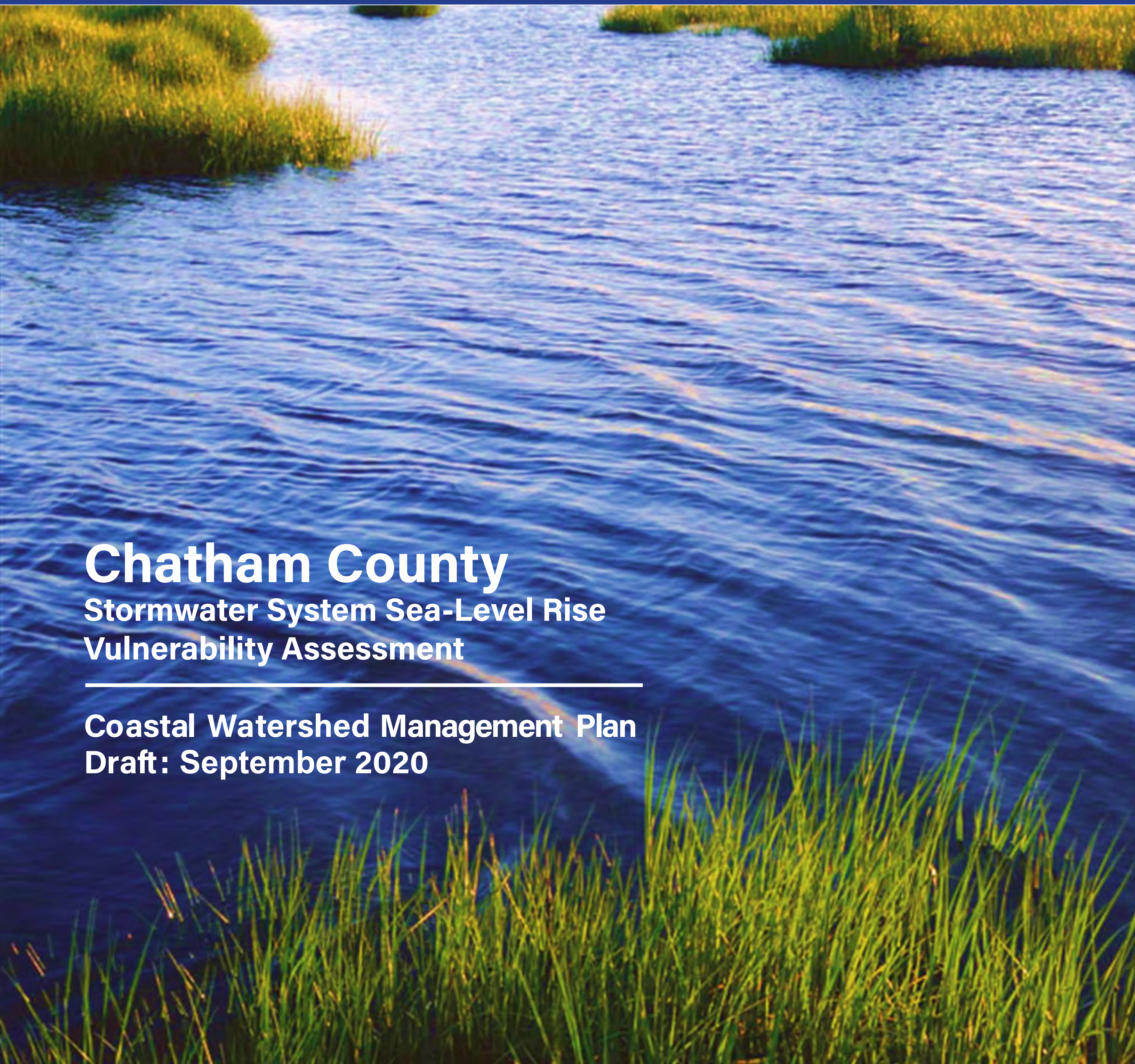

Chatham County

Stormwater System Sea-Level Rise Vulnerability Assessment

Coastal Watershed Management Plan
Draft: September 2020

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List of Acronyms

CIG: Coastal Incentive Grant

CIP: Capital Improvement Project

CRD: Coastal Resources Division

CRS: Community Rating System

CWAAA: Coastal Watershed Adaptation Action Area

CWMP: Coastal Watershed Management Plan

CWPA: Coastal Watershed Planning Area

CZMP: **Coastal Zone Management Plan**

D-FIRM: Digital Flood Insurance Rate Map

DEM: Digital elevation model

DNR: Georgia Department of Natural Resources

FEMA: Federal Emergency Management Agency

FIRM: Flood Insurance Rate Map

GIS: Geographic information systems

GT: Great Diurnal Tide Range

HAT: Highest Astronomical Tide

HUC: Hydrologic Unit Code

IAR: Impact Adjustment Ratio

LDM: Local Design Manual

LIDAR: Light Detection and Ranging

MHHW: Mean Higher High Water

MLLW: Mean Lower Low Water

MS-4: Municipal Separate Storm Sewer System

MSL: Mean Sea Level

NAVD88: North American Vertical Datum of 1988

NED: National Elevation Dataset

NFIP: National Flood Insurance Program

NOAA: National Oceanographic and Atmospheric Administration

NPDES: National Pollution Discharge Elimination System

NTDE: National Tidal Datum Epoch

SFHA: Special Flood Hazard Area

SWMP: Stormwater Management Plan

USACE: United States Army Corps of Engineers

USGS: United States Geological Survey

WMP: Watershed Management Plan

Executive Summary

Executive Summary

This Stormwater System Sea Level Rise Vulnerability Assessment and Coastal Watershed Management Plan (CWMP) is a cooperative effort between Chatham County and City of Savannah to begin assessing the vulnerability of the region's stormwater management systems to future changes in hydrologic conditions, specifically associated with sea-level rise. The purpose of the assessment is to provide actionable information for Chatham County, the City of Savannah, and other jurisdictions to use in developing plans and implementing appropriate capital improvement projects that can increase the resilience of the regional stormwater system to future conditions. This project was funded by a Coastal Incentive Grant (CIG) through Georgia's Coastal Zone Management Program (CZMP), as administered by the Georgia of Department of Natural Resources (DNR), Coastal Resources Division (CRD).

The assessment methodologies and sea-level scenarios in the CWMP are based upon guidance provided by the Federal Emergency Management Agency's (FEMA's) Community Rating System (CRS) for the National Flood Insurance Program (NFIP). A Coastal Watershed Management Plan that accounts for sea-level rise may assist both Chatham County and City of Savannah in receiving credits under CRS that could qualify certain flood insurance policy-holders in their jurisdictions for premium discounts.

Sea level data recorded at the tide gauge at Fort Pulaski begins in 1935 and indicates historic sea-level rise trend of approximately 1 foot over 100 years. More recent global data and local data from Fort Pulaski suggest that this rate is accelerating, although there remains a high degree of uncertainty within the future projections. Minimum guidance from the CRS currently requires vulnerability assessments that are based upon a projection of 4.39 feet of sea-level rise by the year 2100. The CRD has recommended that coastal communities consider a "High" sea level rise scenario of 6.6 feet of sea-level rise by 2100 for future hazard mitigation planning. Infrastructure assessments in this CWMP utilize the minimum guidance from CRS of 4.39 feet of sea-level rise by 2100, but also incorporate the CRD's High scenario for the purpose of coastal watershed delineation and as a baseline for future planning cycles.

Chatham County and the City of Savannah both have a high quality and comprehensive inventory of stormwater infrastructure within geographic information system (GIS) databases. These data support detailed assessments of potential vulnerabilities to current and future tidewater conditions, including interconnections between the two stormwater systems. Continued maintenance and update of these datasets as part of the stormwater management programs in each jurisdiction will be critical in ensuring future updates and improvements to the vulnerability assessments and overall CWMP. Potential expansion of the CWMP to include stormwater infrastructure and associated vulnerability assessments of other incorporated municipalities within Chatham County should also be pursued in future planning cycles.

The results of the vulnerability assessment indicate that up to 3% of inland stormwater drainage structures in unincorporated Chatham County are currently vulnerable to daily tidal inundation, while 8% are currently vulnerable to inundation at least once a year during the year's highest annual tide (HAT). A system of tide gates within the Chatham County stormwater system currently provides protection against extensive tidal backflow during high tide events. The vulnerability assessment for 2100 indicates that up to 19% of structures in unincorporated Chatham County would be vulnerable to daily tidal inundation, with 30% being vulnerable to inundation at least once a year.

Results for the City of Savannah indicate that approximately 0.3% of stormwater inlets are vulnerable to daily tidal inundation, with 1% vulnerable at least once a year during the year's highest annual tide event. A system of tide gates and pump stations within the City of Savannah currently provides protection against extensive tidewater backflow into the stormwater system, and also facilitates drainage during large rainfall events that co-occur with high tide. By 2100, these results increase to 9% of inlet structures being vulnerable to tidal flooding on a daily basis, and 15% being vulnerable at least once a year during the highest annual tide.

A near-term vulnerability within the City of Savannah stormwater system is the low-lying Kayton pump station, which is already vulnerable to tidal flooding that necessitates system shutdown during storm surge events. At its current design elevation, the Kayton pump station could be vulnerable to inundation by annual high tide events by a 2050 sea-level rise condition. Retrofit of this pump station to maintain functioning to a higher tidewater condition should be viewed as a priority for stormwater and flood management resilience within the City of Savannah and the greater metropolitan area.

Tide gates on Tybee Island

Capital improvement projects for the stormwater systems in both Chatham County and the City of Savannah should include assessment of sea-level rise through the expected life cycle design of the projects. Extensive measures that would likely include a combination of shoreline elevation, extensive tide gates, installation of pumps, and strategic disinvestment within areas that may be deemed as infeasible to protect would be required for adaptation to the 2100 sea-level rise condition used in this CWMP. Careful assessment of the benefits and costs of enhanced design and construction measures that would provide protection against future, projected sea-level rise should be incorporated as a standard procedure within the policy-making and decision-making process for capital improvement.

This CWMP is intended to serve as a living document that should be updated, amended, and appended as new information – including updated sea-level rise projections, improvements to the local drainage infrastructure, and empirical observations of localized flood risks – becomes available.

Introduction

1. Introduction

1.1 Community Description

Chatham County is an Atlantic-facing coastal county in southeastern Georgia. The total area of Chatham County, including all incorporated municipalities, is approximately 516.5 square miles. This includes approximately 426.3 square miles of land area and 89.2 square miles of open water. The unincorporated area of Chatham County comprises approximately 329.9 square miles, which includes 249.1 square miles of land and 80.8 square miles of open water. Chatham County also contains large areas of coastal wetlands that are influenced by tidal energies from the Atlantic Ocean, as well as the extensive riverine lowlands associated with the Savannah River (the county's northern boundary) and Ogeechee River (its southern boundary).

The estimated 2018 population for all of Chatham County, including incorporated areas, was 289,195, making it the most populous county in Georgia located outside of the greater Atlanta metropolitan area. The largest incorporated municipality within Chatham County in terms of both land area (108.4 square miles, including 101.5 square miles of land and 6.9 square miles of open water) and population (estimated as 145,862 in 2018) is the City of Savannah. The 2018 population within unincorporated portions of Chatham County is estimated as 93,229.

Other incorporated municipalities within Chatham County are the City of Bloomingdale (14.1 square miles, estimated 2018 population of 2,722), City of Garden City (14.4 square miles, estimated 2018 population of 8,837), City of Pooler (28.0 square miles, estimated 2018 population of 24,132), City of Port Wentworth (16.6 square miles, estimated 2018 population of 8,518), City of Tybee Island (3.1 square miles, estimated 2018 population of 3,110), Town of Thunderbolt (1.6 square miles, estimated 2018 population of 2,660), and Town of Vernonburg (0.4 square miles, estimated 2018 population of 125).

This Coastal Watershed Management Plan was developed by Chatham County in partnership with the City of Savannah to cover coastal stormwater drainage systems and associated infrastructure within the boundaries of unincorporated Chatham County and the City of Savannah. Sea-level rise projection maps and 100-year coastal flood modeling scenarios with sea-level rise, as applied through Hazus 4.2, included all other incorporated and unincorporated areas within Chatham County. Although infrastructure in municipalities other than the City of Savannah was not assessed for vulnerability, it is hoped that the data development approaches and assessment methodologies for drainage infrastructure may be extended into the other incorporated municipalities within Chatham County in the near future.

1.2 Project Purpose

The primary purpose of this project is to analyze impacts of sea level rise on stormwater infrastructure, so that Chatham County and the City of Savannah can make informed decisions regarding infrastructure investments that will mitigate the impacts of future sea level rise. A secondary goal is to perform this study in accordance with ISO/CRS standards such that Chatham County and City of Savannah will satisfy the prerequisite for CRS Class 4. As part of this study, the County and City identified the sections of the drainage system most vulnerable to sea level rise and identified potential CIP projects within these areas that should accommodate future sea level rise in their design approach. Furthermore, potential best practices that should be incorporated as part of future CIP in areas subject to future sea level rise have been identified.

This report is also intended to address recommendations made within the "Chatham County Redevelopment Plan," which is part of the County's Disaster Recovery and Redevelopment Plan (DRRP). This project has improved mapping of areas affected by sea level rise, particularly those impacting the stormwater drainage system, addressing an immediate goal from the DRRP, "E-11," which was to "ensure county-wide sea level rise mapping is completed that indicates the specific areas effected and correlate with the PRA selection process."

This project was undertaken by Chatham County and the City of Savannah because sea level rise is already impacting coastal Georgia. Reports of increasing King Tide flooding and storm surge are becoming more common in Chatham County. Chatham County and Savannah recognize that flooding problems related to sea level rise will increase over the next 50 to 100 years and that the time to understand the potential impacts and to make adaptive changes is now. It may take many years to fund the needed projects to make the drainage system more resilient.

While both the Chatham County and the City of Savannah have existing drainage CIP lists and allocate a proportion of their sales tax revenue to fund them, the potential cost of addressing existing drainage problems, as well as those that will result or be compounded due to sea level rise, underscores the importance of dedicating additional funding to projects addressing sea level rise.

1.3 Project Scope

The Project Team formed for the purpose of this project includes the primary grant applicant Chatham County, the City of Savannah, Stetson University, Goodwyn Mills & Cawood, the Coastal Georgia CRS Users Group, and the Department of Natural Resource, Coastal Resources Division. The project team met regularly to discuss project approach, progress and results. Written summaries of these meetings can be found in the appendix to this report. The scope implemented by the project team is summarized below.

Task 1 Gather Flooding Hotspot Data and Maps from the County's Disaster Recovery and Redevelopment Plan (DRRP)

The Project Team gathered data from the DRRP and then met with DNR-CRD and Chatham County DRRP stakeholders in March of 2019 to review and identify the relevant data from the County's Disaster Recovery Plan and the County's Redevelopment Plan, including flooding hotspot areas and the HAZUS model results related to the impacts of sea level rise (2100 projections) on critical infrastructure. The flooding hotspot data served as a "starting point" for the data gathering and modeling work described in Tasks 2 and 3.

Task 2 Coordinate and gather required data and information for model inputs

Both Chatham County and the City of Savannah maintain and update a GIS inventory of their stormwater infrastructure that includes survey-grade invert elevations. This data was gathered and input into the model. Additional data was also included related to floodplains, critical facilities, proposed drainage CIP from both communities, and future sea level information for 2020, 2050, 2075 and 2100. The Army Corps of Engineers Sea-Level Change Curve Calculator was used to develop an estimated local mean sea level for 2020, 2050, 2075, and 2100. Base annual high tide levels above local MHHW were estimated through 1% Annual Exceedance Level at the Ft. Pulaski gauge. US EPA's CREAT tool was also used to analyze the impacts of sea level rise on municipal infrastructure and programs.

Task 3 Perform sea level rise analysis of stormwater system

Stormwater infrastructure data were assembled to develop elevation values for bottom of structure and top of structure using NOAA's Intermediate-High (Parris et al. 2012) sea level rise projection of 4.39 feet for 2100, which includes regional subsidence rates estimated from the Fort Pulaski tide gauge.

Task 4 Identify and prioritize areas where sea level rise impacts the stormwater system

Based on the modeling conducted in Task 3, the Project Team identified areas of the stormwater system where sea level rise could cause high tide to penetrate the drainage system and potentially cause flooding issues.

Task 5 Identify CIP projects and update Capital Improvement Plan

The Project Team identified and mapped existing drainage CIP for both Chatham County and the City of Savannah and identified those projects that are located within areas of the drainage system most vulnerable to sea level rise. For infrastructure that was identified as being particularly vulnerable, the Project Team identified the need for new CIP or identified best practices that could be utilized to mitigate flood risk. Lastly, policies for CIP selection and design in areas subject to future sea level rise inundation were identified.

Task 6 Update CRS application and submit for review

Project partners have been coordinating with ISO representatives throughout the duration of this project to ensure that the results would be compliant with the 2017 CRS manual, and consistent with other communities that performed a similar watershed study based on sea level rise. Chatham County and City of Savannah will update their CRS applications to include this study, when approved by ISO for Activity 450 – Stormwater Management.

Task 7 **Presentation to Coastal Georgia CRS User's Group and other Coastal Stakeholders**

Presentations on this project and the progress to date have been made to various groups including the CRS Coastal User Group, the Chatham Regional Stormwater Stakeholder Group, and to Coastal Managers at a CRD Brown Bag Presentation Event. A summary of the community engagement and outreach is included later in this report.

Task 8 **Presentation to Local Governments**

The project team presented the results of this study to the County Commission at a regularly advertised Board Meeting on March 6, 2020. The presentation from this meeting is included in the appendix. A similar presentation was made available to Savannah City Council in a recorded format due to meeting constraints related to the COVID-19 pandemic.

1.4 Stakeholder Education and Engagement

It is the desire of the project team that this project will serve as an example for other coastal Georgia communities that want to better understand and plan for the impacts of future sea level rise on their stormwater management systems. In addition, this project is intended to serve as a model for other CRS communities that desire to achieve an ISO rating of 4 through an ISO/CRS-compliant Sea Level Rise Study. Therefore, the process and findings of this study have been presented to various costal stakeholders over the course of this project. A summary of stakeholder meetings, agendas and attendees is summarized in Table 1 below.

Table 1. Stakeholder Engagement and Public Meetings

Meeting Audience	Meeting Agenda	Meeting Date
Coastal GA CRS Users Group	Project Approach and Purpose	February 28, 2019
DRRP Stakeholders	Data Gathering, Project Approach	March 1, 2019
Regional Chatham County Stormwater Stakeholders	Project Progress and Preliminary Results	September 19, 2019
Chatham County Board of Commissioners	Project Results and Recommendations	March 6, 2020
Chatham County - Savannah Metropolitan Planning Organization		
Coastal Managers at a CRD Brown Bag Presentation	Project Results and Recommendations	
Coastal CRS Users Group	Project Results and Recommendations	September 16, 2020

Building Coastal Resilience through Capital Improvements Planning

The American Association of Floodplain Managers (AAFPM) in coordination with the American Planning Association (APA) have launched a project, entitled "Building Coastal Resilience through Capital Improvements Planning." In an effort to coordinate their work with this project, a two-day workshop was held May 28 - 29 2019 with the following goals:

- Provide Chatham County and Savannah team members status update on ASFPM/APA's progress on this project
- Provide ASFPM/APA status update on current flood resilience and capital infrastructure planning processes in Chatham County and the City of Savannah
- Sharing of information as to data sources and planning tools
- Determine how ASFPM/APA can assist Chatham County and Savannah in resilience efforts

Additional information on this workshop can be found in the Appendix to this report.

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Sea-Level Rise in Chatham County

2. Sea-Level Rise in Chatham County

2.1 Sea-Level Rise Projections

The NOAA tide gauge at Fort Pulaski was originally installed in 1935 and is located in Chatham County near the Savannah River's discharge into the Atlantic Ocean.[1] This long record of tidal data and the location of the Fort Pulaski gauge together make a high-quality reference for conditions in Chatham County. The historical trend of sea-level rise for the Fort Pulaski tide gauge record is approximately 3.25 millimeters per year (Figure 1), which is equivalent to 1.07 feet of sea-level rise over 100 years. Land subsidence within the Georgia bight due to a combination of isostatic rebound associated with the retreat of North American ice sheets at the end of the Pleistocene and more local processes associated with groundwater withdrawal are thought to be responsible for a higher rate of observed sea-level rise at Fort Pulaski[2] as compared to the global tide gauge average of approximately 1.7 millimeters per year (0.56 feet per 100 years) observed over the 20th century.[3]

The 2012 report Global Sea Level Rise Scenarios for the United States National Climate Assessment – as commissioned by the NOAA Climate Office in collaboration with the United States Geological Survey (USGS), the United States Army Corps of Engineers (USACE), and the Department of Defense's Strategic Environmental Research and Development Program – provides a comprehensive assessment of historic sea-level rise trends and future projection scenarios. This report notes that scientific analyses of sea-level trends from satellite data and tide gauge records since 1992 indicate that global sea-level rise has accelerated to a current rate of approximately 3.2 millimeters per year, as compared to the 20th century average of 1.7 millimeters per year. This acceleration is explained by a combination of warming ocean waters and increased melt of land-based glaciers and polar ice sheets, which together are increasing the volume of water within the world's ocean basins. The four sea-level rise projection scenarios[4] defined in by this 2012 NOAA report (Low, Intermediate-Low, Intermediate-High, and High) are hereafter referred to as the NOAA-2012 sea-level rise projections within this report.

Tidal Flooding in Thunderbolt, Georgia

Although there is widespread scientific consensus that global sea levels are currently rising and will continue to rise for the foreseeable future, there remains a wide degree of uncertainty as to how rapidly sea levels will rise over the next several decades. For example, the NOAA-2012 global sea-level rise projections for the year 2100 range from a Low scenario of approximately 0.7 feet, an Intermediate-Low scenario of 1.6 feet, an Intermediate-High scenario of 3.9 feet, and a High scenario of 6.6 feet. A more recent 2017 report by NOAA titled Global and Regional Sea Level Rise Scenarios for the United States[5] defines a Low bound of 2100 sea-level rise at approximately 1 foot (i.e., a straight continuation of the trend observed since 1992) and an Extreme bound of 8.2 feet of sea-level rise. The Georgia Department of Natural Resources (GA DNR), Coastal Resources Division (CRD) has also provided guidance that communities within coastal Georgia consider sea-level rise projections between a low of 3.28 feet (1 meter; "CRD Low") and high of 6.56 feet (2 meters; "CRD High") for current planning purposes.[6] A summary of sea-level rise projections for Ft. Pulaski through 2100 is provided as Table 2.

1 https://tidesandcurrents.noaa.gov/stationhome.html?id=867087
2 Davis, G.H. 1987. Land subsidence and sea level rise on the Atlantic coastal plain of the United States. Environmental Geology and Water Sciences 10:67-80.
3 Hay, C.C., E. Morrow, R.E. Kopp, and J.X. Mitrovica. 2015. Probabilistic reanalysis of twentieth-century sea-level rise. Nature 517:481-484.
4 Parris, *supra* note 2.
5 Sweet, W.V., R.E. Kopp, C.P. Weaver, J. Obeysekera, R.M. Horton, E.R. Thieler, and C. Cervas. 2017. Global and Regional Sea Level Rise Scenarios for the United States. NOAA Technical Report NOS CO-OPS 083. https://tidesandcurrents.noaa.gov/publications/techrpt83_Global_and_Regional_SLR_Scenarios_for_the_US_final.pdf
6 http://www.climateodyssey.org/blog-list/2016/5/2/preparing-for-climate-change-in-the-southeast-interview-with-coastal-hazards-specialist-jennifer-kline.

Figure 1. Historical sea-level rise trend at Fort Pulaski, GA[7]

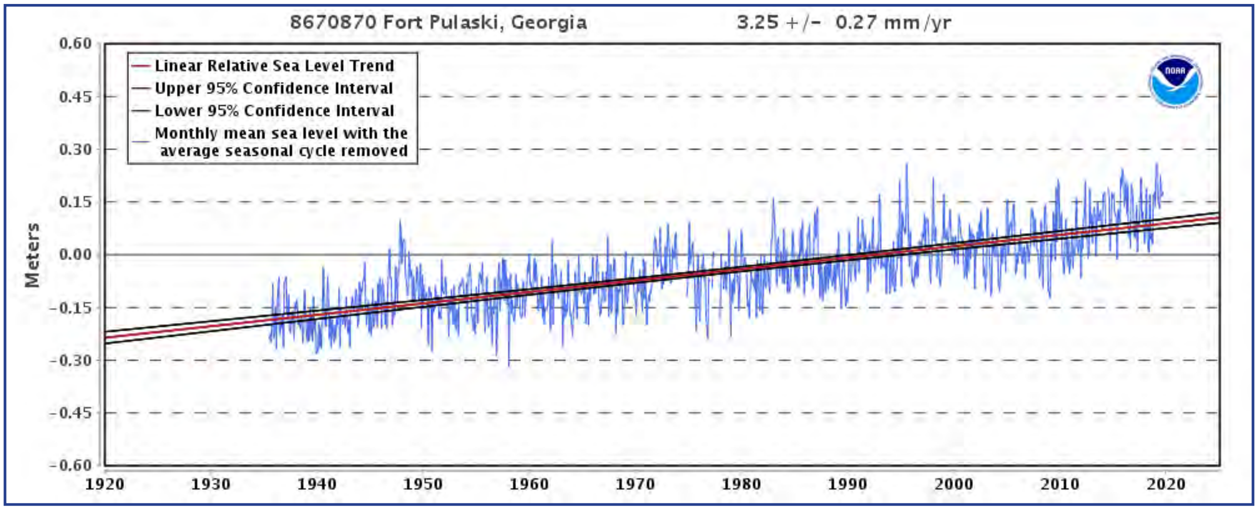
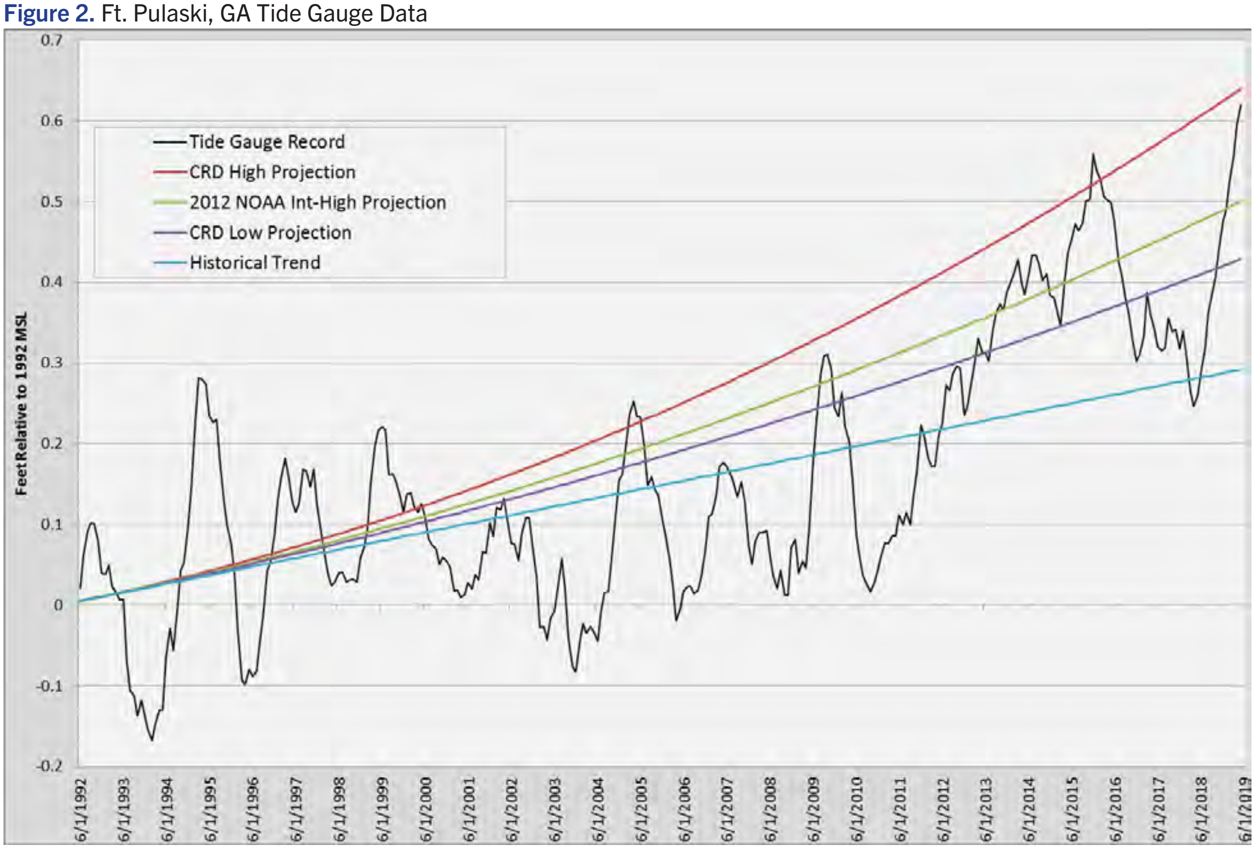


Figure 2. Ft. Pulaski, GA Tide Gauge Data



Note: The above Figure depicts Ft. Pulaski, GA Tide Gauge Data relative to the historical trend sea-level rise and projection scenarios with different rates of sea-level rise acceleration. Plotted as a twelve-month running average using all available sea level data from January 1992 to November 2019. Months on the x-axis are the mid-point of the twelve-month running period.[8]

7 Image from NOAA Tides and Currents, https://tidesandcurrents.noaa.gov/sltrends/plots/8670870_meantrend.png.
8 Data obtained from NOAA Tides and Currents, https://tidesandcurrents.noaa.gov/waterlevels.html?id=8670870.

A twelve-month running average of the Ft. Pulaski tide gauge record since 1992 relative to the historic trend sea-level rise and defined scenario projection curves for this time period is shown as Figure 2. Since 2013, the tide gauge record has generally been in exceedance over the historical trend line, which is consistent with research indicating a recent acceleration of regional and global sea-level rise. However, the tidal gauge record at Fort Pulaski also shows substantial inter-annual variation around the long-term upward trend. This indicates that the range of future sea-level rise projections for Chatham County and its associated municipalities cannot be analytically constrained based solely upon recent trends within the local tide gauge data. A scenario planning approach that acknowledges the underlying uncertainty about future conditions is therefore quite appropriate given the current state of knowledge about sea-level rise. A summary of sea-level rise projections at the Ft. Pulaski tide gauge is provided

Table 2. Sea-level rise projection scenarios for Chatham County, GA, as feet relative to 1992 Mean Sea Level (MSL)

Year	Linear Trend	CRD Low	NOAA Int-High	CRD High
2020	0.30’	0.44’	0.52’	0.66’
2050	0.62’	1.23’	1.55’	2.18’
2075	0.88’	2.14’	2.80’	4.08’
2100	1.15’	3.28’	4.39’	6.56’

2.2 Water Level Datums for Chatham County and City of Savannah

The tide gauge record for the 1992 National Tidal Datum Epoch (NTDE) period of 1983 – 2001 shows the Great Diurnal Tidal Range (GT), or the difference between Mean Higher High Water (MHHW) and Mean Lower Low Water (MLLW), is 7.5 feet at Fort Pulaski. In addition, NOAA has calculated the annual average highest astronomical tide (HAT) for Fort Pulaski as 9.32 feet above MLLW, which is equivalent 5.5 feet above mean sea level (MSL). The HAT is associated with regular gravitational alignment of the moon and sun in combination with seasonal oceanographic patterns, and thus occurs quite predictably and independently of stochastic weather events, such as storm surges, that can also elevate water levels. A tabular summary of key 1992 NTDE water level datums at Fort Pulaski relative to the North American Vertical Datum of 1988 (NAVD88), which is the standard geodetic datum used to reference most modern elevation models in the United States, is provided as Table 3.

Table 3. Tidal datums for Fort Pulaski, GA, under the 1992 National Tidal Datum Epoch (NTDE)

Tidal Datum	NAVD88 Feet
Highest Astronomical Tide (HAT)	5.27’
Mean Higher High Water (MHHW)	3.45’
Mean Sea Level (MSL)	-0.23’
Mean Lower Low Water (MLLW)	-4.05’

For this CWMP, we have followed CRD guidance by defining the coastal watershed planning area in Chatham County and the City of Savannah as all areas that show potential impacts from a 100-year storm surge in combination with the CRD High sea-level rise scenario of 6.6 feet at the year 2100. Transect maps (pp. 64-65) and tabular data (pg. 70) from Volume 1 of the 2018 FEMA Flood Insurance Study for Chatham County and Incorporated areas define the stillwater elevation for a 100-year (i.e., 1% annual return probability) coastal storm surge in the vicinity of Fort Pulaski as 10.2 feet above NAVD88.[9] As described in a later section of this Watershed Management Plan, projections of an enhanced 100-year storm surge elevation due to sea-level rise were developed from this base stillwater elevation and runs of FEMA’s Hazus 4.2 Coastal Flood Model tool.[10] A summary of the revised tidal datums and extreme water levels, relative to NAVD88, by all considered years for the NOAA 2012 Intermediate-High projection scenario and the 2100 CRD High projection scenario is provided in Table 4.

9 FEMA. 2018. Flood Insurance Study, Chatham County, Georgia and Incorporated Areas. FIS Number 13051CV001D. https://www.savannahga.gov/DocumentCenter/View/15405/13051CV001D_FIS.
10 FEMA. 2018. Hazus Flood Model User Guidance. https://www.fema.gov/media-library-data/1564766454464-d77d2c219be0f54315aa79ac5dbc3547/Hazus_4-2_Flood_User_Manual_August_2019.pdf.

Because recent tide gauge data at Ft. Pulaski (Figure 2) have more closely tracked the NOAA-2012 Intermediate High scenario as compared to the CRD High, staff from Chatham County and the City of Savannah have indicated that the NOAA-2012 Intermediate High sea-level rise scenario can and should be considered for near-term decisions about drainage infrastructure planning and design improvements. Visualizations of the NOAA-Intermediate High Sea-Level Rise scenario for projection years 2020 (T1), 2050 (T2), 2075 (T3), and 2100 (T4) are provided in the Map Series 2 Appendix.

All authors of this report – including Chatham County and City of Savannah staff – suggest that future updates to this Coastal Watershed Management Plan should incorporate the latest tide gauge datasets from Fort Pulaski, other water level data sources that may become available, and, as appropriate, new sea-level rise projection scenarios developed using the most up-to-date understanding of local, regional, and global conditions. All underlying datasets developed in support of the CWMP were designed such that they can be readily queried and adapted for revised analyses based upon project-specific needs and updated sea-level rise projection scenario guidance and recommendations.

Table 4. Projected tidal datums and extreme event water levels at Fort Pulaski, GA, with the base 2012 NOAA Intermediate-High sea level rise projection year scenarios and 2100 CRD High projection. All elevations values are referenced to NAVD88

Year	MLLW	MSL	MHHW	HAT	100-Year Surge
1992	-4.05’	-0.23’	3.45’	5.27’	10.20’
2020	-3.53’	0.29’	3.97’	5.79’	10.72’
2050	-2.50’	1.32’	5.00’	6.82’	11.75’
2075	-1.25’	2.57’	6.25’	8.07’	13.00’
2100	0.34’	4.46’	7.84’	9.66’	14.59’
2100 CRD High	2.51’	6.63’	10.01’	11.83’	16.76’

Community Rating System and Sea Level

3. Community Rating System and Sea Level Rise

In recognition of the fact that "floodplains and watershed change over time" due to "many natural and manmade changes," the 2017 Coordinator's Manual for the National Flood Insurance Program (NFIP) Community Rating System (CRS) introduced a series of credit options for "community efforts to anticipate" future flood risk in relation to climate change (pg. 110-15).[11] Because sea-level rise is expected to be an increasingly critical issue for floodplain management, many of the credit options and assessment criteria for coastal communities specifically refer to studies of sea-level rise impact on future hydrologic conditions and local drainage systems. These options are summarized in section 116.c of the Coordinator's Manual as:

- Credit is provided in Section 322.c for communities that provide information about areas (not mapped on the FIRM) that are predicted to be susceptible to flooding in the future because of climate change or **sea level rise.**
- To achieve CRS Class 1, a community must receive credit for using regulatory flood elevations in the V and coastal A Zones that reflect future conditions, including **sea level rise.**
- Credit is provided in Section 342.d when prospective buyers of a property are advised of the potential for flooding due to climate changes and/or **sea level rise.**
- Credit is provided in Section 412.d when the community's regulatory map is based on future-conditions hydrology, including **sea level rise.**
- Credit is provided in Section 432.k when a community accounts for **sea level rise** in managing its coastal A Zones.

Burnside Island Causeway before and after flooding

- Credit is provided in Section 452.b for a coastal community whose watershed master plan addresses the impact of **sea level rise.**
- Credit is provided in Section 512.a, Steps 4 and 5, for flood hazard assessment and problem analysis that address areas likely to flood and flood problems that are likely to get worse in the future, including (1) changes in floodplain development and demographics, (2) development in the watershed, and (3) climate change or sea level rise.

Importantly, the 2017 Coordinator's Manual notes that a mandatory prerequisite for a coastal community to achieve CRS Class 4 status is that the community must "receive credit for managing the impacts of a 100-year storm and/or sea level rise, where applicable, based on a watershed management plan" (pg. 450-14). Each improvement in CRS Class rating (starting from a Class 10) translates into a 5% premium discount on qualifying NFIP policy-holders within the Special Flood Hazard Area (SFHA), meaning that a CRS Class 4 status makes qualified policy-holders within the community eligible for a 30% total premium discount. Because Chatham County is currently rated as a CRS Class 5 community, achieving CRS Class 4 status would result in an additional 5% premium discount for qualified NFIP policy-holders within the SFHA.

CRS Watershed Master Plan – Prerequisites Section 452b:

(1.) The community must have adopted a watershed master plan that evaluates the future conditions, including the impacts of a median projected sea level rise, as based on the National Oceanic and Atmospheric Administration

11 FEMA. 2017. National Flood Insurance Program Community Rating System Coordinator's Manual. FIA-15/2017. https://www.fema.gov/media-library-data/1493905477815-d794671adeed5beab6a6304d8ba0b207/633300_2017_CRS_Coordinators_Manual_508.pdf.

(NOAA) 2012 “intermediate-high” projection curve[12] out to the year 2100, on the local drainage system during multiple rainfall events, including the 100-year rainfall event.

(2.) The community must have adopted regulatory standards that require onsite management of runoff from all storms up to and including the 25-year. The adopted regulatory standards must manage future peak flows so that they do not increase over present values.

(3.) For any plan that is more than five years old, the community must evaluate the plan to ensure that it remains applicable to current conditions.

(4.) WMP1 credit must be received in order to receive credit for any of the other items.

12 Parris, A., P. Bromirski, V. Burkett, D. Cayan, M. Culver, J. Hall, R. Horton, K. Knuuti, R. Moss, J. Obeysekera, A. Sallenger, and J. Weiss. 2020. Global Sea Level Rise Scenarios for the US National Climate Assessment. NOAA Tech Memo OAR CPO-1. https://scenarios.globalchange.gov/sites/default/files/NOAA_SLR_r3_0.pdf

Chatham County Watersheds and Floodplain Areas

4. Chatham County Watersheds and Floodplain Areas

The watersheds of Chatham County and City of Savannah involve a complex interaction of substantial upstream freshwater inflow from two river systems, the Savannah River (watershed area ~10,600 square miles) and the Ogeechee River (watershed area ~5,540 square miles), with a series of Atlantic barrier islands and an extensive coastal estuary and marshland area characterized by the large tidal energies of the Georgia bight. As shown in Figure 3, all twelve-digit Hydrologic Unit Code (HUC-12) level watersheds, as defined by the United States Geological Survey (USGS) National Hydrography Dataset, contained wholly or partly within the boundary of Chatham County or that directly feed into a HUC-12 watershed within Chatham County were identified through an overlay analysis in ArcGIS. The boundary file for Chatham County and associated municipalities developed for the Federal Emergency Management Agency's (FEMA's) 2018 Digital Flood Insurance Rate Map (D-FIRM) process was used as the primary basis for delineating overlap between HUC-12 watersheds and Chatham County. Manual inspection of adjacent watersheds was also performed to identify additional HUC-12 watersheds that have no land area within Chatham County but have direct upstream discharge connectivity into Chatham County at the HUC-12 level.

4.1 Impact Adjustment Ratios

An impact adjustment ratio calculation based on the HUC-12 watersheds was developed for watershed areas in both Chatham County and the City of Savannah. For Chatham County, a total contributing watershed area was calculated to include all non-open water areas located within the County, including incorporated areas, and all HUC-12 watershed areas with less than 50 square miles of contributing area located upstream of Chatham County. All HUC-12 watershed areas that are located downgradient of Chatham County and upstream HUC-12 watersheds with more than 50 square miles of contributing area were excluded from the contributing watershed. A map overview of this HUC-12 watershed analysis for Chatham County is shown as Figure 3. A tabular summary is provided as Table 5.

The HUC-12 analysis produced a total contributing watershed area **(aW) of 543.35 square miles** for Chatham County. A total of **89.2 square miles** of this watershed is classified as open water, which provides an adjusted land area watershed **(aWL) of 452.12 square miles.** Of this watershed area, a total of **26.81 square miles** is located upstream and outside of Chatham County **(aO)** and **178.22 square miles** is located in municipal areas **(aM)**. The impact adjustment ratio **(IAR)** for determining the proportion of the contributing watershed in which Chatham County has jurisdictional and regulatory authority is calculated as:

IARChatham=(aWL-aO-aM)/aWL;

IARChatham = (452.12-26.81-178.22)/543.35 = 54.5%

The HUC-12 analysis produced a total contributing watershed area **(aW) of 141.4 square miles** for the City of Savannah (Table 6). Subtracting 6.9 square miles of open water produces an **aWL of 134.5 square miles.** Of this watershed a total of **33.0 square miles** is located upstream and outside of the City of Savannah's municipal boundaries **(aO).** The impact adjustment ratio **(IAR)** for determining the proportion of the contributing watershed in which Chatham County has jurisdictional and regulatory authority is calculated as:

IARSavannah=(aW-aO)/aW;

IARSavannah=(134.5-33.0)/141.4 = 71.8%

See **Figure 3** on the following page.

Figure 3. Contributing HUC-12 Watersheds to Chatham County, Georgia, and Incorporated Areas

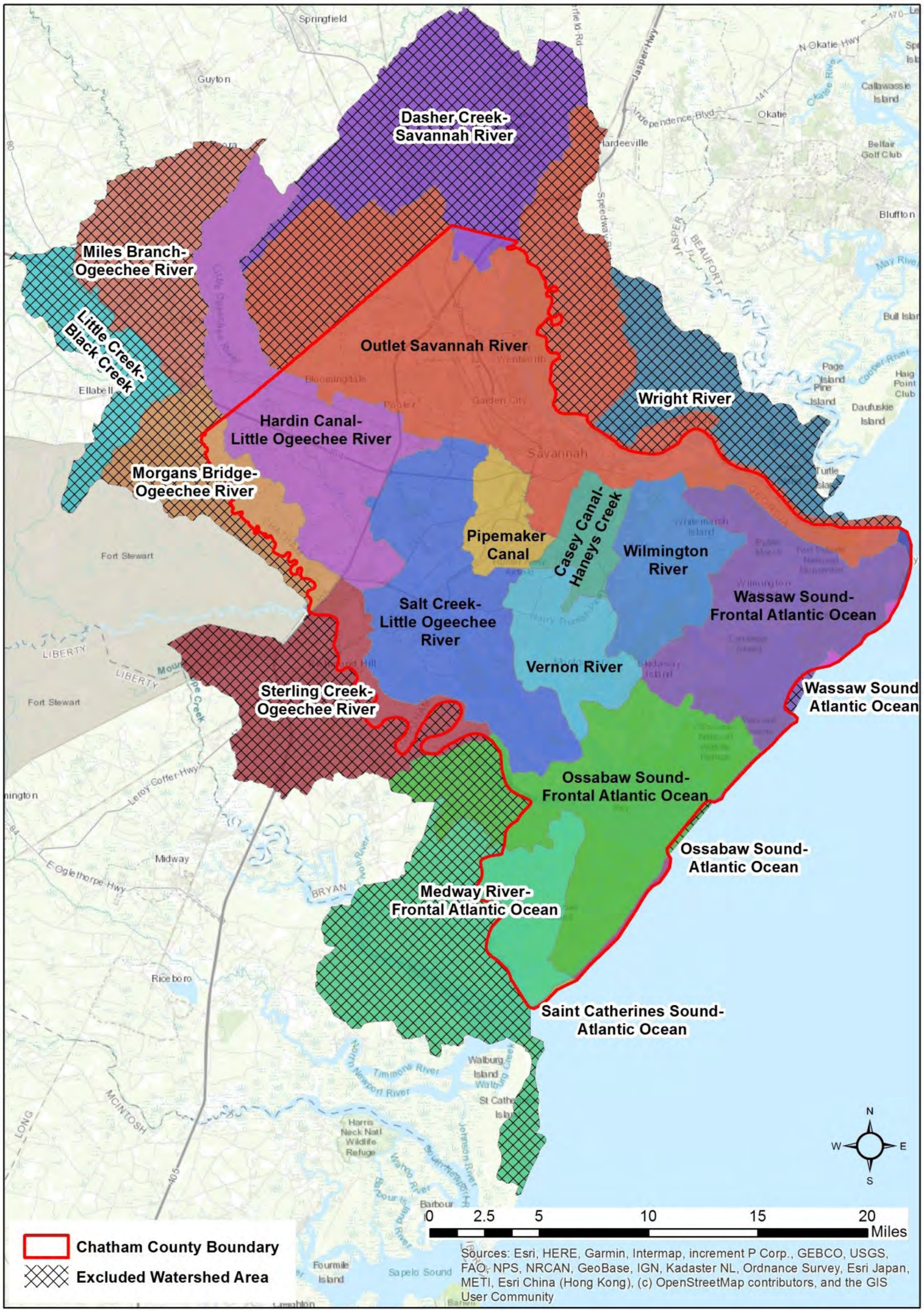


Table 5. HUC-12 Watersheds within or directly connected to Chatham County, Georgia. Values in bold denote watershed areas included within the contributing area for developing the impact adjustment ratio. All areas are as square miles.

HUC-12	Name	Total Area Sq Miles	Inside Chatham County	Outside Chatham County	Drains Into HUC	Notes
030601090305	Dasher Creek-Savannah River	87.86	**3.11**	84.75	030601090307	All outside area is upstream and greater than 50 square miles, excluded from Chatham County watershed area
030601090306	Wright River	42.28	**0.004**	42.27	030601090308	Discharges to HUC outside and downstream of Chatham County. Area outside Chatham County excluded from Chatham County watershed area
030601090307	Outlet Savannah River	196.73	**109.31**	87.42	030601090308	Upstream is greater than 50 square miles, excluded from Chatham County watershed area
030602040101	Wilmington River	32.75	**32.75**	0.00	030602040102	
030602040102	Wassaw Sound-Frontal Atlantic Ocean	69.90	**68.8**	1.10	030602040103	Area outside Chatham County is open water, excluded from Chatham County watershed area
030602040201	Hardin Canal-Little Ogeechee River	74.75	**47.94**	26.81	030602040203	Area upstream is less than 50 square miles, is included in Chatham County watershed area
030602040202	Pipemaker Canal	14.41	**14.41**	0.00	030602040203	HUC-12 for Pipemaker Canal does not match City of Savannah's delineation
030602020605	Morgans Bridge-Ogeechee River	117.02	**13.7**	103.32	030602040301	Upstream area is greater than 50 square miles, excluded from Chatham County watershed area. Upstream contribution includes HUC-12 watersheds 030602020508 (Little Creek-Black Creek) & 030602020604 (Miles Branch-Ogeechee River).

HUC-12	Name	Total Area Sq Miles	Inside Chatham County	Outside Chatham County	Drains Into HUC	Notes
030602040302	Casey Canal-Haneys Creek	13.78	**13.78**	0.00	030602040303	
030602040203	Salt Creek-Little Ogeechee River	73.24	**73.24**	0.00	030602040304	
030602040301	Sterling Creek-Ogeechee River	67.43	**14.11**	53.32	030602040304	All outside area is upstream and greater than 50 square miles, excluded from Chatham County watershed area
030602040303	Vernon River	27.98	**27.98**	0.00	030602040304	
030602040304	Ossabaw Sound-Frontal Atlantic Ocean	86.63	**69.55**	17.08	030602040305	Area outside Chatham County is downstream or open water, excluded from Chatham County watershed area
030602040502	Medway River-Frontal Atlantic Ocean	96.61	**24.14**	72.47	030602040503	Upstream area is greater than 50 square miles, excluded from Chatham County watershed area
030601090309	Savannah River-Atlantic Ocean	0.73	**0.73**	0.00	OCEAN	
030602040103	Wassaw Sound-Atlantic Ocean	0.96	**0.96**	0.00	OCEAN	
030602040305	Ossabaw Sound-Atlantic Ocean	1.67	1.67	0.00	OCEAN	
030602040503	Saint Catherines Sound-Atlantic Ocean	0.35	0.35	0.00	OCEAN	

Table 6. HUC-12 Watersheds within or directly connected to City of Savannah, Georgia. Values in bold denote watershed areas included within the contributing area for developing the impact adjustment ratio. All areas are as square miles.

HUC-12	Name	Total Area Sq Miles	Inside City of Savannah	Outside City of Savannah	Upstream and Outside City of Savannah	Drains Into HUC
030601090307	Outlet Savannah River	196.73	**28.40**	168.33	143.53	030601090308
030602040101	Wilmington River	32.75	**2.40**	30.35	0.00	030602040102
030602040201	Hardin Canal-Little Ogeechee River	74.75	**7.93**	66.82	57.97	030602040203
030602040202	Pipemaker Canal	14.41	**7.97**	6.44	**6.44**	030602040203
030602020605	Morgans Bridge-Ogeechee River	117.02	**4.62**	112.40	112.40	030602040301
030602040302	Casey Canal-Haneys Creek	13.78	**13.56**	0.21	**0.00**	030602040303
030602040203	Salt Creek-Little Ogeechee River	73.24	**26.58**	46.66	**26.56**	030602040304
030602040301	Sterling Creek-Ogeechee River	67.43	**5.73**	61.70	55.22	030602040304
030602040303	Vernon River	27.98	**11.11**	16.87	0.00	030602040304
030602040304	Ossabaw Sound-Frontal Atlantic Ocean	86.63	**0.08**	86.55	0.00	030602040305

4.2 Regulatory Floodplain for Chatham County and Municipalities

The current FEMA regulatory floodplain (1% annual return interval, also known as the 100-year floodplain) for Chatham County and associated municipalities is established by the 2018 D-FIRM (Figure 4). For all of Chatham County, including associated municipalities, the total area within the currently designated regulatory floodplain is 339.8 square miles. With the removal of 89.2 square miles of open water, the land area within the regulatory floodplain area is 250.6 square miles, or 58.8% of the total non-open water within Chatham County, including incorporated areas.

For unincorporated Chatham County, the total area of the regulatory floodplain is 264.1 square miles, which includes 80.8 square miles of open water. The 183.3 square miles of land area within the regulatory floodplain of non-incorporated Chatham County is equivalent to 73.5% of the total non-open water area within the jurisdiction.

For the City of Savannah, the total area of the regulatory floodplain is 45.4 square miles, which includes 6.9 square miles of open water. The 38.5 square miles of land area within the regulatory floodplain of the City of Savannah is equivalent to 37.9% of the total non-open water area within the jurisdiction.

4.3 Coastal Watershed Planning Area (CWPA)

The coastal watershed for Chatham County and associated municipalities is defined in this CWMP as the area subject to a 100-Year storm surge as enhanced by 6.6 feet of sea level rise, as per the 2100 High sea-level rise planning guidance provided by GA DNR-CRD. This 2100 storm surge extent was modeled using FEMA's Hazus 4.2 Coastal Flood Model program with a stillwater elevation of 16.8 feet above NAVD88. This was calculated by adding 6.6 feet of sea-level rise (CRD High projection scenario at 2100) to the existing stillwater height of 10.2 feet above NAVD88 for the 100-year (1% annual return interval) storm surge at Fort Pulaski, as delineated by the 2018 Flood Insurance Study for Chatham County.

All areas within unincorporated Chatham County and the City of Savannah that show susceptibility to inundation under this Hazus Coastal Flood plus sea-level rise at 2100 are deemed as part of the Coastal Watershed Planning Area (CWPA). The CWPA is defined as the geographic area within Chatham County and the City of Savannah that has potential vulnerability to tidal flooding or storm surge through the 2100 CRD High sea-level rise projection scenario. Chatham County and City of Savannah recognize that all areas within the CWPA, including areas not currently within the delineated regulatory floodplain, may be subject to enhanced coastal flooding risk by the year 2100 due to the changing hydrologic conditions associated with climate change and sea-level rise.

The CWPA is visualized in Figure 5 as an overlay of all areas in Chatham County and associated municipalities that showed some level of flood inundation through the 100-Year Hazus Coastal Flood at 2100 under the CRD High sea-level rise projection scenario. The few areas within the current regulatory floodplain (2018 D-FIRM) that are not contained within the CWPA are also visualized in Figure 5. These non-coastal floodplain areas are mostly located in the most inland areas of Chatham County along low-lying streams and riverine lowlands.

A summary comparison of land areas within the current FEMA regulatory floodplain and the CWPA for all of Chatham County (including all municipalities), unincorporated Chatham County, and the City of Savannah is shown in Table 7. It is notable that the CWPA covers a substantially larger area of Chatham County and the City of Savannah as compared to the current regulatory floodplain. The Coastal Watershed Planning Area also comprises a substantial majority of the land area (91.1%) in unincorporated Chatham County and a majority of the land area (60.0%) within the boundaries of the City of Savannah.

Figure 4. Delineated FEMA Flood Zones for Chatham County and associated municipalities, per the 2018 Digital Flood Insurance Rate Map

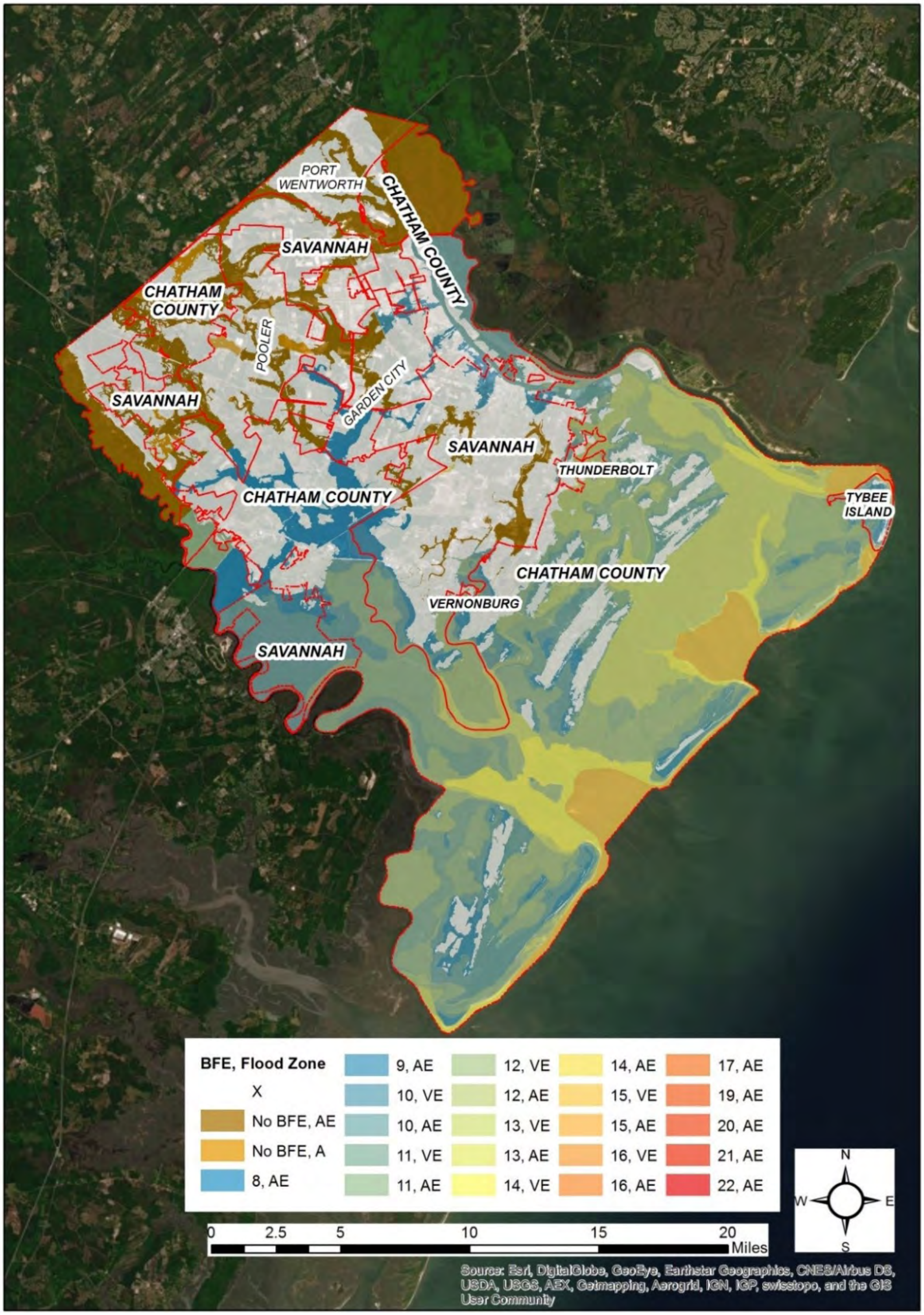


Figure 5: Coastal Watershed Planning Area (CWPA) for Chatham County and City of Savannah. Modeled as the 100-Year Coastal Flood plus 6.6' of sea-level rise within Hazus 4.2 to simulate the Georgia Department of Natural Resources, Coastal Resources Division High Sea-Level Rise Projection Scenario.

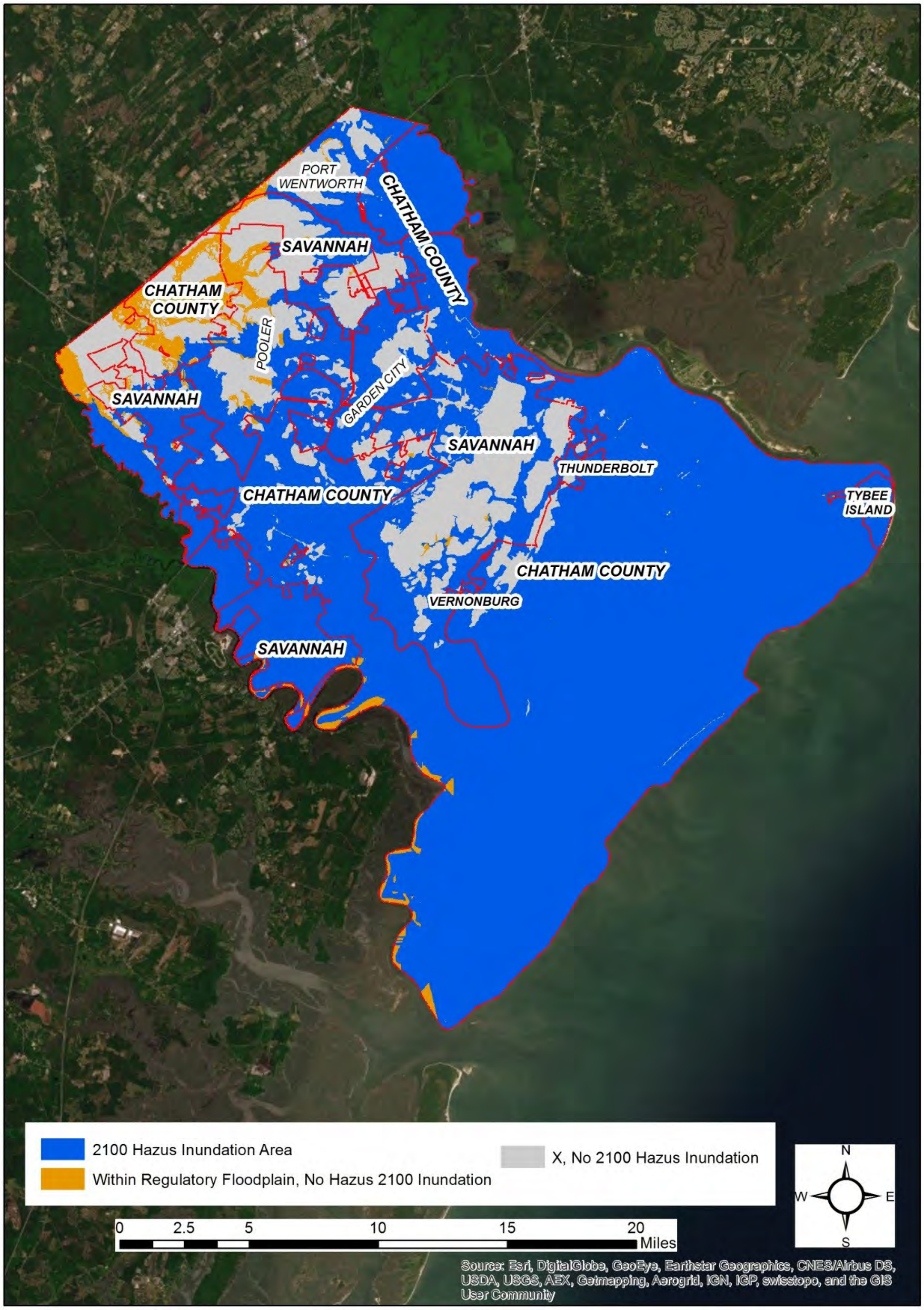
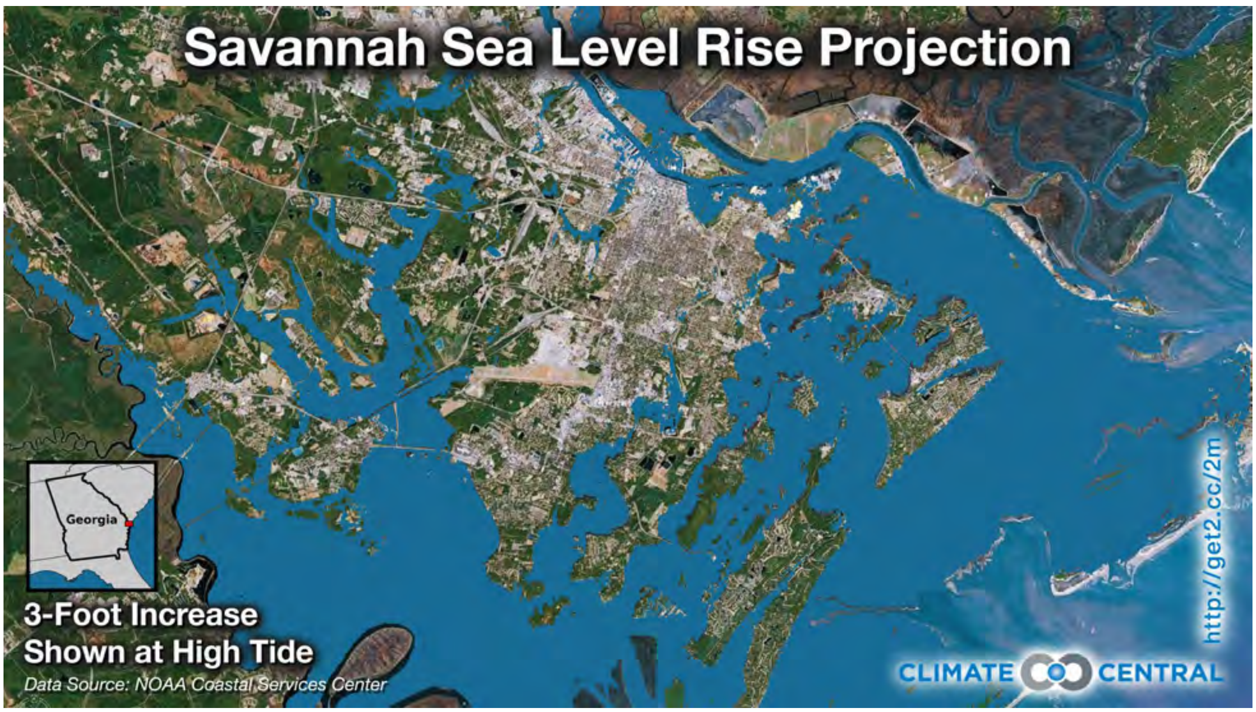


Table 7. Comparison of regulatory floodplain land area with Coastal Watershed Planning Area (CWPA) for Chatham County and City of Savannah. All areas are as square miles.

	Regulatory Floodplain Area (% Jurisdictional Land Area)	**Coastal Watershed Planning Area** (% Jurisdictional Land Area)	**Non-Coastal Regulatory Floodplain Area** (% Floodplain Land Area within Jurisdiction)
All of Chatham County	250.6 (58.8%)	323.3 (75.8%)	18.6 (7.4%)
Unincorporated County	183.3 (73.5%)	227.0 (91.1%)	6.4 (3.5%)
City of Savannah	38.5 (37.9%)	60.9 (60.0%)	2.0 (5.2%)



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Stormwater and Drainage Systems

5. Stormwater and Drainage Systems

The large majority of population within Chatham County lives within a contiguous urban and suburban built area that includes the City of Savannah, Pooler, Garden City, Port Wentworth, Thunderbolt, and unincorporated County areas adjacent to these municipalities. Drainage systems within this built environment, including both natural and human-constructed infrastructure, are highly interconnected and regularly cross jurisdictional boundaries. The City of Savannah has developed detailed drainage basin delineations based on local infrastructure functioning for much of this urbanized area, including most of the City of Savannah (Figure 6). Staff from both Chatham County and the City of Savannah met with the project team on several occasions over the course of the project period to discuss the functioning of the regional stormwater system. Although each governmental entity maintains independent datasets for the purposes of maintaining and managing systems under their individual jurisdictional authority, staff indicated deep awareness of the hydrologic interconnections between the stormwater systems and the clear benefits of close interjurisdictional coordination when assessing and managing long-term vulnerabilities associated with sea-level rise and other climate stressors.

5.1 Chatham County Stormwater Management

Chatham County has a draft Stormwater Management Plan (SWMP) that was last updated on May 9, 2019, in accordance with the County's National Pollutant Discharge and Elimination System (NPDES) Phase I Municipal Separate Storm Sewer System (MS-4) Permit.[13] All activities under the Chatham County SWMP are authorized by the Chatham County Storm Water Ordinance that is published as Chapter 24, Article VII of the Chatham County Code Book.[14] The Chatham County Department of Engineering also maintains an online clearinghouse of documents and other resources related to stormwater management[15] and flood zones.[16]

5.2 City of Savannah Stormwater Management

The City of Savannah houses its Stormwater Management program within its Public Works and Water Resources Division.[17] The most recent version of the City of Savannah's Stormwater Management Ordinance was adopted in November 2018 and is published under Part 4, Public Services, Chapter 11, under the Code of the City of Savannah.[18] The City of Savannah has also adopted a SWMP and a comprehensive Stormwater Management Local Design Manual (LDM) that establishes a consistent set of performance standards and compliance process for stormwater infrastructure.[19]

See **Figure 6** on the following page.

5.3 Stormwater Infrastructure Databases

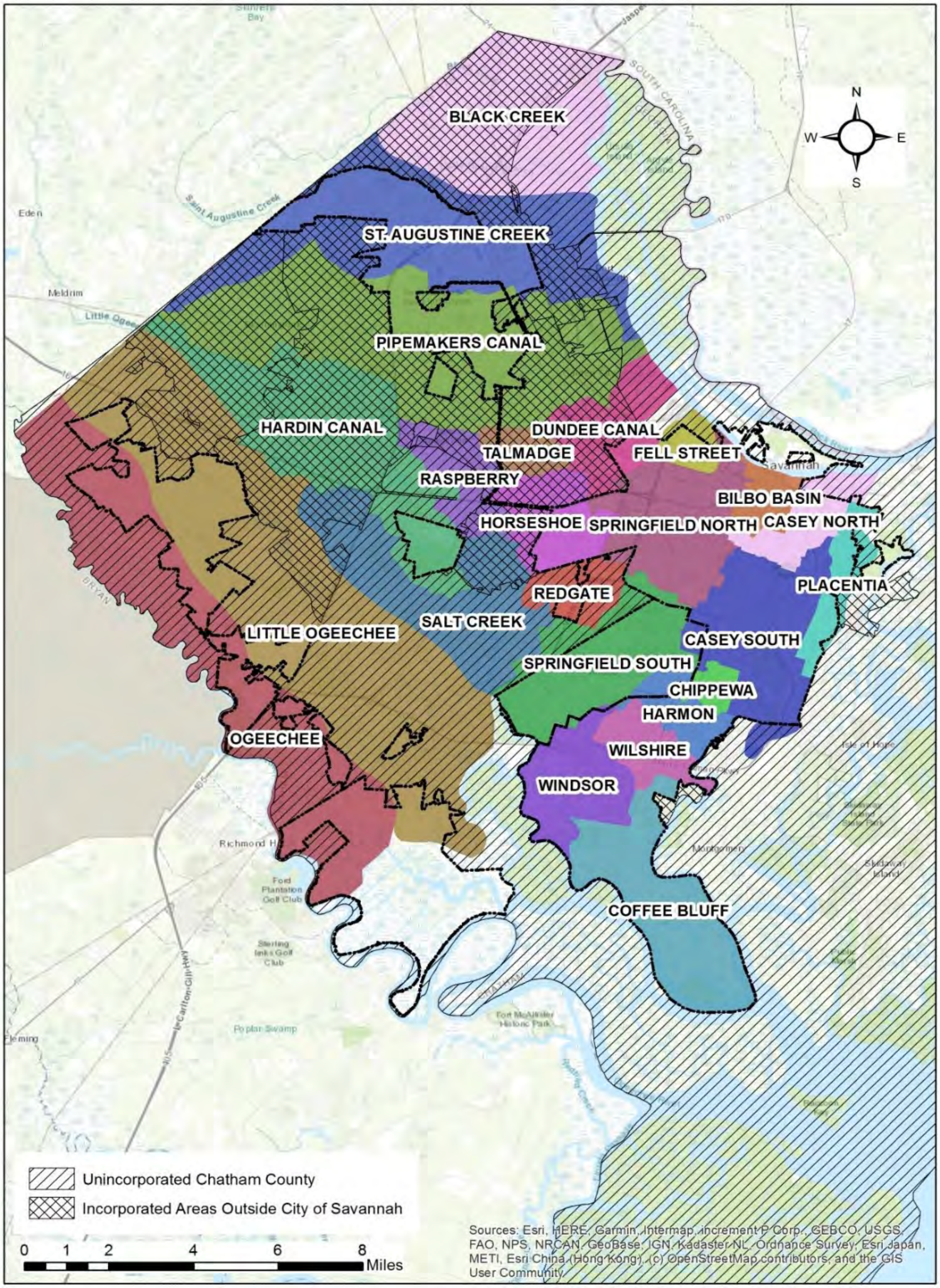
A key element of the overall stormwater management and maintenance programs for both Chatham County and City of Savannah is a comprehensive inventory of stormwater drainage infrastructure within a geographic information system (GIS) format. These GIS databases were supplied to analysts from Stetson University, Clearview Geographic, and GMC for the purpose of developing an assessment of vulnerability to future hydrologic conditions associated with a range of sea-level rise projections for this CWMP. A summary of the database files and infrastructure inventory supplied by Chatham County is shown in Appendix Table 1, with detailed visualizations provided in the Map Series 3 Appendix. A similar summary of the database files and infrastructure inventory provided by the City of Savannah in shown in Appendix Table 2, with detailed visualizations provided in the Map Series 4 Appendix.

5.4 Infrastructure Elevations and Vulnerability Assessment Thresholds

Increased tidal backflow into stormwater conveyance systems due to sea-level rise is a pervasive and chronic stressor that is already having documented and deleterious impacts on the regional stormwater system with Chatham County and its associated municipalities. For this CWMP, a structure by structure vulnerability assessment of infrastructure within the

13 Chatham County SWMP. 2019. https://cccdn.blob.core.windows.net/cdn/Files/Engineering/Staff%20Resources/DRAFT_SWMP_Submitted_Revision_5_10.pdf.
14 Chatham County Code Book. 2019. Chapter 24. https://cccdn.blob.core.windows.net/cdn/Files/ChathamCounty/Code%20Book/Chapter24.PDF.
15 Chatham County, Department of Engineering, Staff Resources, http://engineering.chathamcounty.org/Stormwater/Staff-Resources.
16 Chatham County, Department of Engineering, Flood Facts for Unincorporated Chatham County Residents, http://engineering.chathamcounty.org/Flood-Zones/Facts-for-Citizens
17 City of Savannah, Stormwater Management, https://www.savannahga.gov/508/Stormwater-Management.
18 City of Savannah Stormwater Management Ordinance, https://www.savannahga.gov/DocumentCenter/View/80/Stormwater-Management-Ordinance.
19 City of Savannah Stormwater Management Local Design Manual, https://www.savannahga.gov/DocumentCenter/View/81/City-of-Savannah-Stormwater-Management-Local-Design-Manual.

Figure 6: Stormwater drainage basins as delineated by City of Savannah Stormwater Management. Colored without hash marks are within the City of Savannah's jurisdictional boundary.



Chatham County and City of Savannah stormwater conveyance systems to both regular tidal flooding and the 100-year Hazus Coastal Flood was developed for the NOAA-2012 Intermediate-High sea-level rise scenarios at 2020 (0.52'), 2050 (1.55'), 2075 (2.80'), and 2100 (4.39').

For all surface drainage features (e.g., ditches, canals, and stormwater ponds), assessments of potential system compromise due to vulnerability to tidal flooding or storm surge overwash were determined through elevations derived from the digital elevation model (DEM) for Chatham County, as based upon a 1-meter raster grid developed from the 2009 Chatham County LIDAR project, developed using tiles processed by the National Oceanographic and Atmospheric Administration (NOAA).[20] This 1-meter DEM (Map Series 1 Appendix) was used as the basis for extracting estimates of ground elevations for all infrastructure where site-level survey data was not available.

For inlets, manholes, and outfalls that connect into pipe conveyances, assessments of flood vulnerability were developed in relation to two critical elevation values:

(1) Bottom of structure (i.e., bottom invert elevation). Bottom of structure vulnerability is assessed as depth above the bottom invert level at MSL, MHHW, and HAT for each sea-level rise projection scenario year. Structures that experience bottom flooding due to tidal penetration would be expected to show reduced drainage capacity during heavy rainfall events that occur at the given tidal stage, thus resulting in greater risk of localized flooding due to system failure. The base bottom of structure vulnerability assessment does not account for regular functioning of tide gates and pump stations within the stormwater systems that, in practice, currently reduce the tidal penetration impacts to levels below those shown in the assessment. Instead, the base vulnerability assessment provides a framework for understanding where adaptive infrastructure would be required, both currently and into the future, to prevent regular tidal penetration into the stormwater system.

(2) Top of the structure (i.e., ground elevation). Top of structure vulnerability is assessed as depth above ground level at MSL, MHHW, HAT, and the Hazus 100-Year Coastal Flood for each sea-level rise projection scenario year. Structures that experience top of structure tidal flooding would be expected to have no drainage capacity during rainfall events due to a combination of tidal backflow or surface water flooding that completely inundates the structure. The base top of structure vulnerability assessment also does not account for regular functioning of tide gates and pump stations within the stormwater systems. Stormwater engineers and floodplain managers from both Chatham County and City of Savannah recognize that a baseline 100-year storm surge event that shows extensive top of structure vulnerability for the stormwater system would, in practice, exceed the performance capacities for most current tide gate and pump station structures within Chatham County and the City of Savannah. Such a scenario is also acknowledged to create the potential for catastrophic flooding and widespread stormwater system failure, particularly within low-lying areas where stormwater infrastructure shows the potential for substantial inundation. The extreme nature of this risk from storm surge flooding is the primary reason that widespread mandatory evacuations to protect human life are ordered for Chatham County and associated municipalities, including the City of Savannah, when coastal Georgia is threatened by large hurricanes.[21]

Where available, ground survey elevations for the bottoms and tops of individual structures were used to determine flooding vulnerability for these structures. A summary of structure-level survey elevation data available within the relevant Chatham County and City of Savannah stormwater geodatabase files are presented, respectively, in Table 8 and Table 9. For infrastructure where site survey information was not available, top of structure elevation using data was estimated by extracting values from the 1-meter LIDAR-based DEM shown in the Map Series 1 appendix. Top of structure elevation estimates for approximately 92% of stormwater structures without site survey elevation data were obtained from the 1-meter NOAA DEM.[22] For all remaining structures, top of structure elevation estimates were obtained from the 30-meter DEM also used for the Hazus Coastal Flood Model.

20 2009 Chatham County Georgie LIDAR. https://inport.nmfs.noaa.gov/inport/item/49725.Published. Published bare earth accuracy is +/-0.25 feet at the 95th percentile confidence interval.

21 Chatham County Emergency Management. 2015. Chatham County Multi-Jurisdiction Pre-Disaster Hazard Mitigation Plan. https://cccdn.blob.core.windows.net/cdn/Files/CEMA/Plans/!Chatham%20Base%20HMP.pdf.

22 Comparison of ground level survey data with values from the 1-meter NOAA DEM produced a root mean square error (RMSE) of 0.96 feet.

Table 8. Chatham County Stormwater inventory with site survey elevation data

Dataset	Bottom of Structure (%)	Top of Structure (%)
OUTFALLS_TO_STATEWATERS	161 (37.2%)	161 (37.2%)
STORM_WATER_STRUCTURES	11,041 (52.4%)	2,504 (11.9%)

Table 9. City of Savannah Stormwater inventory with site survey elevation data

Dataset	Bottom of Structure (%)	Top of Structure (%)
Stormwater_DW_Screening_Pts	127 (60.2%)	127 (60.2%)
Stormwater_Headwalls	540 (43.5%)	473 (37.8%)
Stormwater_Inlets	12,049 (85.9%)	12,622 (90.0%)
Stormwater_Manholes	4,970 (79.1%)	5,734 (91.3%)

Bottom of structure elevation estimates for pipe conveyance features without site-level survey elevation data were developed through several approaches. For structures where depth to bottom measures were taken at the site level, bottom of structure elevation was estimated by subtracting depth to bottom from the top elevation derived from a DEM. For all other structures without site-level data, a statistical analysis of features with site-level bottom of structure data was used to apply an estimated bottom of structure value, which was calculated as depth below the structure's calculated DEM ground elevation. A summary of the bottom of structure estimates used for Chatham County stormwater features in provided in Table 10. Estimates of City of Savannah features are provided in Table 11.

Table 10. Assumed bottom of structure depth below ground elevation for stormwater features without site survey information, Chatham County

Dataset	Assumed Bottom of Structure Depth
OUTFALLS_TO_STATEWATERS	4.00'
STORM_WATER_STRUCTURES	4.00'

Table 11. Assumed bottom of structure depth below ground elevation for stormwater features without site survey information, City of Savannah

Dataset	Assumed Bottom of Structure Depth
Stormwater_DW_Screening_Pts	8.00'
Stormwater_Headwalls	4.00'
Stormwater_Inlets	5.00'
Stormwater_Manholes	7.00'

City of Savannah Tide Gates

The City of Savannah's Stormwater Management program currently maintains a system of seven tide gates that are designed to mitigate and prevent tidal infiltration into the stormwater system. Potential vulnerability to City of Savannah tide gates under high tide and 100-year coastal flood conditions was determined by assessment of site-level ground elevations at the tide gate locations. The assumption behind this assessment is that overtopping of the tide gate both restricts the drainage capacity of the conveyance system within a design rainfall event and, under extreme conditions, bank overflow at a tide gate location could result in surface water flooding that completely bypasses the regular backflow protection provided by the tide gate. A summary of the tide gate stations, basin served, and overtopping elevation are provided in **Table 12.**

Table 12. City of Savannah Outfall Tide Gates

Tide Gate Description	Stormwater Basin	Receiving Water	Top of Structure Elevation, as NAVD88 feet
Marriott Pedestrian Ramp	Bilbo	Savannah River	6.6’
Bilbo Box on Savannah River, 12’ Width	Bilbo	Savannah River	7.8’
Bilbo Box, Old Landfill, 20’ Width	Casey South	Savannah River	2.9’
Grant Street, 3’ Width	Coffee Bluff	Vernon River	5.0’
Coffee Bluff, Robin Road into marsh	Coffee Bluff	Vernon River	4.7’
Victory Drive Bridge, 4’ Width	Placentia	Placentia Canal	2.7’
White Bluff Road	Wilshire	Wilshire Canal	4.4’

City of Savannah Stormwater Pump Stations

The City of Savannah maintains a system of seven stormwater pump stations to assist with conveyance of stormwater. One of the systems (the Gwinnett Street Pump Station, which services the Bilbo stormwater drainage) assists with water passage through a railroad underpass and does not discharge to a receiving waterbody. The other six systems directly assist with discharge to tidal waters and also provide some degree of defense against tidewater backflow into the stormwater system.

Stormwater engineers with the City of Savannah’s Stormwater Management provided pumping capacity data for the stormwater pumping systems, as well as storm surge elevations that would be expected to inundate the pump system or otherwise result in complete loss of pumping capacity. The pumping capacities for these systems, the drainage basin served by the systems, and failure point elevations are provided in Table 13.

Table 13. City of Savannah Stormwater Pump Stations

Pump Station	Stormwater Basin	Pumping Capacity (GPM)	Tidewater Failure Threshold, as NAVD88 feet
Gwinnett Street	Bilbo	20,000	N/A
Kayton	Casey North	574,000	6.5’
DeRenne	Casey South	858,000	8.0’
Montgomery Cross	Casey South	412,500	8.0’
Fell Street	Fell Street	150,000	8.07’
Lathrop	Fell Street	495,000	13.57’
Springfield	Springfield North	480,000	9.0’


Springfield Pump Station

Stormwater System Vulnerability to Regular Tidal Flooding with Sea-Level

6.1 Chatham County Stormwater System Outfalls

The Chatham County stormwater system has a total of 433 documented outfall points into state waters. The vulnerability of these outfalls to regular tidal flooding at the adjusted MSL, MHHW, HAT tidal datums for the NOAA Intermediate-High Sea-Level Rise projection scenarios in 2020, 2050, 2075, and 2100 is shown in Table 14. Notably, a total of 28% of outfalls show a top of structure below the estimated 2020 MHHW, indicating potential for daily tidal penetration into the stormwater systems serviced by these outfalls. More than double this amount, or 64%, of outfalls show top of structure inundation at the projected 2020 HAT datum. Under the 2100 NOAA-Intermediate High projection scenario, approximately 88% of outfalls would show top of structure inundation at MHHW and 93% would show top of structure inundation at HAT. A detailed visualization of HAT impacts is shown in the Map Series 5 Appendix, and a further breakdown of top of structure inundation of outfalls by HUC-12 watershed in Chatham County is provided in Table 15.

Table 14. Chatham County Stormwater System, Tidal Flooding Vulnerability Assessment Summary for Outfalls to State Waters by Sea-Level Rise Scenario

Scenario (NAVD88 Elevation)	Bottom of Structure	Top of Structure
2020 MSL (0.29’)	92 (21%)	19 (4%)
2020 MHHW (3.97’)	295 (68%)	121 (28%)
2020 HAT (5.79’)	385 (89%)	275 (64%)
2050 MSL (1.32’)	154 (36%)	26 (6%)
2050 MHHW (5.00’)	349 (81%)	212 (49%)
2050 HAT (6.82’)	394 (91%)	353 (82%)
2075 MSL (2.57’)	224 (52%)	52 (12%)
2075 MHHW (6.25’)	391 (90%)	314 (73%)
2075 HAT (8.07’)	408 (94%)	384 (89%)
2100 MSL (4.46’)	324 (75%)	167 (39%)
2100 MHHW (7.84’)	407 (94%)	379 (88%)
2100 HAT (9.66’)	413 (95%)	403 (93%)

Table 15. Chatham County Stormwater System, Top of Structure Flooding Vulnerability Assessment Summary for Outfalls to State Waters under Highest Astronomical Tide (HAT), by NOAA Intermediate-High Sea-Level Rise Projection Scenario Year and HUC-12 Watershed. Detailed paneled visualizations of HAT impacts provided in Map Series 5.

HUC-12	Total Inventory	2020	2050	2075	2100
Casey Canal-Haners Creek	9	8 (89%)	9 (100%)	9 (100%)	9 (100%)
Hardin Canal-Little Ogeechee River	2	2 (100%)	2 (100%)	2 (100%)	2 (100%)
Morgans Bridge-Ogeechee River	3	0 (0%)	0 (0%)	0 (0%)	0 (0%)
Ossabaw Sound-Frontal Atlantic Ocean	2	1 (50%)	1 (50%)	2 (100%)	2 (100%)
Outlet Savannah River	23	7 (30%)	11 (48%)	18 (78%)	20 (87%)
Salt Creek Little Ogeechee River	92	50 (54%)	64 (70%)	72 (78%)	76 (83%)
Sterling Creek-Ogeechee River	3	3 (100%)	3 (100%)	3 (100%)	3 (100%)
Vernon River	72	48 (67%)	67 (93%)	70 (97%)	72 (100%)
Wassaw Sound-Frontal Atlantic Ocean	78	62 (79%)	73 (94%)	76 (97%)	78 (100%)
Wilmington River	149	94 (63%)	123 (83%)	132 (89%)	139 (93%)

6.2 Chatham County Stormwater System Inland Structures

The Chatham County stormwater system has a total of 21,070 inventoried structures in addition to the outfalls into state waters. The raw count vulnerability of these structures to regular tidal flooding at the adjusted MSL, MHHW, HAT tidal datums for the NOAA Intermediate-High Sea-Level Rise projection scenarios in 2020, 2050, 2075, and 2100 is shown in Table 16. Approximately, 3% of structures show top of structure inundation vulnerability under 2020 MHHW and 8% show vulnerability to 2020 HAT. The top of structure tidal inundation vulnerability rises to 19% for 2100 MHHW and 30% for 2100 HAT. A more detailed breakdown by structure type (Table 17; Map Series 5) indicates that a comparatively large percentage of vulnerability is associated with culvert headwalls and tide gate systems within the underground pipe infrastructure, with smaller relative vulnerability for inlet structures. A geographic breakdown by HUC-12 watershed (Table 18) indicates that there is proportionally more current and future tidal flooding vulnerability within watersheds directly adjacent to the Atlantic Ocean and tidal river systems as compared to the more inland watersheds of Chatham County.

Table 16. Chatham County Stormwater System, Tidal Flooding Vulnerability Assessment Summary for all Inlets, Manholes, and Culvert Structures in the STORM_WATER_STRUCTURES database

Scenario (NAVD88 Elevation)	Bottom of Structure	Top of Structure
2020 MSL (0.29’)	601 (3%)	49 (0.2%)
2020 MHHW (3.97’)	3533 (17%)	579 (3%)
2020 HAT (5.79’)	6139 (29%)	1657 (8%)
2050 MSL (1.32’)	1029 (5%)	97 (0.4%)
2050 MHHW (5.00’)	5011 (24%)	1082 (5%)
2050 HAT (6.82’)	7491 (36%)	2823 (13%)
2075 MSL (2.57’)	1967 (9%)	224 (1%)
2075 MHHW (6.25’)	6747 (32%)	2110 (10%)
2075 HAT (8.07’)	9332 (44%)	4319 (20%)
2100 MSL (4.46’)	4238 (20%)	806 (4%)
2100 MHHW (7.84’)	8975 (43%)	4060 (19%)
2100 HAT (9.66’)	11774 (56%)	6412 (30%)

Table 17. Chatham County Stormwater System, Detailed Top of Structure Tidal Flooding Vulnerability Summary for Highest Astronomical Tide (HAT) by NOAA Intermediate High Sea-Level Rise Projection Scenario Year. Includes raw count of impacted structure types and percentage of each structure type impacted by each projection scenario year within the STORM_WATER_STRUCTURES database. Detailed paneled visualizations provided in Map Series 5.

Structure	2020	2050	2075	2100
Box Culvert	11 (41%)	14 (52%)	18 (67%)	21 (78%)
Control Structure	10 (11%)	18 (20%)	24 (27%)	31 (34%)
Curb Inlet	30 (0.8%)	218 (6%)	455 (12%)	743 (20%)
Drop Inlet	21 (3%)	46 (7%)	98 (14%)	141 (21%)
End of Pipe	1038 (11%)	1537 (17%)	2170 (23%)	3107 (34%)
Flared End Section	195 (11%)	332 (18%)	487 (27%)	684 (38%)
Grate Inlet	30 (3%)	98 (9%)	192 (17%)	314 (28%)
Headwall	105 (12%)	163 (19%)	239 (28%)	358 (41%)
Honeycomb Inlet	0 (0%)	0 (0%)	0 (0%)	0 (0%)
Hooded Grate Inlet	15 (3%)	73 (12%)	117 (20%)	199 (33%)
Junction Box	3 (7%)	6 (15%)	7 (17%)	13 (32%)

Structure	2020	2050	2075	2100
Manhole	15 (1%)	43 (15%)	94 (8%)	191 (16%)
Outlet Structure	1 (5%)	2 (10%)	3 (15%)	5 (25%)
Roof Inlet	23 (4%)	49 (10%)	87 (17%)	140 (27%)
Tee Junction	0 (0%)	0 (0%)	0 (0%)	0 (0%)
Tide Gate	39 (76%)	43 (84%)	48 (94%)	51 (100%)
Unknown	104 (12%)	154 (18%)	237 (28%)	354 (42%)
Weir	5 (7%)	7 (10%)	13 (18%)	22 (31%)
Yard Inlet	4 (5%)	12 (14%)	22 (27%)	29 (35%)

Table 18. Chatham County Stormwater System Top of Structure Tidal Flooding Vulnerability Summary for Highest Astronomical Tide (HAT) by NOAA Intermediate High Sea-Level Rise Projection Scenario Year, by HUC-12 Watershed. Includes raw count and percentage for all Inlets, Manholes, and Culvert Structures in the STORM_WATER_STRUCTURES database for each projection scenario.

HUC-12	Total Inventory	2020	2050	2075	2100
Casey Canal-Haneys Creek	203	29 (14%)	49 (24%)	56 (28%)	70 (34%)
Hardin Canal-Little Ogeechee River	1650	21 (1%)	32 (2%)	62 (4%)	131 (8%)
Morgans Bridge-Ogeechee River	522	3 (0.6%)	4 (0.7%)	5 (1%)	7 (1%)
Ossabaw Sound-Frontal Atlantic Ocean	76	5 (7%)	7 (9%)	14 (18%)	38 (50%)
Outlet Savannah River	1612	119 (7%)	172 (11%)	222 (14%)	303 (19%)
Pipemaker Canal	1372	37 (3%)	52 (4%)	106 (8%)	193 (14%)
Salt Creek Little Ogeechee River	5743	368 (6%)	605 (11%)	885 (15%)	1248 (22%)
Sterling Creek-Ogeechee River	67	33 (49%)	43 (64%)	46 (69%)	49 (73%)
Vernon River	2566	284 (11%)	514 (20%)	657 (26%)	786 (31%)
Wassaw Sound-Frontal Atlantic Ocean	2747	315 (11%)	570 (21%)	966 (35%)	1545 (56%)
Wilmington River	4467	441 (10%)	773 (17%)	1298 (29%)	2040 (46%)

6.3 City of Savannah Stormwater Discharge Structures

The City of Savannah stormwater system has a total of 211 discharge station points. The vulnerability of these discharge stations to regular tidal flooding at the adjusted MSL, MHHW, HAT tidal datums for the NOAA Intermediate-High Sea-Level Rise projection scenarios in 2020, 2050, 2075, and 2100 is shown in Table 19. A total of 9% of discharge stations show a top of structure below the estimated 2020 MHHW, providing the potential for daily tidal penetration into the stormwater systems. Approximately 28% of these discharge structures show top of structure inundation at the projected 2020 HAT. Under the 2012-NOAA-Intermediate High projection scenario for 2100, approximately 52% of outfalls would show top of structure inundation at MHHW and 80% would show top of structure inundation at HAT.

A detailed visualization of HAT impacts to these discharge structures is shown as part of Map Series 5, and a further breakdown of top of structure inundation by delineated stormwater basin (or HUC-12 watershed) is provided in Table 20. Notably, approximately 4% of the discharge station points are within stormwater basins serviced by one of the City of Savannah's stormwater pump stations. Not surprisingly, the proportion of the discharge station points with vulnerability to tidal flooding at 2020 HAT is higher (50%) in basins served by stormwater pump systems than across the other stormwater basins within the City of Savannah that do not currently have pump stations. Also, control elevations for the pump stations are currently sufficient to avoid failure due to regular tidal inundation from a regular 2020 HAT event. However, the Kayton pump station, which services the Casey North stormwater basin, would be subject to possible failure at the projected 2050 HAT without appropriate upgrades to this pump station system. The DeRenne (Casey South), Montgomery Cross (Casey South), and Fell Street (Fell Street) pump stations show vulnerability to inundation failure at the projected 2075 HAT. The Springfield North pump station shows vulnerability at the 2100 HAT.

Table 19. City of Savannah Stormwater System, Tidal Flooding Vulnerability Assessment Summary for Discharge Structures (Stormwater_DW_Screening_Pts) by Sea-Level Rise Scenario

Scenario (NAVD88 Elevation)	Bottom of Structure	Top of Structure
2020 MSL (0.29')	78 (37%)	2 (1%)
2020 MHHW (3.97')	162 (77%)	18 (9%)
2020 HAT (5.79')	180 (85%)	59 (28%)
2050 MSL (1.32')	92 (44%)	3 (1%)
2050 MHHW (5.00')	173 (82%)	43 (20%)
2050 HAT (6.82')	192 (91%)	83 (39%)
2075 MSL (2.57')	127 (60%)	16 (8%)
2075 MHHW (6.25')	183 (93%)	72 (34%)
2075 HAT (8.07')	196 (93%)	111 (53%)
2100 MSL (4.46')	171 (81%)	29 (14%)
2100 MHHW (7.84')	196 (93%)	109 (52%)
2100 HAT (9.66')	199 (94%)	168 (80%)

Table 20. City of Savannah Top of Discharge Structure Tidal Flooding Vulnerability Summary for Highest Astronomical Tide (HAT) at NOAA Intermediate High Sea-Level Rise Projection Scenario Year and by Stormwater Drainage Basin. Bolded drainage basins are served by pump stations for outfall assistance. Asterisk indicates that the projection scenario tidewater level exceeds current control elevation for a pump station within the basin. Detailed paneled visualizations provided in Map Series 5.

Drainage Basin	Total Inventory	2020	2050	2075	2100
Bilbo	17	2 (12%)	4 (23%)	5 (29%)	9 (53%)
Casey North	3	2 (67%)	2 (67%)*	3 (100%)*	3 (100%)*
Casey South	5	4 (80%)	4 (80%)	5 (100%)*	5 (100%)*
Chippewa	11	1 (9%)	1 (9%)	3 (27%)	4 (36%)
Coffee Bluff	22	9 (41%)	11 (50%)	15 (68%)	19 (86%)
Dundee Canal	7	4 (57%)	4 (57%)	6 (86%)	6 (86%)
Fell Street	3	1 (33%)	1 (33%)	2 (67%)*	3 (100%)*
Harmon	32	11 (34%)	12 (38%)	16 (50%)	21 (66%)
Horseshoe	3	2 (67%)	2 (67%)	3 (100%)	3 (100%)

Drainage Basin	Total Inventory	2020	2050	2075	2100
Outlet Savannah River (HUC-12)	20	8 (40%)	13 (65%)	17 (85%)	20 (100%)
Pipemakers Canal	2	1 (50%)	1 (50%)	1 (50%)	2 (100%)
Placentia	13	4 (31%)	6 (46%)	6 (46%)	7 (54%)
Springfield North	5	2 (40%)	2 (40%)	2 (40%)	3 (60%)*
St. Augustine Creek	1	0 (0%)	0 (0%)	0 (0%)	0 (0%)
Wilshire	24	3 (13%)	6 (25%)	12 (50%)	14 (58%)
Windsor	43	5 (12%)	14 (33%)	15 (35%)	21 (49%)

6.4 City of Savannah Stormwater Headwall Structures

The City of Savannah stormwater system has a total of 1,252 documented culvert headwall structures. The vulnerability of headwalls to regular tidal flooding at the adjusted MSL, MHHW, HAT tidal datums for the NOAA Intermediate-High Sea-Level Rise projection scenarios in 2020, 2050, 2075, and 2100 is shown in Table 21. A total of 11% of headwalls show a top of structure below the estimated 2020 MHHW, and approximately 20% of headwalls show top of structure inundation at 2020 HAT. Under the 2100 NOAA-Intermediate High projection scenario, approximately 31% would show top of structure inundation at MHHW and 40% would show top of structure inundation at HAT.

A detailed visualization of HAT impacts to headwall structures is shown as part of Map Series 5, and a further breakdown of top of structure inundation by delineated stormwater basin (or HUC-12 watershed) is provided in Table 22. Approximately 48% of the headwall points are within stormwater basins serviced by one of the City of Savannah's stormwater pump stations, and the proportion of headwalls with vulnerability to tidal flooding at 2020 HAT is higher (27%) in basins served by stormwater pump systems than across stormwater basins without pump station service.

Table 21. City of Savannah Stormwater System, Tidal Flooding Vulnerability Assessment Summary for Headwall Structures (Stormwater_Headwalls) by Sea-Level Rise Scenario

Scenario (NAVD88 Elevation)	Bottom of Structure	Top of Structure
2020 MSL (0.29')	108 (9%)	28 (2%)
2020 MHHW (3.97')	348 (28%)	142 (11%)
2020 HAT (5.79')	507 (40%)	248 (20%)
2050 MSL (1.32')	146 (12%)	46 (4%)
2050 MHHW (5.00')	447 (36%)	204 (16%)
2050 HAT (6.82')	564 (45%)	317 (25%)
2075 MSL (2.57')	252 (20%)	79 (6%)
2075 MHHW (6.25')	537 (43%)	284 (23%)
2075 HAT (8.07')	654 (52%)	405 (32%)
2100 MSL (4.46')	400 (32%)	177 (14%)
2100 MHHW (7.84')	637 (51%)	387 (31%)
2100 HAT (9.66')	753 (60%)	497 (40%)

Flooding on Abercorn Street on July 20, 2018.

Table 22. City of Savannah Top of Headwall Structure Tidal Flooding Vulnerability Summary for Highest Astronomical Tide (HAT) at NOAA Intermediate High Sea-Level Rise Projection Scenario Year and by Stormwater Drainage Basin. Bolded drainage basins are served by pump stations for outfall assistance. Detailed paneled visualizations provided in Map Series 5.

Drainage Basin	Total Inventory	2020	2050	2075	2100
Casey North	7	1 (14%)	2 (29%)*	2 (29%)*	3 (43%)*
Casey South	284	77 (27%)	96 (34%)	119 (42%)*	138 (49%)*
Chippewa	36	2 (6%)	3 (8%)	6 (17%)	8 (22%)
Coffee Bluff	26	8 (31%)	13 (50%)	17 (65%)	19 (73%)
Dundee Canal	34	3 (9%)	3 (9%)	5 (15%)	10 (29%)
Fell Street	21	7 (33%)	8 (38%)	12 (57%)	14 (67%)
Harmon	50	3 (6%)	3 (6%)	5 (10%)	6 (12%)
Horseshoe	12	1 (8%)	2 (17%)	3 (25%)	6 (50%)
Little Ogeechee	25	7 (28%)	7 (28%)	8 (32%)	9 (36%)
Ogeechee	11	0 (0%)	0 (0%)	0 (0%)	0 (0%)
Outlet Savannah River (HUC-12)	9	6 (67%)	6 (67%)	6 (67%)	7 (78%)
Pipemakers Canal	32	1 (3%)	1 (3%)	2 (6%)	3 (9%)
Placentia	49	11 (22%)	15 (31%)	22 (45%)	30 (61%)
Springfield North	293	77 (26%)	91 (31%)	113 (39%)*	138 (47%)*
Springfield South	26	0 (0%)	0 (0%)	0 (0%)	1 (4%)
St. Augustine Creek	70	3 (4%)	4 (6%)	5 (7%)	7 (10%)
Talmadge	2	0 (0%)	0 (0%)	0 (0%)	1 (50%)
Wilmington River (HUC-12)	2	0 (0%)	0 (0%)	1 (50%)	1 (50%)
Wilshire	128	20 (16%)	26 (20%)	32 (25%)	41 (32%)
Windsor	135	21 (16%)	37 (27%)	47 (35%)	55 (41%)

6.5 City of Savannah Stormwater Inlet Structures

The City of Savannah stormwater system has a total of 14,031 documented inlet structures. The vulnerability of inlets to regular tidal flooding at the adjusted MSL, MHHW, HAT tidal datums for the NOAA Intermediate-High Sea-Level Rise projection scenarios in 2020, 2050, 2075, and 2100 is shown in Table 23. A total of 0.3% of inlets show a top of structure below the estimated 2020 MHHW and approximately 1% of inlets show top of structure inundation at 2020 HAT. Under the 2100 NOAA-Intermediate High projection scenario, approximately 9% would show top of structure inundation at MHHW and 15% would show top of structure inundation at HAT.

A detailed visualization of HAT impacts to inlets is shown as part of Map Series 5, and a further breakdown of top of structure inundation by delineated stormwater basin (or HUC-12 watershed) is provided in Table 24. Approximately 54% of the inlet points are within stormwater basins serviced by one of the City of Savannah's stormwater pump stations. The proportion of inlets with vulnerability to tidal flooding at 2020 HAT is higher (1%) in almost all delineated stormwater basins served by stormwater pump systems than across stormwater basins without pump station service. Inlets within a section of the HUC-12 Outlet Savannah River watershed, but without a separate stormwater basin delineation by the City of Savannah, show the largest proportion of vulnerability to 2020 HAT (32%) and very high vulnerability (86%) of inlets under 2100 HAT.

Table 23. City of Savannah Stormwater System, Tidal Flooding Vulnerability Assessment Summary for Inlet Structures (Stormwater_Inlets) by Sea-Level Rise Scenario

Scenario (NAVD88 Elevation)	Bottom of Structure	Top of Structure
2020 MSL (0.29’)	233 (2%)	0 (0%)
2020 MHHW (3.97’)	853 (6%)	45 (0.3%)
2020 HAT (5.79’)	1444 (10%)	154 (1%)
2050 MSL (1.32’)	316 (2%)	1 (0%)
2050 MHHW (5.00’)	1170 (8%)	93 (0.7%)
2050 HAT (6.82’)	1807 (13%)	365 (3%)
2075 MSL (2.57’)	522 (4%)	9 (0.1%)
2075 MHHW (6.25’)	1597 (11%)	244 (2%)
2075 HAT (8.07’)	2401 (17%)	652 (5%)
2100 MSL (4.46’)	1010 (7%)	314 (2%)
2100 MHHW (7.84’)	2332 (17%)	1307 (9%)
2100 HAT (9.66’)	3392 (24%)	2179 (15%)

Table 24. City of Savannah Top of Inlet Structure Tidal Flooding Vulnerability Summary for Highest Astronomical Tide (HAT) at NOAA Intermediate High Sea-Level Rise Projection Scenario Year and by Stormwater Drainage Basin. Bolded drainage basins are served by pump stations for outfall assistance. Detailed paneled visualizations provided in Map Series 5.

Drainage Basin	Total Inventory	2020	2050	2075	2100
Bilbo	1444	22 (2%)	48 (3%)	69 (5%)	111 (8%)
Casey Canal-Haney’s Creek (HUC-12)	1	0 (0%)	0 (0%)	0 (0%)	0 (0%)
Casey North	1305	1 (0%)	2 (0%)*	20 (2%)*	99 (8%)*
Casey South	3501	25 (1%)	83 (2%)	140 (4%)*	203 (6%)*
Chippewa	333	0 (0%)	0 (0%)	0 (0%)	2 (0.6%)
Coffee Bluff	396	8 (2%)	16 (4%)	26 (7%)	60 (15%)
Dundee Canal	135	0 (0%)	3 (2%)	4 (3%)	6 (4%)
Fell Street	559	14 (3%)	29 (5%)	54 (10%)*	122 (22%)*
Harmon	617	0 (0%)	2 (0.3%)	8 (1%)	28 (5%)
Horseshoe	158	0 (0%)	1 (0.6%)	1 (0.6%)	6 (4%)
Little Ogeechee	148	3 (2%)	15 (10%)	20 (14%)	32 (22%)
Ogeechee	279	0 (0%)	1 (0.3%)	17 (6%)	67 (24%)
Outlet Savannah River (HUC-12)	137	44 (32%)	60 (44%)	94 (69%)	118 (86%)
Pipemakers Canal	142	0 (0%)	0 (0%)	0 (0%)	1 (0.7%)
Placentia	894	4 (0%)	20 (2%)	41 (5%)	68 (8%)
Raspberry	12	0 (0%)	0 (0%)	0 (0%)	0 (0%)
Redgate	6	0 (0%)	0 (0%)	0 (0%)	0 (0%)
Springfield North	2151	33 (2%)	80 (4%)	140 (7%)	217 (10%)*
Springfield South	124	0 (0%)	0 (0%)	0 (0%)	0 (0%)
St. Augustine Creek	480	0 (0%)	0 (0%)	0 (0%)	1 (0.2%)

Drainage Basin	Total Inventory	2020	2050	2075	2100
Talmadge	25	0 (0%)	0 (0%)	1 (4%)	2 (6%)
Vernon River (HUC-12)	1	0 (0%)	0 (0%)	0 (0%)	0 (0%)
Wilmington River (HUC-12)	32	0 (0%)	1 (3%)	1 (3%)	2 (6%)
Wilshire	552	0 (0%)	0 (0%)	2 (0.4%)	6 (1%)
Windsor	599	1 (0%)	4 (0.7%)	14 (2%)	32 (5%)

6.6 City of Savannah Stormwater Manhole Structures

The City of Savannah stormwater system has a total of 6,280 documented manhole structures. The vulnerability of inlets to regular tidal flooding at the adjusted MSL, MHHW, HAT tidal datums for the NOAA Intermediate-High Sea-Level Rise projection scenarios in 2020, 2050, 2075, and 2100 is shown in Table 25. A total of 0.3% of inlets show a top of structure below the estimated 2020 MHHW and approximately 1% of inlets show top of structure inundation at 2020 HAT. Under the 2100 NOAA-Intermediate High projection scenario, approximately 4% would show top of structure inundation at MHHW and 9% would show top of structure inundation at HAT.

A detailed visualization of HAT impacts to manholes is shown as part of Map Series 5, and a further breakdown of top of structure inundation by delineated stormwater basin (or HUC-12 watershed) is provided in Table 26. Approximately 60% of the manholes are within stormwater basins serviced by one of the City of Savannah's stormwater pump stations. The proportion of manholes points with vulnerability to tidal flooding at 2020 HAT is higher (1%) in almost all delineated stormwater basins served by stormwater pump systems than across stormwater basins without pump station service. Manholes within a section of the HUC-12 Outlet Savannah River watershed, but without a separate stormwater basin delineation by the City of Savannah, show the largest proportion of vulnerability to 2020 HAT (6%) and very high vulnerability (89%) of manholes under 2100 HAT.

Table 25. City of Savannah Stormwater System, Tidal Flooding Vulnerability Assessment Summary for Manhole Structures (Stormwater_Manholes) by Sea-Level Rise Scenario

Scenario (NAVD88 Elevation)	Bottom of Structure	Top of Structure
2020 MSL (0.29')	221 (4%)	1 (0%)
2020 MHHW (3.97')	698 (11%)	17 (0.3%)
2020 HAT (5.79')	1040 (17%)	74 (1%)
2050 MSL (1.32')	313 (5%)	1 (0%)
2050 MHHW (5.00')	903 (14%)	33 (0.5%)
2050 HAT (6.82')	1251 (20%)	144 (2%)
2075 MSL (2.57')	470 (7%)	3 (0%)
2075 MHHW (6.25')	1130 (18%)	97 (2%)
2075 HAT (8.07')	1546 (25%)	283 (5%)
2100 MSL (4.46')	790 (13%)	20 (0.3%)
2100 MHHW (7.84')	1483 (24%)	254 (4%)
2100 HAT (9.66')	1958 (31%)	545 (9%)

Table 26. City of Savannah Top of Manhole Structure Tidal Flooding Vulnerability Summary for Highest Astronomical Tide (HAT) at NOAA Intermediate High Sea-Level Rise Projection Scenario Year and by Stormwater Drainage Basin. Bolded drainage basins are served by pump stations for outfall assistance. Detailed paneled visualizations provided in Map Series 5.

Drainage Basin	Total Inventory	2020	2050	2075	2100
Bilbo	772	18 (2%)	29 (4%)	40 (5%)	59 (8%)
Casey North	803	1 (0.1%)	4 (0.5%)*	20 (2%)*	68 (8%)*
Casey South	1515	16 (1%)	27 (2%)	44 (3%)*	59 (4%)*
Chippewa	130	0 (0%)	0 (0%)	1 (0.8%)	1 (0.8%)
Coffee Bluff	175	4 (2%)	11 (6%)	18 (10%)	27 (15%)
Dundee Canal	48	2 (4%)	3 (6%)	7 (15%)	8 (17%)
Fell Street	368	10 (3%)	18 (5%)	50 (14%)*	104 (28%)*
Harmon	170	0 (0%)	0 (0%)	2 (1%)	6 (4%)
Horseshoe	34	0 (0%)	0 (0%)	2 (6%)	4 (12%)
Little Ogeechee	30	0 (0%)	1 (3%)	6 (20%)	8 (27%)
Ogeechee	66	0 (0%)	2 (3%)	2 (3%)	8 (12%)
Outlet Savannah River (HUC-12)	64	4 (6%)	8 (13%)	17 (27%)	57 (89%)
Pipemakers Canal	22	0 (0%)	0 (0%)	0 (0%)	0 (0%)
Placentia	419	0 (0%)	5 (1%)	11 (3%)	27 (6%)
Raspberry	1	0 (0%)	0 (0%)	0 (0%)	0 (0%)
Springfield North	1075	19 (2%)	36 (3%)	62 (6%)	104 (10%)*
Springfield South	38	0 (0%)	0 (0%)	0 (0%)	0 (0%)
St. Augustine Creek	139	0 (0%)	0 (0%)	0 (0%)	0 (0%)
Vernon River (HUC-12)	5	0 (0%)	0 (0%)	0 (0%)	0 (0%)
Wilmington River (HUC-12)	10	0 (0%)	0 (0%)	0 (0%)	1 (10%)
Wilshire	135	0 (0%)	0 (0%)	0 (0%)	0 (0%)
Windsor	231	0 (0%)	0 (0%)	1 (0.4%)	4 (2%)

River Street during high tide

Stormwater System Vulnerability to Regular Tidal Flooding with Sea-Level

7. Stormwater System Vulnerability to 100-Year Coastal Flood with Sea-Level Rise

A series of vulnerability assessments for stormwater infrastructure in relation to overtopping by the Hazus 100-Year Coastal Flood was conducted for Chatham County and City of Savannah. Hazus Coastal Flood model runs were performed using a 30-meter resolution DEM, based upon the 2009 Chatham County LIDAR project, which is part of the United States Geological Survey (USGS) National Elevation Dataset (NED). The 30-meter NED raster interpolates across all “null” data cells and provides a manageable file size appropriate for the computational burdens associated with running the Hazus Coastal Flood modeling runs at a regional scale.

Structure overtopping by the storm surge associated with this coastal flood condition would be expected to result in complete loss of function of the structure for precipitation drainage purposes and, in some cases, could result in the structures serving as a backflow conduit for storm surge waters to flood into built areas.

As presented above in Table 4, the adjusted stillwater elevations for a 100-year Coastal Flood in the years 2020, 2050, 2075, and 2100 under the NOAA Intermediate-High Sea-Level Rise projection scenario were used to develop all vulnerability assessments presented in this section. An additional 100-Year Hazus Coastal Flood scenario running the 2100 CRD High scenario was also developed for delineating the CWPA boundary. Detailed visualizations of the infrastructure vulnerability are presented in the Map Series 6 Appendix.

7.1 Chatham County Stormwater System

As shown in Table 27, the Chatham County stormwater system shows high vulnerability to outfall overtopping (95%) and structure inundation (43%) with the “base case” 2020 Hazus 100-Year Coastal Flood. With the 2100 scenario (4.39’ of sea-level rise), almost all outfalls (99%) and a substantial majority of other structures (76%) show vulnerability to overtopping with a Hazus 100-Year Coastal Flood event.

Table 27. Summary of Chatham County Stormwater Infrastructure with Top of Structure Vulnerability to 100-Year Hazus Coastal Flood by NOAA Intermediate-High Sea-Level Rise Projection Year. Visual details in Map Series 6.

	2020	2050	2075	2100
Outfalls	411 (95%)	421 (97%)	425 (98%)	429 (99%)
Structures	9,005 (43%)	11,313 (54%)	14,073 (67%)	15,997 (76%)

A breakdown of outfall vulnerability by HUC-12 Watershed (Table 28) shows that the major stormwater drainage systems within Chatham County all have a high level of vulnerability to storm surge at outfall sites. Because outfalls are naturally located in the lowest point of a watershed, this high degree of vulnerability is not surprising. A similar HUC-12 Watershed assessment of all other structure (Table 29) demonstrates some differences in vulnerability among different watersheds, with coastal watersheds generally showing a higher degree of vulnerability from more inland watersheds. However, the sea-level rise scenarios in particular show the potential for storm surge to travel substantially inland through coastal riverine corridors, and the overall results underscore that storm surge combined with the threat of future sea-level rise is a very serious hazard risk that is likely to require consistent and continuous mitigation planning within Chatham County and associated municipalities.

Table 28. Chatham County Outfalls with Top of Structure Vulnerability to 100-Year Hazus Coastal Flood with NOAA Intermediate-High Sea Level Rise, by HUC-12 Watershed

HUC-12	Total Inventory	2020	2050	2075	2100
Casey Canal-Haneys Creek	9	9 (100%)	9 (100%)	9 (100%)	9 (100%)
Hardin Canal-Little Ogeechee River	2	2 (100%)	2 (100%)	2 (100%)	2 (100%)
Morgans Bridge-Ogeechee River	3	1 (33%)	1 (33%)	1 (33%)	2 (67%)

HUC-12	Total Inventory	2020	2050	2075	2100
Ossabaw Sound-Frontal Atlantic Ocean	2	2 (100%)	2 (100%)	2 (100%)	2 (100%)
Outlet Savannah River	23	18 (78%)	18 (78%)	19 (83%)	20 (87%)
Salt Creek Little Ogeechee River	92	92 (100%)	92 (100%)	92 (100%)	92 (100%)
Sterling Creek-Ogeechee River	3	3 (100%)	3 (100%)	3 (100%)	3 (100%)
Vernon River	72	70 (97%)	72 (100%)	72 (100%)	72 (100%)
Wassaw Sound-Frontal Atlantic Ocean	78	77 (99%)	77 (99%)	78 (100%)	78 (100%)
Wilmington River	149	137 (92%)	145 (97%)	147 (99%)	149 (100%)

Table 29. Chatham County Stormwater System, Top of Structure Tidal Flooding Vulnerability Summary for 100-Year Hazus Coastal Flood with NOAA Intermediate High Sea-Level Rise, by HUC-12 Watershed

HUC-12	Total Inventory	2020	2050	2075	2100
Casey Canal-Haneys Creek	203	95 (47%)	107 (53%)	116 (57%)	125 (62%)
Hardin Canal-Little Ogeechee River	1650	483 (29%)	591 (36%)	746 (45%)	1008 (61%)
Morgans Bridge-Ogeechee River	522	8 (2%)	8 (2%)	9 (2%)	70 (13%)
Ossabaw Sound-Frontal Atlantic Ocean	76	76 (100%)	76 (100%)	76 (100%)	76 (100%)
Outlet Savannah River	1612	339 (21%)	396 (25%)	510 (32%)	555 (34%)
Pipemaker Canal	1372	257 (19%)	389 (28%)	641 (47%)	851 (62%)
Salt Creek Little Ogeechee River	5743	1969 (34%)	2850 (50%)	4056 (71%)	4797 (84%)
Sterling Creek-Ogeechee River	67	57 (85%)	63 (94%)	63 (94%)	63 (94%)
Vernon River	2566	973 (38%)	1231 (48%)	1514 (59%)	1719 (67%)
Wassaw Sound-Frontal Atlantic Ocean	2747	1803 (66%)	2197 (80%)	2544 (93%)	2669 (97%)
Wilmington River	4467	2943 (66%)	3403 (76%)	3796 (85%)	4062 (91%)

7.2 City of Savannah Stormwater System

Modeled vulnerabilities to the 100-Year Hazus Coastal Flood and 2012-NOAA Intermediate-High Sea-Level Rise scenarios for the City of Savannah's stormwater system are shown in Table 30 and provided through detailed map visualizations in Map Series 6. Discharge points unsurprisingly shows high vulnerability to overtopping (61% of structures) with the "base case" 2020 Hazus 100-Year Coastal Flood. Headwall structures, which include culvert outfalls, also show the potential for substantial overtopping (31% of structures) for the 2020 scenario. With the 2100 scenario (4.39' of sea-level rise), a large majority of discharge points (86%) and headwalls (67%) show overtopping risk. A similar proportion of inlets (13%) and manholes (12%) show inundation potential at the 2020 Hazus 100-Year Coastal Flood, with approximately a third of inlets (35%) and manholes (33%) showing vulnerability to overtopping at the 2100 sea-level rise scenario.

Table 30. Summary of City of Savannah Stormwater Infrastructure with Top of Structure Vulnerability to 100-Year Hazus Coastal Flood by NOAA Intermediate-High Sea-Level Rise Projection Year. Visual details in Map Series 6.

	2020	2050	2075	2100
Discharge Points	128 (61%)	143 (68%)	168 (80%)	181 (86%)
Headwalls	382 (31%)	531 (42%)	729 (58%)	831 (67%)
Inlets	1853 (13%)	2860 (20%)	4024 (29%)	4956 (35%)
Manholes	763 (12%)	1174 (19%)	1693 (27%)	2052 (33%)

Site-level model results for the 100-Year Hazus Coastal Flood scenarios for the City of Savannah's pump stations are shown in Table 31. Notably, all pump stations except the Gwinnett Street (Bilbo basin) and Lathrop (Fell Street basin) show the potential for substantial inundation at the 2020 scenario. The Lathrop pump station did not show inundation from the Hazus models at either 2020 or 2050, but does shows potential vulnerability by the 2075 and 2100 sea-level rise scenario. These results suggest that the City's current stormwater pumping system would be mostly non-functional in the event of a storm surge with the magnitude indicated by the Hazus 100-Year Coastal Flood models, even as early as the 2020 scenario.

Table 31. Projected Inundation depth above Tidewater Failure Threshold for City of Savannah Stormwater Pump Stations for 100-Year Hazus Coastal Flood at 2012-NOAA Intermediate-High Sea-Level Rise projection year. Values as feet above structure failure level, including wave height.

Pump Station	Stormwater Basin	2020	2050	2075	2100
Gwinnett Street	Bilbo	N/A	N/A	N/A	N/A
Kayton	Casey North	5.6'	7.1'	8.4'	10.0'
DeRenne	Casey South	4.1'	5.6'	6.9'	8.5'
Montgomery Cross	Casey South	3.2'	4.7'	6.0'	7.6'
Fell Street	Fell Street	3.5'	5.0'	6.3'	7.9'
Lathrop	Fell Street	N/A	N/A	0.9'	2.5'
Springfield	Springfield North	3.2'	4.7'	5.9'	7.5'

Detailed results for Hazus 100-Year Coastal Flood vulnerability to City of Savannah discharge structures, headwalls, inlets, and manholes as inventoried by stormwater drainage basin are provided in Tables 32-35. Basins with pump stations for outfall assistance generally show a high total level of vulnerable structures, indicating a high potential for major flooding of built areas in the event of pump station failure during a high water level coastal flooding event.

Table 32. City of Savannah Top of Discharge Structure Tidal Flooding Vulnerability Summary for Hazus 100 Year Coastal Flood at NOAA Intermediate High Sea-Level Rise Projection Scenario Year and by Stormwater Drainage Basin. Bolded drainage basins are served by pump stations for outfall assistance.

Drainage Basin	Total Inventory	2020	2050	2075	2100
Bilbo	17	12 (71%)	15 (88%)	16 (94%)	16 (94%)
Casey North	3	2 (67%)	3 (100%)	3 (100%)	3 (100%)
Casey South	5	5 (100%)	5 (100%)	5 (100%)	5 (100%)
Chippewa	11	2 (18%)	6 (54%)	11 (100%)	11 (100%)
Coffee Bluff	22	22 (100%)	22 (100%)	22 (100%)	22 (100%)
Dundee Canal	7	5 (71%)	5 (71%)	5 (71%)	5 (71%)
Fell Street	3	3 (100%)	3 (100%)	3 (100%)	3 (100%)
Harmon	32	27 (84%)	27 (84%)	28 (88%)	28 (88%)

Drainage Basin	Total Inventory	2020	2050	2075	2100
Horseshoe	3	3 (100%)	3 (100%)	3 (100%)	3 (100%)
Outlet Savannah River (HUC-12)	20	19 (95%)	19 (95%)	19 (95%)	19 (95%)
Pipemakers Canal	2	0 (0%)	0 (0%)	0 (0%)	0 (0%)
Placentia	13	9 (69%)	10 (77%)	10 (77%)	10 (77%)
Springfield North	5	4 (80%)	5 (100%)	5 (100%)	5 (100%)
St. Augustine Creek	1	0 (0%)	0 (0%)	0 (0%)	0 (0%)
Wilshire	24	7 (29%)	7 (29%)	15 (63%)	21 (88%)
Windsor	43	8 (19%)	13 (30%)	23 (53%)	30 (70%)
Windsor	43	8 (19%)	13 (30%)	23 (53%)	30 (70%)

Table 33. City of Savannah Top of Headwall Structure Tidal Flooding Vulnerability Summary for Hazus 100-Year Coastal Flood at 2012-NOAA Intermediate High Sea-Level Rise Projection Scenario Year and by Stormwater Drainage Basin. Bolded drainage basins are served by pump stations for outfall assistance.

Drainage Basin	Total Inventory	2020	2050	2075	2100
Casey North	7	4 (57%)	4 (57%)	4 (57%)	4 (57%)
Casey South	284	135 (48%)	153 (54%)	178 (63%)	187 (66%)
Chippewa	36	1 (3%)	3 (8%)	9 (25%)	16 (44%)
Coffee Bluff	26	19 (73%)	21 (81%)	25 (96%)	26 (100%)
Dundee Canal	34	7 (21%)	7 (21%)	14 (41%)	14 (41%)
Fell Street	21	11 (52%)	12 (57%)	16 (76%)	16 (76%)
Harmon	50	14 (38%)	20 (40%)	23 (46%)	24 (48%)
Horseshoe	12	9 (75%)	9 (75%)	12 (100%)	12 (100%)
Little Ogeechee	25	6 (24%)	17 (68%)	18 (72%)	24 (96%)
Ogeechee	11	0 (0%)	1 (9%)	3 (27%)	5 (45%)
Outlet Savannah River (HUC-12)	9	8 (89%)	8 (89%)	8 (89%)	8 (89%)
Pipemakers Canal	32	4 (13%)	6 (19%)	9 (28%)	9 (28%)
Placentia	49	29 (59%)	35 (71%)	42 (86%)	43 (88%)
Springfield North	293	39 (13%)	119 (41%)	167 (57%)	204 (70%)
Springfield South	26	0 (0%)	3 (12%)	14 (54%)	20 (77%)
St. Augustine Creek	70	13 (19%)	27 (39%)	37 (53%)	40 (57%)
Talmadge	2	1 (50%)	1 (50%)	1 (50%)	1 (50%)
Wilmington River (HUC-12)	2	1 (50%)	1 (50%)	1 (50%)	1 (50%)
Wilshire	128	24 (19%)	25 (20%)	68 (53%)	89 (70%)
Windsor	135	56 (41%)	59 (44%)	80 (59%)	88 (65%)

Table 34. City of Savannah Top of Inlet Structure Tidal Flooding Vulnerability Summary for Hazus 100-Year Coastal Flood at 2012-NOAA Intermediate High Sea-Level Rise Projection Scenario Year and by Stormwater Drainage Basin. Bolded drainage basins are served by pump stations for outfall assistance. Detailed paneled visualizations provided in Map Series 7.

Drainage Basin	Total Inventory	2020	2050	2075	2100
Bilbo	1444	92 (6%)	121 (8%)	181 (13%)	223 (15%)
Casey Canal-Haney's Creek (HUC-12)	1	0 (0%)	0 (0%)	0 (0%)	0 (0%)
Casey North	1305	142 (11%)	252 (19%)	444 (34%)	534 (41%)
Casey South	3501	416 (12%)	511 (15%)	670 (19%)	806 (23%)
Chippewa	333	1 (0.3%)	6 (2%)	17 (5%)	48 (14%)
Coffee Bluff	396	90 (23%)	143 (36%)	221 (56%)	284 (72%)
Dundee Canal	135	14 (10%)	23 (17%)	29 (21%)	39 (29%)
Fell Street	559	270 (48%)	359 (64%)	424 (76%)	432 (77%)
Harmon	617	80 (13%)	155 (25%)	182 (29%)	228 (37%)
Horseshoe	158	30 (19%)	48 (30%)	85 (54%)	107 (68%)
Little Ogeechee	148	63 (43%)	112 (76%)	133 (90%)	146 (99%)
Ogeechee	279	134 (48%)	211 (76%)	242 (87%)	255 (91%)
Outlet Savannah River (HUC-12)	137	122 (89%)	125 (91%)	125 (91%)	128 (93%)
Pipemakers Canal	142	26 (18%)	41 (29%)	74 (52%)	83 (58%)
Placentia	894	116 (13%)	160 (18%)	184 (21%)	226 (25%)
Raspberry	12	0 (0%)	0 (0%)	0 (0%)	1 (8%)
Redgate	6	0 (0%)	0 (0%)	0 (0%)	0 (0%)
Springfield North	2151	119 (55%)	384 (18%)	642 (30%)	842 (39%)
Springfield South	124	0 (0%)	1 (1%)	9 (7%)	21 (17%)
St. Augustine Creek	480	27 (6%)	59 (12%)	71 (15%)	80 (17%)
Talmadge	25	13 (52%)	13 (52%)	15 (60%)	15 (60%)
Vernon River (HUC-12)	1	0 (0%)	0 (0%)	0 (0%)	0 (0%)
Wilmington River (HUC-12)	32	9 (28%)	14 (44%)	20 (63%)	20 (63%)
Wilshire	552	15 (3%)	19 (3%)	90 (16%)	182 (33%)
Windsor	599	74 (12%)	103 (17%)	166 (28%)	253 (42%)

Table 35. City of Savannah Top of Manhole Structure Tidal Flooding Vulnerability Summary for Hazus 100-Year Coastal Flood at 2012-NOAA Intermediate High Sea-Level Rise Projection Scenario Year and by Stormwater Drainage Basin. Bolded drainage basins are served by pump stations for outfall assistance. Detailed paneled visualizations provided in Map Series 7.

Drainage Basin	Total Inventory	2020	2050	2075	2100
Bilbo	772	47 (6%)	57 (7%)	99 (13%)	125 (16%)
Casey North	803	69 (9%)	140 (17%)	241 (30%)	300 (37%)
Casey South	1515	100 (7%)	117 (8%)	197 (13%)	259 (17%)
Chippewa	130	0 (0%)	2 (2%)	4 (3%)	12 (9%)
Coffee Bluff	175	38 (22%)	58 (33%)	87 (50%)	113 (65%)

Drainage Basin	Total Inventory	2020	2050	2075	2100
Dundee Canal	48	8 (17%)	10 (21%)	11 (23%)	14 (29%)
Fell Street	368	216 (59%)	274 (74%)	312 (85%)	319 (87%)
Harmon	170	21 (12%)	48 (28%)	59 (35%)	71 (42%)
Horseshoe	34	8 (24%)	12 (35%)	20 (59%)	25 (74%)
Little Ogeechee	30	14 (47%)	18 (60%)	24 (80%)	30 (100%)
Ogeechee	66	30 (45%)	52 (79%)	57 (86%)	61 (92%)
Outlet Savannah River (HUC-12)	64	64 (100%)	64 (100%)	64 (100%)	64 (100%)
Pipemakers Canal	22	1 (5%)	3 (14%)	5 (23%)	8 (36%)
Placentia	419	43 (10%)	66 (16%)	72 (17%)	79 (19%)
Raspberry	1	0 (0%)	0 (0%)	0 (0%)	0 (0%)
Springfield North	1075	67 (6%)	190 (18%)	309 (29%)	379 (35%)
Springfield South	38	0 (0%)	0 (0%)	2 (5%)	6 (16%)
St. Augustine Creek	139	0 (0%)	6 (4%)	20 (14%)	23 (17%)
Vernon River (HUC-12)	5	0 (0%)	0 (0%)	1 (20%)	2 (40%)
Wilmington River (HUC-12)	10	2 (20%)	9 (90%)	9 (90%)	9 (90%)
Wilshire	135	5 (4%)	7 (5%)	33 (24%)	63 (47%)
Windsor	231	30 (13%)	41 (18%)	67 (29%)	90 (39%)

Capital Improvement Projects (CIPs)

8. Capital Improvement Projects (CIPs)

Chatham County and the City of Savannah have each developed a list of planned Capital Improvement Projects (CIPs) intended to improve stormwater drainage within their jurisdictions in the future. The City and County CIPs involve a variety of drainage improvement projects including well defined projects at specific locations such as culvert replacements and stormwater pipe installation as well as more general work such as drainage basin studies, neighborhood drainage system improvements, and funding for a general area. Additionally, some CIP projects include work at multiple locations such as pump station improvements. The current CIPs are included in this study so that planning, design, construction, and implementation of these projects will be performed while considering the potential impacts of sea level rise.

8.1 CCIP Vulnerability Assessment

Due to the variety of the drainage projects, the potential impacts of SLR on CIPs were not assessed using the same methodology as existing stormwater structures in this study (i.e. based on top and bottom elevations of structures). Instead, the City and County CIPs were mapped (for those projects where a specific or approximate location could be established) so that their locations could be compared to sea level rise inundation projection maps to help approximate the threat to the project from the modeled sea level rise scenarios at 2020, 2050, 2075, and 2100. As with the previously discussed structure vulnerability assessments, the CIP vulnerability assessment does not account for regular functioning of tide gates and pump stations within the stormwater systems that, in practice, currently reduce the tidal penetration impacts to levels below those shown in the assessment.

The CIP Vulnerability Map shown in Figure 7 includes the City and County CIP locations as well as the modeled sea level rise inundation maps for the highest astronomical tide (HAT) for the sea level rise scenarios summarized below. Chatham County stormwater drainage CIPs are summarized Table 36 and City of Savannah CIPs are summarized in Table 37. These tables also include the year the project may be impacted by regular tidal flooding based on the modeled HAT scenario under the 2012-NOAA Intermediate-High sea-level rise projection.

8.2 Coastal Watershed Adaptation Action Areas (CWAAAs)

The large coastline exposure, high natural resource values of the coastal marshland ecosystems, and the extreme nature of the potential storm surge risk in Chatham County together make it physically impractical and prohibitively expensive to consider large-scale public works – such as substantial storm surge barriers – for “hard” protection against the existing 100-year coastal flood event in Chatham County. Instead, regulatory policy actions, mostly importantly including the adoption and enforcement of enhanced free board regulations, for private property within the regulatory floodplain areas of Chatham County and City of Savannah are currently being utilized as the primary tool for mitigating the exposure of property to potential flood losses from events at and beyond the existing 100-year regulatory floodplain.

Based on current knowledge and technologies, it also seems highly improbable that large-scale public works will be feasible as a future strategy for mitigating 100-year coastal flooding events that are enhanced by sea-level rise to magnitudes beyond the currently delineated 100-year floodplain area. Continued update and enforcement of enhanced building regulations and freeboard ordinances to reflect the movement of the 100-year regulatory floodplain due to rising sea levels, while also enforcing mandatory evacuations during the approach of large hurricanes capable of producing large storm surges, is likely to remain as the fundamental hazard mitigation planning strategy for storm surge-driven flooding in Chatham County, City of Savannah, and other municipalities within the full extent of the CWPA.

However, stormwater program officials in both Chatham County and City of Savannah do believe it is technologically feasible to consider upgrades of drainage and flood mitigation infrastructure to lessen the impacts of regular tidal flooding into drainage infrastructure. The impacts from tidewater infiltration include the progressive loss of volumetric drainage potential during rainfall events as tidewater infiltrates into stormwater conveyance systems, as well as backflow into the built environment from stormwater conveyance systems when the tidewater and/or surficial groundwater height exceeds the top of structure elevation for stormwater infrastructure.

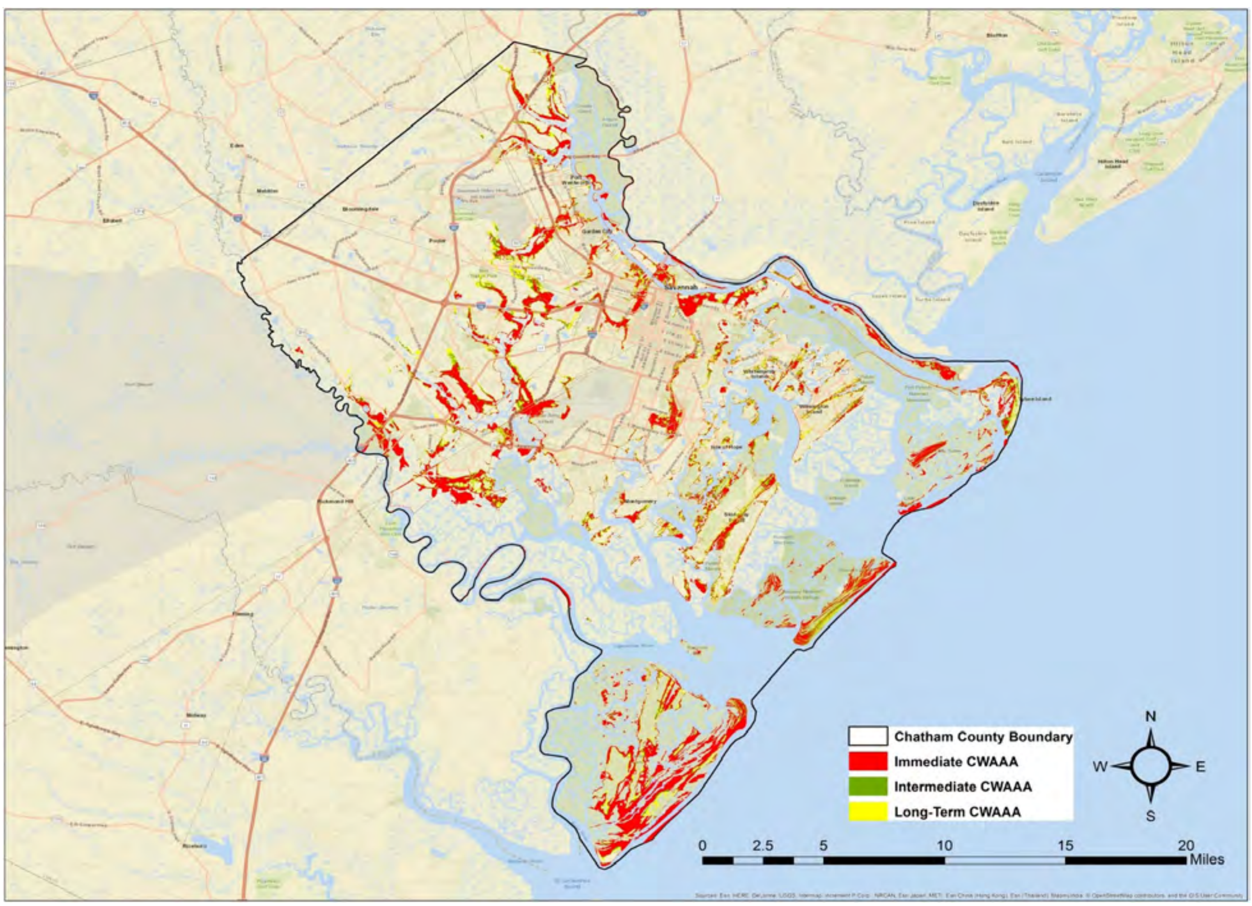
To assist with the process of prioritizing future capital improvement projects, potential infrastructure upgrades, and regulatory policy tools that can mitigate the impacts of increased chronic flooding associated with sea-level rise, the CWMP proposes the establishment of three Coastal Watershed Adaptation Action Areas (CWAAAs) for Chatham County and the City of Savannah (Appendix Figure 1).

(1.) Immediate CWAAA includes all watershed areas and stormwater infrastructure with a ground elevation below 6' NAVD88, which is comparable to the 2020 HAT (5.79' NAVD88) as projected under the 2012-NOAA Intermediate-High sea-level rise projection scenario. Any additional areas within the built environment where regular tidal flooding or precipitation-based flooding of low-lying areas is known to occur more than once per year by the year 2020 or before may also be defined as part of the Immediate CWAAAA.

(2.) Intermediate CWAAA includes all watershed areas and stormwater infrastructure with a ground elevation below 7' NAVD88, which is comparable to the 2050 HAT (6.82' NAVD88) as projected under the 2012-NOAA Intermediate-High sea-level rise projection scenario. Any additional areas within the built environment where regular tidal flooding or precipitation-based flooding of low-lying areas is known to occur more than once every ten years by the year 2020 or before may also be defined as part of the Intermediate CWAAAA.

(3.) Long-term CWAAA includes all watershed areas and stormwater infrastructure with a ground elevation below 8' NAVD88, which is comparable to the 2075 HAT (8.07' NAVD88) as projected under the 2012-NOAA Intermediate-High sea-level rise projection scenario. Any additional areas within the built environment where regular tidal flooding or precipitation-based flooding of low-lying areas is known to occur more than once every twenty-five years by the year 2020 or before may also be defined as part of the long-term CWAAAA.

Figure 7: Coastal Watershed Adaptation Action Areas for Chatham County



8.3 Potential Strategies for CIP Resiliency

The CIP Sea Level Rise Vulnerability Map (Figure 8) can aid City and County personnel responsible for drainage CIP implementation in evaluating the potential for the sea level rise scenarios to impact the projects and to develop internal guidance for the design of future drainage CIPs that requires consideration of the projected risk for sea level rise during the lifespan of the infrastructure system. Potential strategies to lessen the vulnerability of CIPs to the impacts of projected sea level rise are summarized below.

(1.) CIP planning should consider the location of the project in relation to sea level rise projections. If a stormwater control structure is proposed close to the shoreline, the planning should consider the use of measures located upstream that may be at less risk of sea level rise. Additionally, alterative locations to those with high groundwater elevations should be considered since sea level rise may also result in increased groundwater levels. Green infrastructure that utilize infiltration practices should be installed in areas where the depth to groundwater is likely to be sustained in the future if groundwater levels were to rise in conjunction with sea level rise. Above ground practices, such as rain gardens, may be preferable in some areas to below ground structures such as infiltration chambers which may fail as groundwater levels increase due to SLR.

(2.) CIPs should be designed for future conditions that incorporate sea level rise rather than designs that only account for existing conditions. Hydraulic modeling is performed utilizing tailwater conditions representing the typical water depths immediately downstream of a hydraulic structure. Hydraulic modeling for CIP design should also be performed utilizing tailwater conditions that reflect the modeled SLR water depths to account for the hydraulic effects of sea level rise.

(3.) Where feasible, CIP designs should allow flexibility for future modification if conditions were to change due to sea level rise. For example, bioretention or stormwater detention facilities could include adjacent, reserve areas to allow for expansion of the treatment and/or storage capacity in the future if needed.

(4.) The design of future critical infrastructure projects that are at risk of sea level rise could incorporate common floodproofing measures, including:

a. Elevate buildings and components such as mechanical and electric equipment

b. Install back-up power

c. Install backflow prevention (i.e. tide gates, tidal flaps, etc.) devises on outfalls

d. Utilize flood walls, levees, and berms where appropriate

e. Dry floodproofing to prevent flood waters from entering the structure such as waterproof coatings, impermeable membranes, sealants, or waterproof doors

f. Wet floodproofing to prevent or provide resistance to flood damage while allowing floodwaters to enter the structure such as water-resistant materials and flood vents

(5.) Maintenance Activities: Increased inspection and maintenance may be necessary for structural control CIPs to ensure the measures operate properly. For example, tidal flaps must be routinely inspected to ensure that debris has not become lodged in the flap such that it cannot close upon an incoming tide. Also, non-structural practices, such as street sweeping and ditch maintenance, could be prioritized upstream of CIPs experiencing impacts from sea level rise to reduce the sources of sediment and debris draining to the structure and further reducing the capacity of the drainage system.

Figure 8: Capital Improvement Project (CIP) Sea Level Rise Vulnerability Map

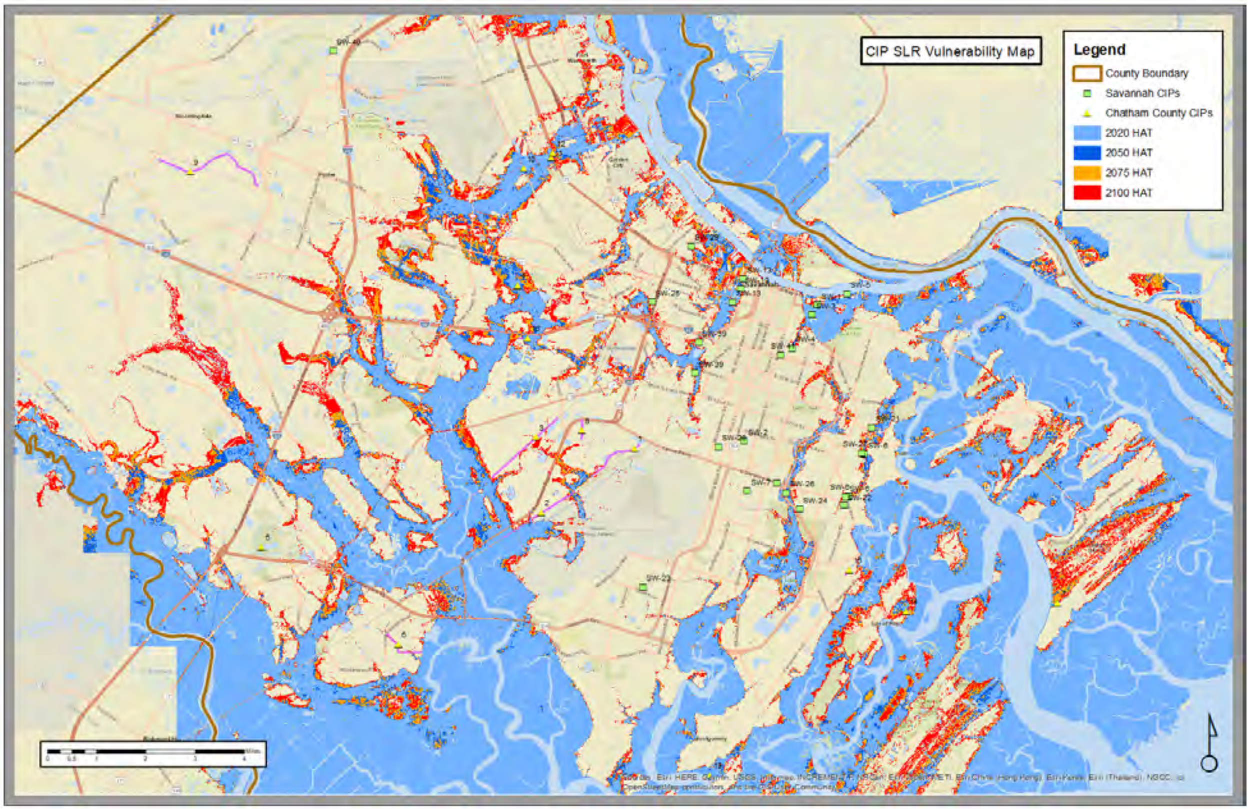


Table 36. Chatham County Stormwater Drainage Capital Improvement Projects (CIPs)

Map ID	Project Name	SLR Threat [1]	Description
1	Westlake Drainage	2100 [2]	Area of apartment complex where flooding occurs
2	CSX Diversion	2075 [2]	Proposed channel diversion for overflow relief of Redgate Canal
3	Westside Diversion	2100 [2]	Proposed channel diversion for overflow relief of Redgate Canal
4	Talmadge Ave / Salt Creek	2020	Replace undersized culvert under Central GA Railroad and downstream improvements to Salt Creek
5	Henderson Community Drainage	2050	General drainage improvements
6	Georgetown Canal	2020	Upsize and replace primary outfall from Georgetown Community
7	Wilmington Island Road	2020	Replace existing culvert and drainage diversion
8	Marshall Branch Phase 3	2100	Improvements to capacity and access from Marshall to Veterans Parkway
9	Hardin Canal	Unknown	No established solution and could involve multiple locations

Map ID	Project Name	SLR Threat [1]	Description
10	Pipemakers Canal - Norfolk Southern	2020	Extension of existing railroad bridge and channel diversion
11	Pipemakers Canal - CSX	2020	New railroad bridge and divert channel to crossing
12	Pipemakers Canal - SR21	2020	Add two additional box culverts to increase capacity
13	Shipyard Road Outfall	2020	Maintenance and capacity improvements downstream of Shipyard Road
14	Barnett Outfall	2020	Create access to drainage channel for future maintenance
15	Nottingham Canal	2020	Capacity improvements to drainage channel
16	Horseshoe Canal	2020	No established solution or specific location

(1) Based on Highest Astronomical Tide (HAT) predictions

(2) Projects are related

Table 37. City of Savannah Projected 5-20 Year Stormwater Drainage CIPs

Map ID	Project Name / Description	SLR Threat [3]
SW-1	Bilbo Canal Phase 1 - DR-308	2020
SW-2	Casey Phase 2 - DR-911	None
SW-3	Bilbo Canal Phase 2 - DR-308	2020
SW-4	Bolton Street 102” Brick Lining - DR-131	None
SW-5	Kayton Outfall Boxes lining - DR-131	2020
SW-6	Placentia Basin Drainage Improvements - DR-132	2020
SW-7	Andover Drainage Improvements	None
SW-8 (1)	Paving Support Annual Fund	N/A
SW-9 (2)	Pump Station CNG Power Conversion	Multiple Locations
SW-10 (2)	Stormwater Pump Station Components Rehab - DR-402	Multiple Locations
SW-11(1)	Brickline Replacement Annual Fund - DR-505	N/A
SW-12 (2)	Pump Station Exterior Rehabilitation	Multiple Locations
SW-13	Springfield Basin Phase 1 Improvements	2020
SW-14 (1)	Drainage System Upgrade	N/A
SW-15 (1)	Stormwater Annual Manhole Adjustments	N/A
SW-16 (1)	Chippewa-Harmon Drainage Basin Study	N/A
SW-17 (1)	Coffee Bluff Drainage Basin Study	N/A
SW-18 (1)	Bilbo Basin Drainage Improvements	N/A
SW-19 (1)	Casey North Drainage Improvements	N/A
SW-20	E. DeRenne Drainage Improvements	None
SW-21	Evergreen Drainage Improvements	2020
SW-22	Hughes Avenue Drainage Improvements	None
SW-23	Leeds Gate Drainage Improvements	2020
SW-24	Lovett Lane Drainage Improvements	None
SW-25	Lynes Avenue Drainage Improvements	2050

Map ID	Project Name / Description	SLR Threat [3]
SW-26	Spalding Street Drainage Improvements	2020
SW-27	Sunset Boulevard Drainage Improvements	2050
SW-28	Sylvan Terrace Drainage Improvements	None
SW-29	Tuten-Rankin-Haygood Drainage Improvements	2075
SW-30 (1)	Dundee Canal Drainage Basin Study	N/A
SW-31 (1)	Fell Street Drainage Basin Study	N/A
SW-32 (1)	Ogeechee and Little Ogeechee Drainage Basin Studies	N/A
SW-33 (1)	St. Augustine Creek Drainage Basin Study	N/A
SW-34 (1)	Wilshire Canal Drainage Basin Study	N/A
SW-35 (1)	Windsor Drainage Basin Study	N/A
SW-36 (2)	Pump Station Controls Upgrade	Multiple Locations
SW-37 (2)	Pump Station Site Improvements	Multiple Locations
SW-38 (2)	Pump Station Storm Proofing	Multiple Locations
SW-39	Springfield Basin Phase 2-4 Improvements	2050
SW-40	Benton Boulevard Drainage Improvements--Benton Lake Area	2050
SW-41	Henry Street Underpass Traffic Gate	None
SW-42 (1)	DR-133 Annual Cave In fund	N/A
SW-43 (1)	Stormwater Utility	N/A

(1) No specific location

(2) Various pump station locations

(3) Based on Highest Astronomical Tide (HAT) predictions

Summary and Recommendations

9. Summary and Recommendations

Chatham County, the City of Savannah, and other associated municipalities are located in a coastal watershed area that is subject to increased flooding vulnerability due to climate change stressors, particularly due to the chronic long-term impacts of sea-level rise. This joint Coastal Watershed Management Plan (CWMP), as coordinated between Chatham County and the City of Savannah (the largest municipality within Chatham Count), represents an important step in identifying and prioritizing tidal flooding vulnerabilities to sea level rise within the regional stormwater drainage system for the purpose of coordinating immediate, intermediate, and long-term adaptation actions. The CWMP is meant to serve as a living document that will be updated as new information about climate change, sea level rise, and infrastructure conditions in Chatham County, City of Savannah, and other associated municipalities may become available.

9.1 Key Outcomes and Results

This initial CWMP has produced the following four key technical outcomes that can serve as the basis for developing structural improvements, as through the Capital Improvement Projects (CIPs) process, and other local government policy-making:

(1.) Delineation of a Coastal Watershed Planning Area (CWPA) within Chatham County and all associated municipalities that is based upon a FEMA Hazus Coastal Flood model of the current 100-year coastal surge as enhanced by 6.56 feet of sea-level rise, which corresponds to the High sea-level rise projection scenario currently defined by Georgia Department of Natural Resources (DNR), Coastal Resources Division (CRD) as an upper-bound for future hazards planning purposes.

(2.) Delineation of three Coastal Watershed Adaptation Action Areas (CWAAAs) – an Immediate (2020), Intermediate (2050), and Long-Term (2075) – that prioritize areas within Chatham County, City of Savannah, and other associated municipalities based upon elevation-based estimates of vulnerability to regular tidal and rainfall-induced flooding as enhanced by sea-level rise.

(3.) A comprehensive vulnerability assessment that identifies structure-level vulnerabilities of stormwater infrastructure with Chatham County and City of Savannah to regular tidal flooding and storm surge-driven flooding, as enhanced by up to 4.39 feet of sea-level rise through 2100.

(4.) A summary of Capital Improvement Projects (CIPs) within Chatham County and City of Savannah with an overlay of site-level tidal inundation mapping that include up to 4.39 feet of sea-level rise through 2100.

9.2 Recommended Management Practices

The stormwater management programs in both Chatham County and City of Savannah maintain very detailed and thorough geographic information systems (GIS) inventories of stormwater infrastructure within their jurisdictions. These datasets support the development of comprehensive vulnerability assessments that identify structures that are likely to be subject to tidal inundation in the absence of structural interventions to prevent this infiltration. Much of the tidal infiltration pressure within stormwater systems in Chatham County and City of Savannah is currently managed and mitigated through a series of tide gates maintained by both Chatham County and City of Savannah, as well as a series of stormwater pump facilities operated and maintained by the City of Savannah.

The vulnerability assessments within this CWMP indicate the following priorities for structural maintenance and upgrades within the stormwater systems of Chatham County and City of Savannah, for the purpose of adapting to elevated tides that will accompany sea-level rise:

(1.) Upgrade of the City of Savannah's Kayton pump station to maintain functionality at a minimum tidal flood height of 8' NAVD88, thereby meeting a similar flood height threshold as other pump stations within the City of Savannah's stormwater system.

(2.) Continued maintenance of the existing tide gate systems within Chatham County and City of Savannah, with systematic upgrades to install additional tide gates in areas where regular tidal infiltration is already occurring or is forecast to occur before 2050.

(3.) Development of internal guidance for the design of future drainage CIPs that requires consideration of the projected risk for sea level rise during the lifespan of the infrastructure system.

(4.) Increased usage of "green infrastructure" interventions to reduce impervious cover and improve volumetric stormwater storage capacity in higher, upland areas of Chatham County, thereby reducing runoff volume into tidal waterways.[23]

(5.) Prioritization of future capital improvement projects, potential infrastructure upgrades, and regulatory policy tools that can mitigate the impacts of increased chronic flooding associated with sea-level rise in the three CWAAAs.

In addition, there is a need to develop more refined local tidal datum estimates based on local water level data throughout the marshland, estuarine, and riverine expanses of Chatham County. This is because default datum corrections for Chatham County, as currently made available through the NOAA Datum tool, were evaluated by the project team and deemed as lacking appropriate resolution and calibration for use in this current vulnerability assessment. Researchers from Georgia Tech are currently working with local officials in Chatham County and City of Savannah on an innovative "Smart Sensor" program that involves installation of a large network of water level sensors throughout the local tidal watershed areas. The vulnerability assessment within the current CWMP should be revised once sufficient data is available for development of a more robust tidal datum correction surface for Chatham County and associated municipalities.

Green Infrastructure in Habersham Village

23 https://www.sealevelsensors.org/

Data Appendix

Data Appendix Table 1. Chatham County Stormwater Infrastructure Geodatabase

File Name	File Description	Attribute Inventory
GREEN_INFRASTRUCTURE	Polygons of implemented green infrastructure projects	274 implemented projects
OUTFALLS_TO_STATEWATERS	Points of stormwater outfall structure locations that discharge into state waters	433 outfall points
STORM_WATER_CANALS	Lines of stormwater canals	187 miles of canal features covering unincorporated and incorporated areas
STORM_WATER_DITCHES	Lines of stormwater ditches	217 miles of ditch features, including 153 miles of County maintained and 64 miles maintained by entities other than Chatham County
STORM_WATER_PIPES	Lines of underground stormwater pipes	207 miles of pipe features, including 170 miles of county-maintained and 37 miles maintained by entities other than Chatham County
STORM_WATER_RESERVOIR_AREA	Polygons of stormwater reservoirs	251 stormwater reservoirs with a total area covering 377 acres
STORM_WATER_STRUCTURES	Points of stormwater inlets, culverts, access areas, and outlet points within the constructed stormwater management system	27 Box Culverts 89 Control Structures 3,792 Curb Inlets 681 Drop Inlets 9,241 End of Pipe Outlets 1,817 Flared End Sections 1,114 Grate Inlets 866 Headwalls 1 Honeycomb Inlet 598 Hooded Grate Inlets 41 Junction Boxes 1,170 Manholes 20 Outlet Structures 512 Roof Inlets 1 Tee Junction 51 Tide Gates 838 Unknown Structure Type 71 Weirs 83 Yard Inlets

Data Appendix Table 2. City of Savannah Stormwater Infrastructure Geodatabase

File Name	File Description	Attribute Inventory
Stormwater_Conduit_Lines	Lines of underground stormwater pipes	413 miles of stormwater pipe features
Stormwater_Drainage_Basins	Polygons of delineated stormwater drainage basins	Hydrologic delineation for 24 stormwater drainage basins with information about outfall type, receiving water, and any pump station service
Stormwater_DW_Screening_Pts	Points of sampling points for stormwater discharge	194 unique stormwater outfalls 4 unique inlet features 13 unique manhole features
Stormwater_Headwalls	Points of stormwater outfalls and culvert intakes with headwall construction	1,252 Headwalls
Stormwater_Inlets	Points of stormwater inlets	1,622 Curb-Grate Inlets 10,282 Curb Inlets 158 Dome Inlets 1,764 Grate Inlets 2 Manholes 199 Roof Inlets
STORMWATER_MAINTAINED_DITCHES	Lines of ditches maintained by City of Savannah Stormwater Management	160 miles of stormwater ditch features
Stormwater_Manholes	Points of stormwater manhole access points	6,282 Manholes
Stormwater_Pump_Stations	Points of stormwater pump stations, including number of pumps and capacity	7 Pump Stations
Stormwater_Tide_Gates	Points of tide gates to prevent tidal infiltration into stormwater systems	6 Tide Gates
1 Swing Gate		
Stormwater_Flooded_Structures	Points of structures with documented flooded history	Record of 2992 flooded structure events
Stormwater_Flooded_Intersections	Points of intersections with known flood history	Record of 203 intersections with documented flood history