan information. You are limiting options for residents in the same report that says the City could raise the gutter and crown elevation so streets are drivable which may flood their yards more and proposing projects that offer 3-4" of water level improvement. Most of the yards around here flood in major rain events, several inches, and that water flows to the low spaces under the crawl spaces for those not on a slab on grade and creates mold and mildew that never dries out in their closets and lesser used rooms for months of the year. Even if homes are restricted to rebuilding on pilings or columns, they are going to make some improvement to the level of their yard so they don't flood the areas beneath their house and their garage at every major rain event. I am not advocating that stem walls are the answer, I just comment that if an ordinance is made to this extreme it should be supported with a detailed master drainage plan for homeowners to follow so that they can see improvement on their significant investment and contribute to positive drainage in the neighborhood. Everyone acting individually will likely not provide the solution.

Response – Yes, we agree, and we should discuss this further for the public meetings and any wording refinements and future phases.

> Client response: We should probably talk through this and determine how we want to approach this. We do have recommendations that have made it through the City Commission and are at the Planning and Zoning Board next for ordinance considerations. I've attached what went to the Commission and PZB for discussion on this item. We may want to make reference to this in the report. The April 6th item for PZB was briefly discussed and they opted to move it to the May meeting for further discussion.
>
> *The Building Task Force has made efforts to address infill within residential neighborhoods. Please refer to Appendix E. We will add references to the building task force recommendations in the report in Section 6. Future work orders can help refine the model or conduct additional studies to determine whether certain standards or ordinance have any impact in reducing flooding.*

4.2 Mitigation Alternative #2

Mitigation Alternative #2 consists of strategies required to meet the 100-year level of service as discussed in the previous section. **Figure 4-8** summarizes the upgrades needed to meet the 100-year level of service. **Appendix A** summarizes the model input parameter values specified for the Mitigation Alternative #2 model. The alternative consists of upgrades required under Mitigation Alternative #1 with expansions as discussed in the following sections.

4.2.1 Coquina Ditch Dredging

To increase the capacity for the 100-year event, Coquina Ditch is dredged 1 feet with bottom width expanded to 20 feet. Side slope will remain at design standards of 4 ft horizontal for every 1 ft vertical. The ditch bottom and slopes should be cleared to maintain a lower roughness coefficient. Dredging the ditch allows for the removal of sediments that may have accumulated at the bottom of the ditch, and allows the ditch bottom to align with the inverts of the culvert and outfall pipes that enter the ditch. **Figure 4-7** shows the cross section of the existing and proposed ditch.

Figure 4-7: Coquina Ditch Mitigation #2 Cross Section

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