Georgia Coastal Region Enhancing Coastal Resilience Using Green Infrastructure

Final Report

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Acronyms

FEMA – Federal Emergency Management Agency

GBS – General Building Stock

UDF – User Defined Facilities

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Executive Summary

The Georgia Coastal Management Program (GCMP) completed a study in 2011 that examined the potential impacts of hurricane winds and flooding along the Georgia coastline. This study builds upon the previous work by examining in considerably greater detail not only the impacts of these hazards, but the potential value that mitigation such as green infrastructure can offer.

Like the first study this project has generated innovative simulations of the potential predicted effects of a warming climate, such as sea-level rise and more intense coastal storms. A warming atmosphere can produce major changes in temperatures, land cover, precipitation (drought, fire, and floods), wildlife risks, rising seas (increased erosion, salt marsh loss), stronger storms producing increased storm damage, and economic losses among other effects that occur over several decades or longer. With these changes to the atmosphere, the intensity, power, destructive energy (i.e., a combination of intensity and duration) and frequency of hurricanes is likely to increase (Emmanuel, 2005: CCSP, 2008: Karl et al 2009). Also, with a predicted sea level rise of at least one meter by 2100, the Southeast will likely see an increase in storm surge, which could easily be the most costly consequence of long-term hazards (Karl et al., 2009). Hurricane intensity is also projected to increase, which will likely increase storm surge (Knutson and Tulyea 2004).

To capture a range of possible current and future conditions a total of 118 wind and flood scenarios were modeled in two Georgia communities, Tybee Island and the City of Hinesville. Tybee Island was chosen as the location to model current as well as possible future wind risk and coastal flood risk based on Category 1 through 4 hurricanes. Current and potential riverine flood hazards, both within and without additional green infrastructure, were evaluated for the City of Hinesville. Current modeled hazards included potential flooding resulting from five modeled return periods (10, 25, 50, 100 and 500). Future hazards considered these same return periods while also evaluating a range of possible flood extents for each return period based on different assumptions about future rainfall intensity in the study area. Future predictions for both riverine and coastal flood hazards also incorporated projections of population and building changes.

As with the previous study, the most significant benefit is likely to be increased awareness and understanding of coastal Georgia's vulnerability to long-term hazards by the local decision makers and coastal stakeholders. However, as a result of evaluating specific mitigation options this study also provides additional guidance on how to mitigate risk and increase the resiliency of Georgia coastal communities.

Section 1 Introduction

Two Georgia communities were included in this study, the City of Tybee Island and a portion of the City of Hinesville. The City of Tybee Island, Georgia is located adjacent to the City of Savannah. The City of Tybee Island encompasses the entire island. According to the US Census Bureau, the 2016 population was 3,068.[1]

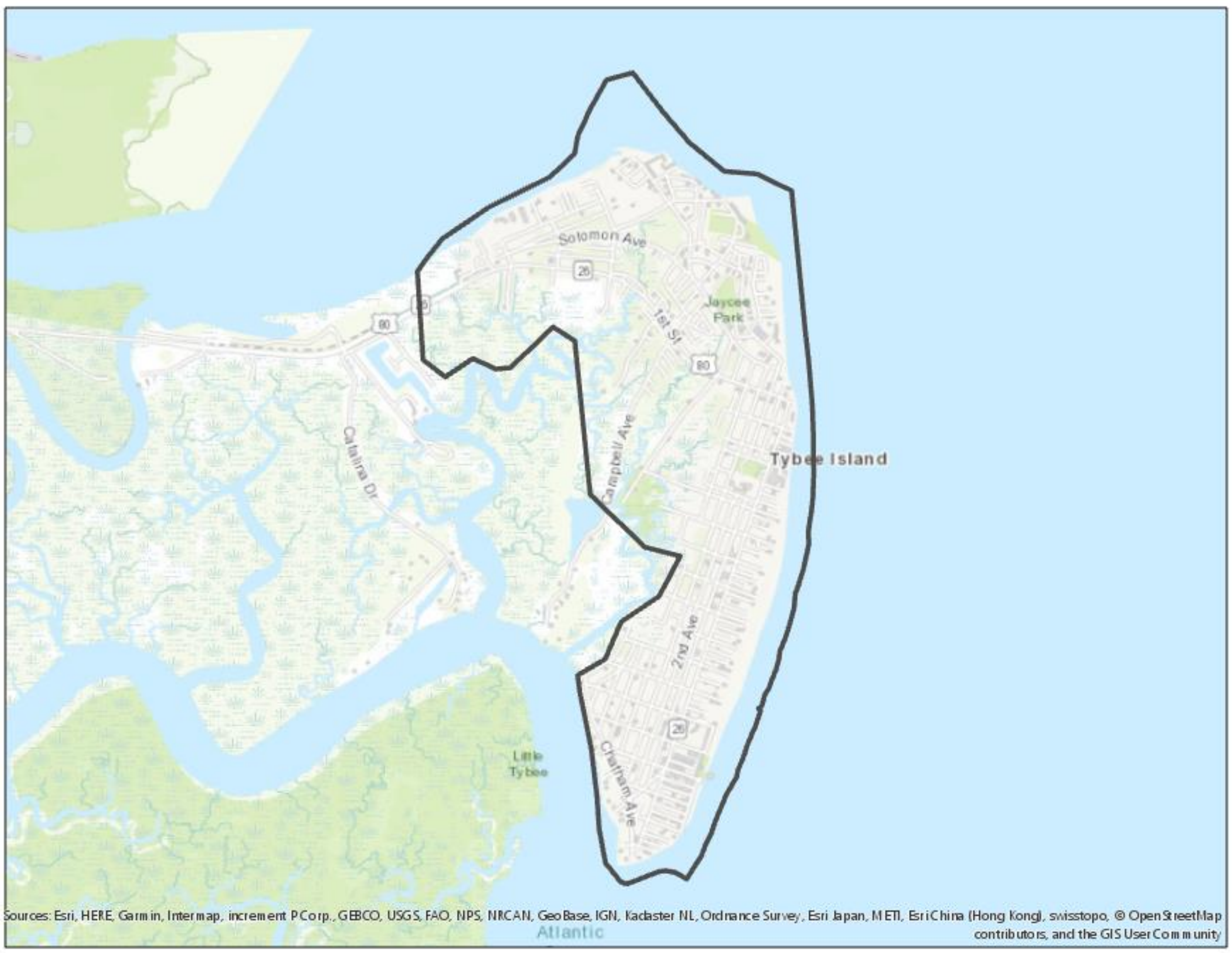

Figure 1: Tybee Island, Georgia Study Area

[1] U.S. Census Bureau, American Community Survey, latest 5-Year Estimate

The Upper Newport River watershed encompasses a portion of the City of Hinesville in Liberty County. For this project we studied a subset of the streams in this county that impact the Hinesville, Georgia area. These streams are the Mills Creek, Peacock Canal, and Alligator Creek.

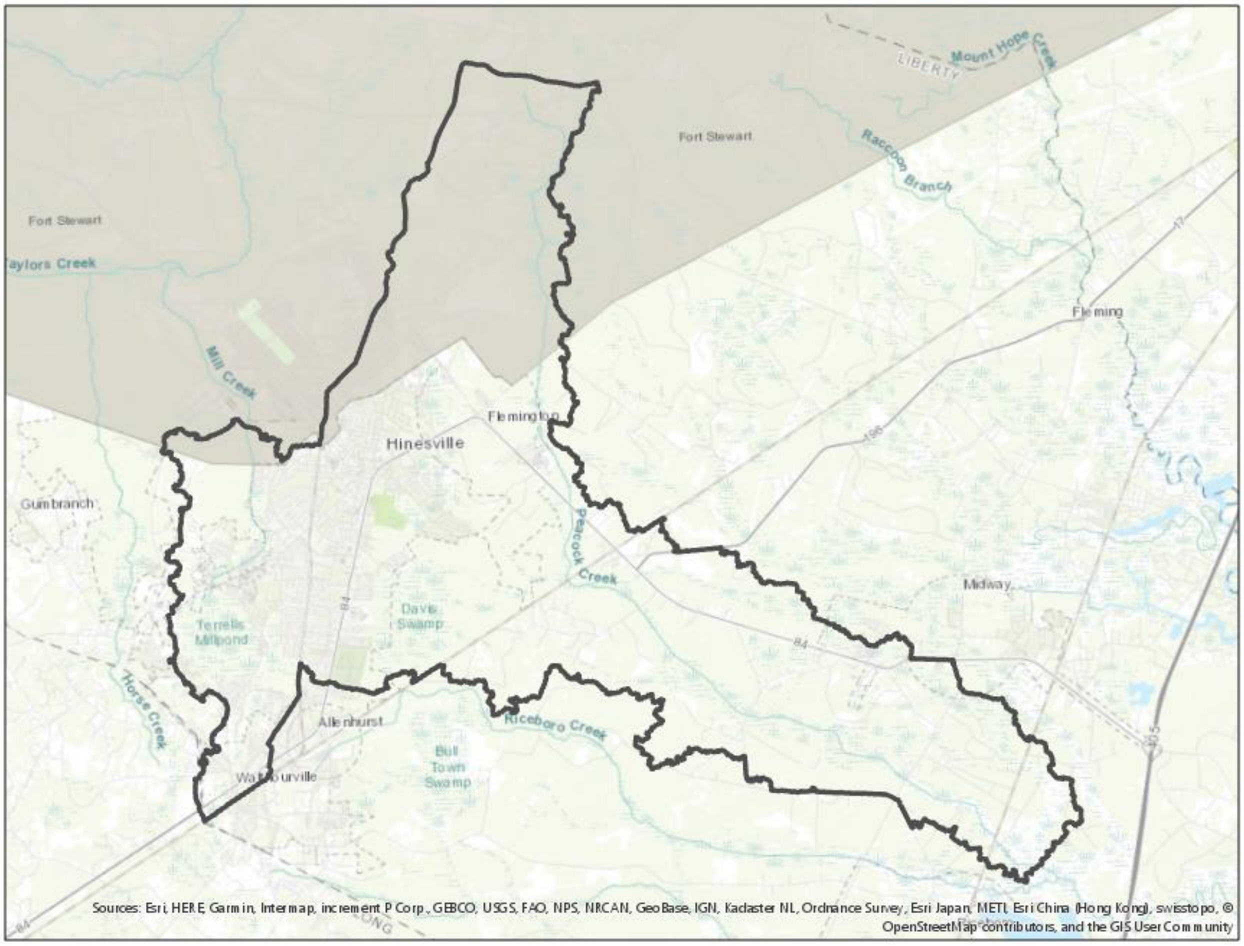

Figure 2: Hinesville, Georgia Study Area

Section

2

Inventory Development

2.1 Overview

Two versions of building inventory were development for this study, one to support analysis of the impact of hazards on the current built environment and the other to support analysis of the impact of future hazards. Sections 2.1 , 2.2 and 2.3 discuss the development of the current built environment inventory while Section 2.4 addresses the methodology for developing the inventory to reflect expected future development within the study area.

While there exist a growing number of data sources that describe the current built environment, most of these currently suffer from one or more characteristics that make their use for a study of this type less than ideal. These may include being out of date, incomplete, or even fee-based. Beginning in 2011, a number of entitities within the State of Georgia embarked on an initiative to develop tools and data about the built environment that could support better informed modeling of the impacts of natural hazards. This effort was a collaboration between the Georgia Emergency Management Agency, the Georgia Department of Natural Resources and the Coastal Regional Commission of Georgia.

Building exposure data, hereinafter referred to in this report as 'building inventory,' to represent current building stock were derived from county parcel maps, building footprints (for the Liberty County portion of the study) and computer-aided-mass appraisal (CAMA) files. For the Tybee Island portion of this study we leveraged and, as described later in this report, enhanced data compiled from a previous study for Chatham County. That data included parcels from 2014 and CAMA data from October of 2015. For Liberty County we created a new dataset for this study based on CAMA data, parcels and building footprints received in September of 2017. For both the Liberty and Chatham County inventory, building and content replacement costs were updated with 2018 values using Hazus-MH 4.2.1 as explained later in this section.

The inventory was formatted to be consistent with the requirements of Hazus-MH Release 4.2.1, the modeling platform selected for this project. Hazus-MH is a GIS-based tool developed by the U.S. Federal Emergency Management Agency that is an extension of Esri's ArcGIS Desktop release 10.5.1. It enables the estimation of social and economic impacts from hazards associated with floods, earthquakes and hurricanes. To estimate these impacts requires three key inputs. These include a description of what is exposed to the hazard, the building inventory; a description of the hazard itself; and a methodology for assessing losses. This part of the report focuses on the building inventory. Aspects of the Hazus-MH hazard and loss estimation methodology of relevance to the study will be discussed later in the report.

Hazus-MH comes with a building inventory for the entire United States, which means that any community can produce an assessment of risk with minimal effort. While the 'out-of-the-box' inventory provides a reasonable depiction of exposure for assessing regional impacts, it tends to offer limited utility for localized estimations. For this reason, it was decided for this project that the Hazus-MH provided inventory should be updated with the refined inventory produced for Georgia. Building inventory in Hazus-MH can be represented in two different ways, points for individual buildings – referred to in Hazus-MH as User Defined Facilities– and in an aggregated format referred to in Hazus-MH as the General Building Stock. Both representations were used for this project due to the requirements of the study.

User Defined Facilities were programatically located at the centroids of building footprints for Liberty County based on the availability of a GIS compatible building footprint layer. Figure 2 shows an example in which the user defined facilities are shown as yellow dots that represent the modeled locations of buildings.

Figure 3: Example of User Defined Facility Inventory in Hinesville

No GIS compatible building footprint layer was available for Chatham County where Tybee Island is located. Therefore, buildings were programmatically located at parcel centroids. Given the relatively small size of Tybee Island, the project team determined that this process could lead to questionable analysis results in instances where modeled buildings were too far from their actual locations. Therefore, selected building points on Tybee Island deemed most critical to the analysis were manually moved to the actual building location using a GIS contextual layer available from Esri for reference[2]. An example of such buildings, provided in Figure 4, shows a location on the southern portion of Tybee Island. Figure 5 shows the manually adjusted location of these points based on the GIS contextual layer.

[2] Contextual Layer Source: Esri, Garmen, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, OpenStreetMap contributors and the GIS User Community.

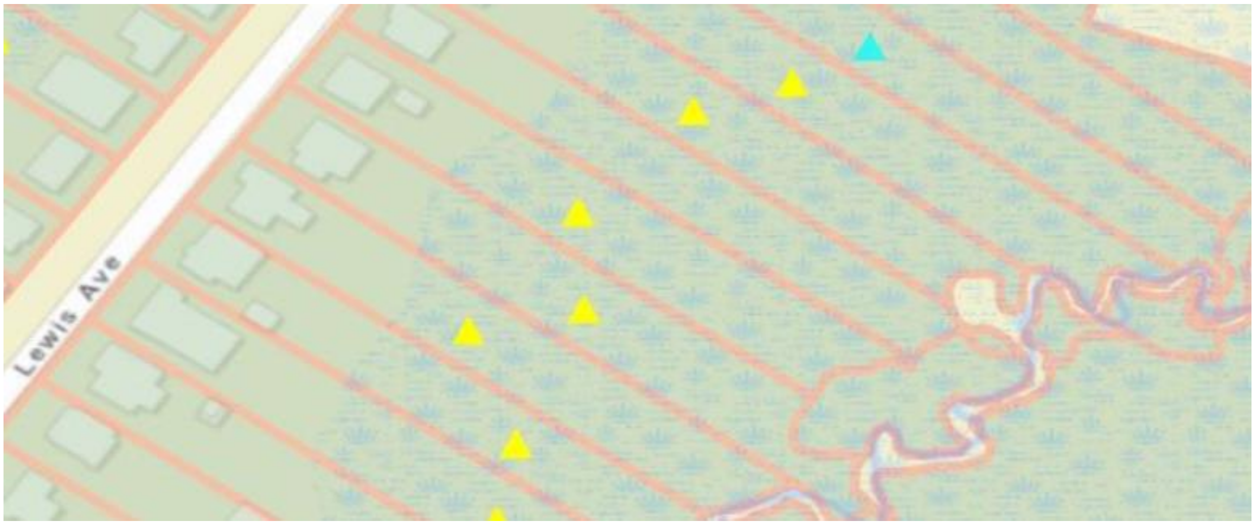

Figure 4: Default structure location at parcel centroid - Tybee Island

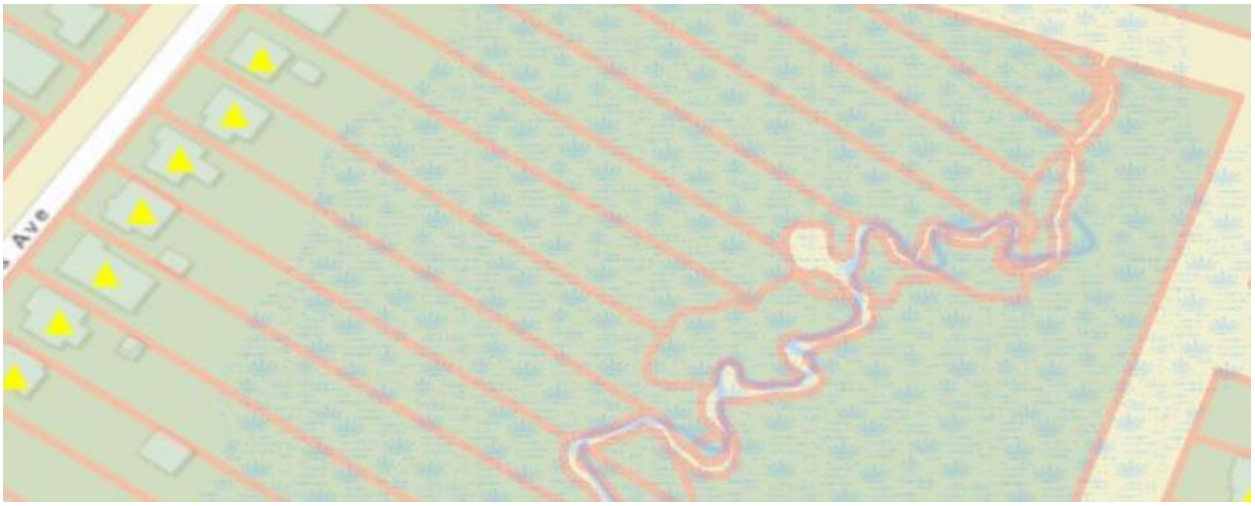

Figure 5: Adjusted structure location - Tybee Island

Tybee Island also contains three hotel complexes that required manual editing of the data to make it suitable for use in the analysis. Figure 6 illustrates the actual location of these structures.

Figure 6: Location of multi-unit structures on Tybee Island

Figure 7 illustrates the location of the parcels associated with these structures. Note that the parcels are drawn well away from the actual location of the structures. This is a strategy used by some counties for structures having multiple floors and units. While this may meet property tax assessment needs, for modeling purposes at this scale it would be inappropriate to locate these units at the centroids of these parcels given that damages are assessed based on the depth of water at the location of the building points. That would place the buildings, in some cases, offshore thus yielding unrealistic results.

Figure 7: Location of Parcels associated with structures referenced in Figure 6.

We manually relocated the building points within the boundary of the building to address this issue as illustrated in Figure 8. In addition, we modified the first floor elevations of each building, since the first level of each building represented the location of a parking area, to represent the estimated elevation of each unit. Those on the first floor were assigned a value of 8', those on the second floor a value of 16' and those on the 3rd floor a value of 24'. We assigned first floor elevations for other buildings in the study based on the default methodology applied in Hazus-MH that accounts for whether a building is in a regulated area, and has a corresponding flood risk boundary; whether the building is in a coastal or riverine area; and the type of foundation upon which the building is constructed.

Figure 8: Example of manually located building points

The General Building Stock Inventory was aggregated to geographic boundaries supported by Hazus-MH for modeling losses from hurricanes and floods. For hurricane loss estimations, aggregation occurs at the level of 2010 census tracts. For flood loss estimations, aggregation occurs at the level of 2010 census blocks. It is assumed in Hazus-MH that building stock is evenly distributed across census boundaries. This assumption can lead to over or underestimations of hazard impact in some cases. For this reason, in Hazus-MH 4.2.1, census blocks are clipped to remove areas without population such as vacant land, forested areas and water bodies. Figure 3 shows an example of the General Building Stock inventory for the flood model with unpopulated areas clipped out. Labels represent building counts in each census block.

Figure 9: Example of General Building Stock Inventory.

Both the User Defined Facility inventory and the General Building Stock inventory were attributed with information gathered from the CAMA data necessary to support the calculation of losses. For the User Defined Facility Inventory examples of these attributes include a description of how each structure is used (e.g. residential, commercial, industrial, etc.); the material from which each structure is built (e.g. wood, concrete, steel, etc.) the size of the structure; costs of replacement for the structure, its contents and any inventory; the foundation type and first floor elevation; and so forth.

In addition to the General Building Stock inventory and the User Defined Inventory described above, Hazus-MH also includes a type of inventory referred to as Essential Facilities. These types of structures include police stations; fire stations; care facilities such as hospitals and clinics; and emergency operation centers. Given the not-for-profit purpose of these facilities, they are usually not accounted for in CAMA data which is collected for tax assessment purposes. For this reason we also leveraged updates of the Hazus-MH Essential Facility data completed by the Coastal Regional Commission of Georgia as part of this project.

2.2 General Building Stock and User Defined Facility Updates

CAMA data is typically used for taxation purposes. It includes information about the ownership of each property, structural and use characteristics of any buildings on the property, and a variety of other information.

In the past, property assessment information was stored in paper form. However, most county assessors have now transitioned to digital representations of the type of information stored and managed by CAMA software. While there are some commonalities across CAMA software, such as the fact that they all store information about properties, the data structure and options vary widely between software. In addition, even in cases where two counties may use the same CAMA software they often elect to populate fields with different codes or other values customized to their needs. While this offers a great deal of flexiblity for taxation purposes, it can make use of this type of data for hazard modeling and other purposes somewhat challenging.

In order to address these types of challenge for this project, the development of inventory required the creation of tools that could convert the CAMA data from its native format to a Hazus-MH compliant format that is consistent across all counties. The Polis Center developed these tools with Esri's Data Interoperability extension and delivered them to the Georgia Department of Natural Resources so that they can maintain consistently updated versions of their building data into the future. Assumptions based on other sources of information or expert opinion were incorporated within the tools and associated workflow documentation where CAMA data information was not available or consistently reliable. For example, building replacement costs were auto-calculated by the Hazus-MH Comprehensive Data Management System tool that leverages published 2018 R.S. Mean building construction cost and a regional adjustment factor that accounts for the variability of construction material costs within specific regions of the United States. Costs were further adjusted for the single-family residential structures to account for the assumed relationship in the cost of materials used to construct that type of building by leveraging available demographic data available in Hazus-MH that reports variations in income within individual census blocks. Another example relates to content costs, a representation of the cost to replace furnishings and other non-structural components of a building, which are not reported in CAMA files. Content replacement cost values were auto-populated by applying a percentage of the replacement cost of the structure. For example, for a RES1 (single family residential) building, the content values was assumed to be 50% of the building replacement cost. The complete list of occupancy type to content replacement value conversions can be found in the Hazus-MH model documentation.

Figure 10 offers an example of the type of tool used for this project. In this example a value of '0004' is translated to 'RES1' which, in Hazus-MH, refers to a single family dwelling.

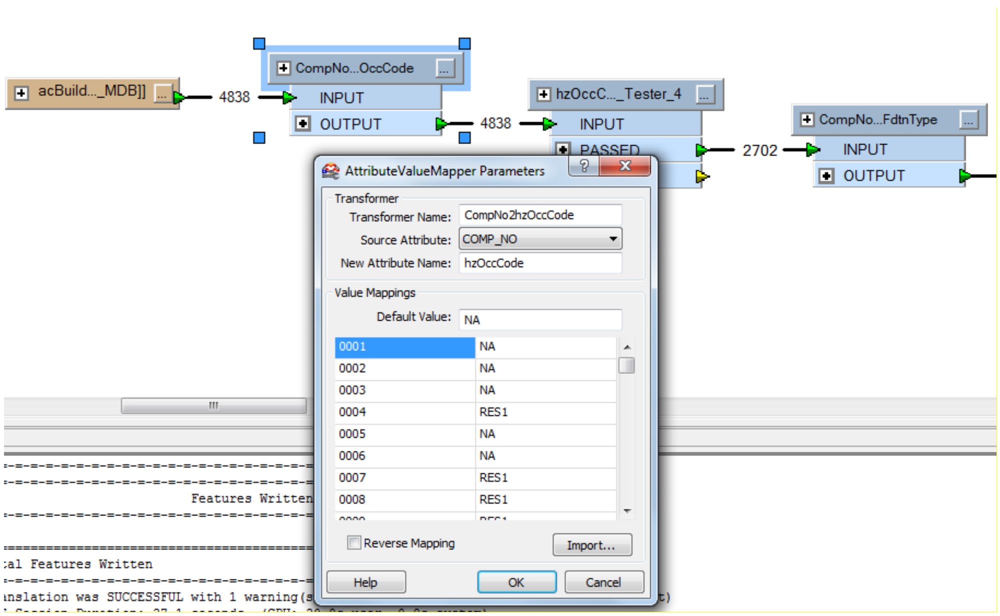

Figure 10: Example of Data Conversion Tool Interface

While the data collected from the counties for this project yielded what is believe to be useful information about the built environment against which to model potential impacts of flooding, these data were not intended to be perfect in nature. There were, for example, a number of assumptions made about building characteristics that would impact the specifics of the model output. For example, given the lack of information in the CAMA data about first floor elevations, default first floor elevation values applied in Hazus for riverine pre and post-FIRM structures were universally applied to all buildings in the dataset with the exception of selected multi-unit structures on Tybee Island noted earlier in the report. This would have the result in some cases of overestimating impacts of flooding where first floor elevations were actually higher than modeled. However, given the predicted depth of water along the coastline in the modeled scenarios we believe this impact would be limited in nature. Future analysis could seek to further improve the estimates by refining these assumptions.

After update, there are a total of 103,257 buildings in Chatham County with a combined building replacement cost value of slightly over $44.6 Billion and 23,493 buildings in Liberty County with a combined building replacement cost of just over $5 Billion.

The following tables provide match rates between parcel data and CAMA data for each of the counties in the study. They also provide default as well as updated Hazus-MH building counts and building replacement costs.

Chatham County

Percentage Match Rate: 99.6%

Occupancy	Building Count – Default Hazus 4.2.1	Building Count Updated Hazus 4.2.1	Replacement Cost Default Hazus 4.2.1 (X $1,000)	Replacement Cost Updated Hazus 4.2.1 (X $1,000)
Commercial	5,914	9,193	$4,995,317	$13,441,177
Industrial	1,362	1,427	$967,810	$10,037,757
Residential	93,115	92,124	$23,499,832	$20,335,607
Agricultural	180	30	$51,937	$8,210
Religious	802	364	$753,307	$397,762
Government	164	32	$155,479	$145,322
Educational	197	87	$430,814	$268,344

Table 1: Chatham County General Building Stock Inventory Update Statistics

Liberty County

Percentage Match Rate: 99.9%

Occupancy	Building Count – Default Hazus 4.2.1	Building Count Updated Hazus 4.2.1	Replacement Cost Default Hazus 4.2.1 (X $1,000)	Replacement Cost Updated Hazus 4.2.1 (X $1,000)
Commercial	786	1,066	$474,215	$1,120,564
Industrial	157	63	$113,054	$210,557
Residential	22,303	22,122	$4,423,768	$3,946,207
Agricultural	28	9	$7,231	$3,886
Religious	101	166	$67,648	$137,073
Government	62	34	$41,629	$44,479
Educational	51	33	$49,810	$295,531

Table 2: Liberty County General Building Stock Inventory Update Statistics

2.3 Essential Facility Updates

Updates of the Hazus-MH Essential Facilities were completed by the Coastal Regional Commission of Georgia in a previous study in 2016. The update process included verification of the existence and location of each facility. Aerial imagery was used to verify the location. County websites, along with local knowledge, were used to verify the name, address, replacement cost and other information about each facility where possible.

The following table provides information about the default and updated county for each facility type by county.

Facility Type	Default Hazus-MH 4.2.1 Essential Facility Count	Updated Essential Facility Count
Chatham County		
Fire Stations	20	40
Police Stations	15	20
Emergency Operation Centers	0	1
Medical Care Facilities	5	4
Schools	87	159
Liberty County		
Fire Stations	8	14
Police Stations	6	6
Emergency Operation Centers	0	1
Medical Care Facilities	2	1
Schools	22	21

Table 3: Essential Facility Inventory Update Statistics

2.4 Future Condition Inventory Development

In order to adequately measure the impacts of future flooding and hurricanes, a future building dataset was developed for Hinesville and Tybee Island that captures a simulated building stock for the year 2080. It would be unrealistic to determine the exact number and locations of future buildings over the next 60 years and this dataset is one potential possibility of many for each location. The future building inventories for each location were developed differently and independently using separate methodologies and datasets. The datasets used for the future inventory methodologies are included in Table 4.

County	Dataset	Source
Liberty	National Land Cover Dataset	US department of Agriculture
Liberty	National Hydrologic Dataset (NHD)	US Geologic Survey
Liberty	US Census Transportation Layer	US Census
Liberty	National Flood Hazard Layer	Federal Emergency Management Agency
Liberty and Chatham	Existing Building Points (Polis)	The Polis Center
Chatham	Tybee Island, Georgia was the City of Tybee Island Carrying Capacity Study[3] (CCS)	City of Tybee
Chatham	Chatham County Parcels	Chatham County

Table 4: Input datasets for future inventory update estimates

[3] "City of Tybee Island Carrying Capacity Study". Ecological Planning Group. September 2016

Hinesville, Georgia Future Building Data Development

To develop a future building stock for Hinesville, Georgia a layer that depicts the potential future building locations was developed. Within this layer buildings were populated by weighted toward Hinesville's city center. The first layer used was the 2011 National Land Cover Dataset (NLCD) for the study area around Hinesville (Figure 11).

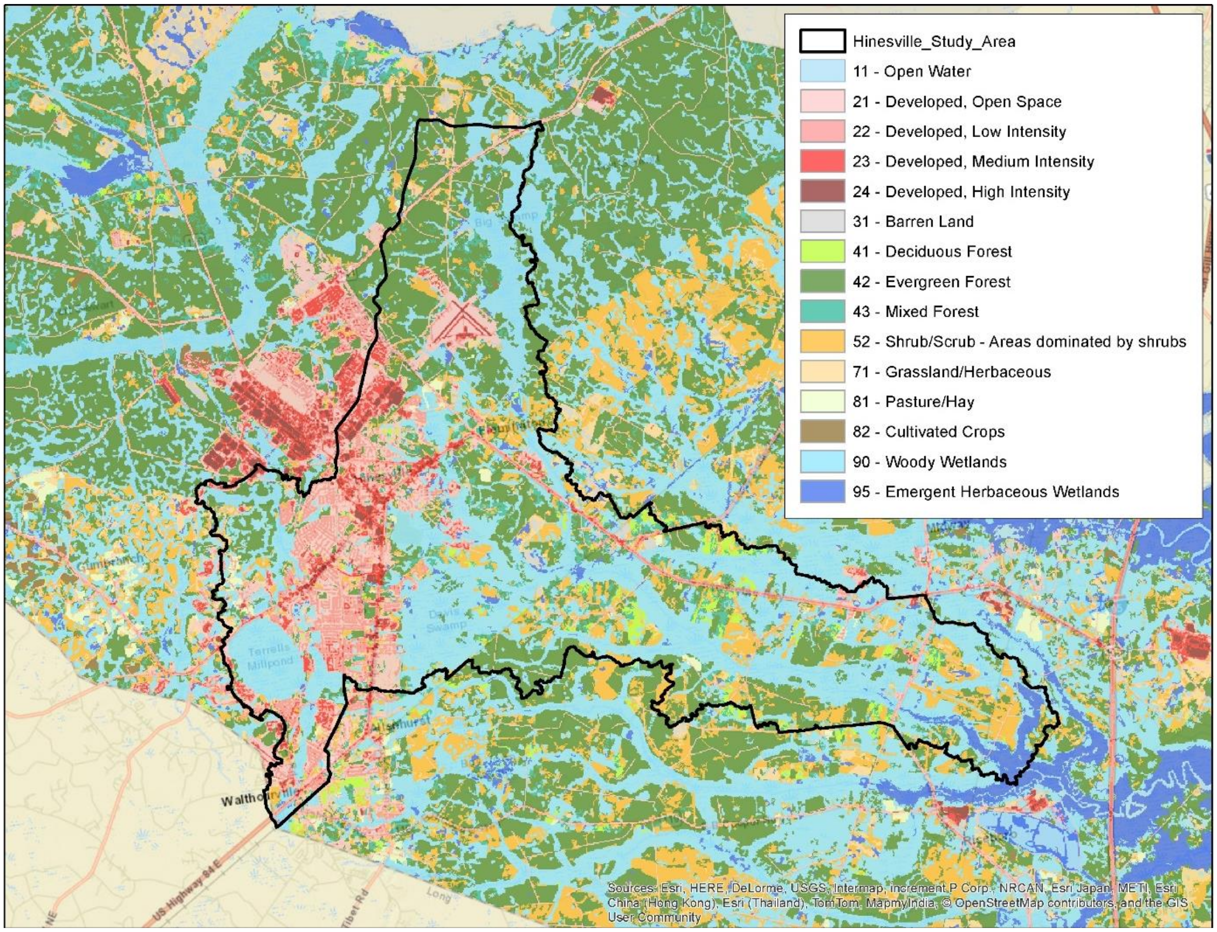

Figure 11: Example of Data Conversion Tool Interface

Areas without the potential for new construction were removed from the NLCD. For this study we did not include the possibility of teardowns of existing structures and then for lots to be split for more structures or multi-unit structures. The following NLCD classes were used as 'buildable'.

Class	Description
31	Barren Land
41	Deciduous Forest
42	Evergreen Forest
43	Mixed Forest
52	Shrub/Scrub
71	Grassland
81	Pasture/Hay

82 Cultivated Crops
90 Woody Wetlands
95 Emergent Herbaceous Wetlands

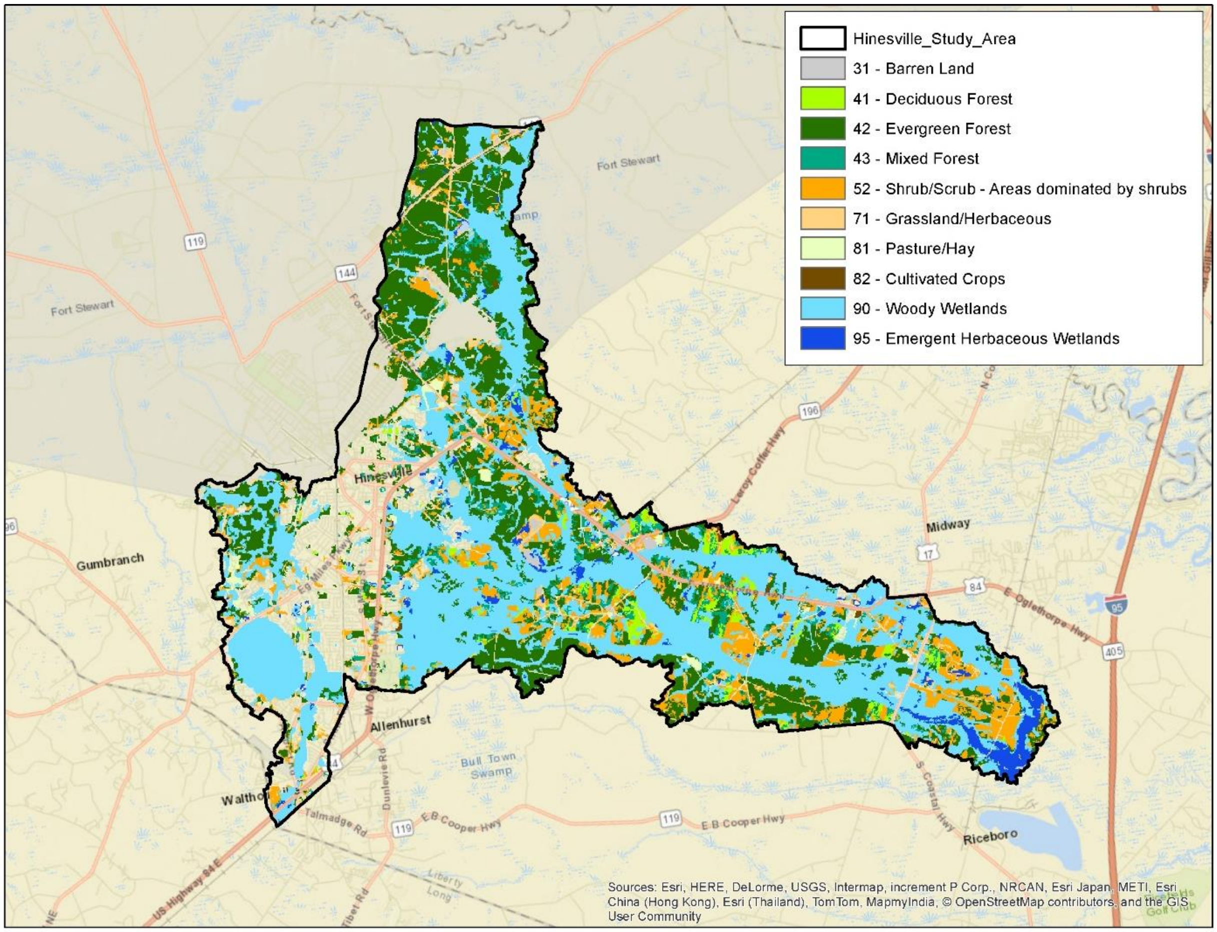

Figure 12: NLCD 2011 for the Hinesville study area for only the land use / land cover classes that were considered buildable.

Because the NLCD is at a resolution of 30m, it does not capture small scale features. To capture other non-buildable areas, datasets detailing the locations of water bodies and the transportation network were used. The National Hydrologic Dataset (NHD) for the study area was used to remove areas from the buildable layer with water. Since this layer is a linear feature, it was buffered by 80 feet to include a conservative value of stream width. The final water polygon was then removed from the buildable layer. For roadways, the 2017 transportation layer from the US Census was used to remove those areas within the study region that have roadways. This dataset is also linear and buffer distances were determined by the MAF/TIGER Feature Class Code (MTFCC). The final transportation polygon was also removed from the buildable layer. In the final step the floodway (from the National Flood Hazard Layer) was removed from the study area to simulate no building construction in the floodway. The final layer determined to be 'buildable' is shown in Figure 13.

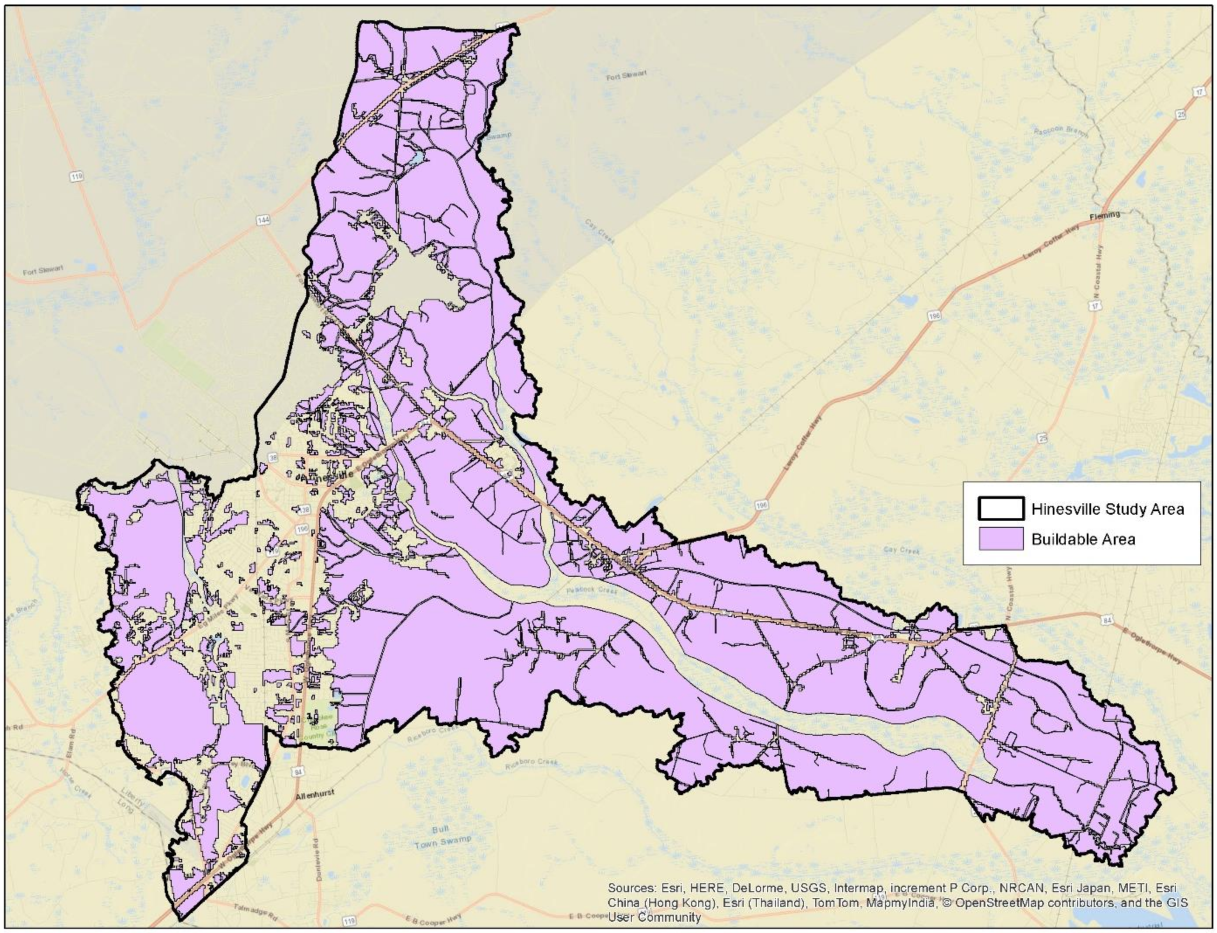

Figure 13: NLCD 2011 for the Hinesville study area for only the land use / land cover classes that were considered buildable.

The structure model assumes an average yearly growth rate of 113 residential and commercial buildings per year through 2080. This rate reflects the growth rate in residential housing units from 2010 – 2016 (~0.5% per year). Due to the uncertainty of other building types (religious, government, etc.) only residential and commercial building changes were modeled forward from 2018 through 2080. This future building inventory is to serve as a 'What-If" scenario for the Hinesville community. While this simulation is plausible, it is unlikely this exact arrangement of buildings will occur in 2080. This model is to demonstrate the value of careful planning within and adjacent to the floodplain. The final building inventory is shown in Figure 14 and totaled in Table 5.

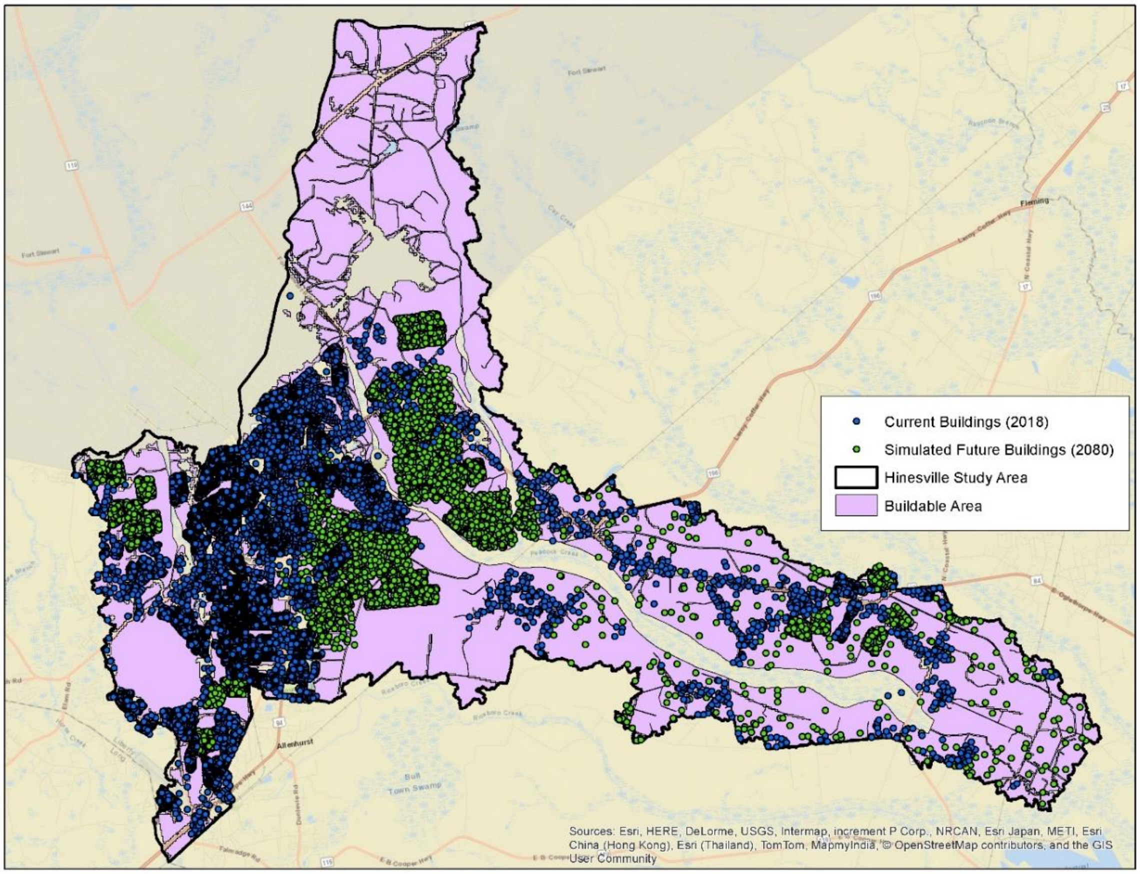

Figure 14: Final buildable area with the current and future building stock.

Percentage Match Rate: 99.9%

Occupancy	Building Count Updated Hazus 4.2.1	Building Count Projected in 2080	Replacement Cost Updated Hazus 4.2.1 (X $1,000)	Replacement Cost Projected in 2080 (X $1,000)
Commercial	1,066	1,321	$1,120,564	$1,174,147
Industrial	63	63	$210,557	$210,569
Residential	22,122	30,891	$3,946,207	$5,787,627
Agricultural	9	9	$3,886	$3,891
Religious	166	166	$137,073	$137,077
Government	34	34	$44,479	$44,483
Educational	33	33	$295,531	$295,535

Table 5: Liberty County General Building Stock Inventory Update Statistics

Tybee Island, Georgia Future Building Data Development

The basis for the development of a future building stock for Tybee Island, Georgia was the City of Tybee Island Carrying Capacity Study[4] (CCS). In this study, the full 100% build out for Tybee Island was studied and determined. Using the methodology in the study we computed a future building stock that is similar, but not exactly identical to the 2016 study. The following methodology is from the CCS.

"The methodology used for this analysis began with the identification of all parcels currently zoned R-2. These properties were then broken down into the following categories based on lot size:

- Less the 6,750 square feet. Parcels in this category could only be developed as single family homes.
- 6,750 - 11,250 square feet. Parcels in this category could be developed as two-family residential, either as a duplex, or as two, single-family residential parcels (if over 9,000 square feet).
- 11,250 - 13,500 square feet. These parcels could be split and developed with one-single family and one, two-family structure.
- Over 13,500 square feet. Parcels that can be developed as two, two-family structures.
- Unique. Certain unique conditions were also considered. This includes significantly large parcels that could be sub-divided a number of different ways. For example, a large property with a significant amount of marsh may limit its development potential. Additionally, a large undeveloped property may have be large enough for a larger subdivision of land."

In the CCS only the aforementioned land parcels were addressed in the 'full build-out' scenario. A recent trend showed the R-2 parcels (single or two family) of sufficiently large size were being divided to add

[4] "City of Tybee Island Carrying Capacity Study". Ecological Planning Group. September 2016

additional R-2 properties. We used the CCS strategy to develop the future building inventory. Based upon the parameters above, each parcel was split according to its size and a new property was added.

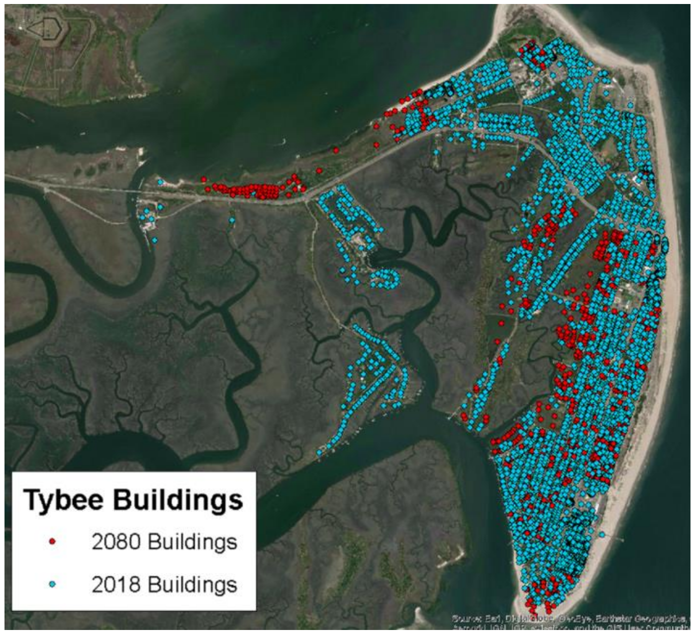

Figure 15: Final buildings for Tybee Island.

Percentage Match Rate: 99.9%

Occupancy	Building Count Updated Hazus 4.2.1	Building Count Projected in 2080	Replacement Cost Updated Hazus 4.2.1 (X $1,000)	Replacement Cost Projected in 2080 (X $1,000)
Commercial	9,193	9,191	$13,441,177	$13,440,123
Industrial	1,427	1,427	$10,037,757	$10,037,808
Residential	92,124	92,823	$20,335,607	$20,572,086
Agricultural	30	30	$8,210	$8,215
Religious	364	357	$397,762	$392,442
Government	32	32	$145,322	$145,336
Educational	87	84	$268,344	$265,183

Table 6: Chatham County Inventory Update Statistics

Section

3

Modeled Hazard Scenarios

3.1 Study Scenarios

Hazus-MH provides a wide range of options for defining a hazard. Some of these rely on Hazus-MH to generate the hazard while others allow for expert input. We applied a combination of these. 118 hazard wind and flood scenarios were developed. Of these, two dozen addressed current conditions and the remainder modeled future conditions. This section describes the purpose of each scenario, the methodology used to develop it, and any limitations related to assessing the estimated loss impacts.

Scenarios modeled in this study included:

- Scenarios 1 through 10: Current Riverine Flooding Risk with and without Green Infrastructure
- Scenarios 11 through 18: Current Coastal Flooding Related Flood Risk with and without Green Infrastructure
- Scenarios 19 through 26: Current Hurricane Wind Related Risk with and without Mitigation
- Scenarios 27 through 56: Future Riverine Flooding Risk with a projected, future, building stock, with and without Green Infrastructure
- Scenarios 57 through 86: Future Riverine Flooding Risk with the current building stock, with and without Green Infrastructure
- Scenarios 87 through 102: Future Coastal Flooding Risk with and without Green Infrastructure
- Scenarios 103 through 118: Future Hurricane Wind Related Risk with and without Mitigation

3.2 Scenario Hazard Methodology

3.2.1 Present day flood scenarios

Scenarios 1 through 10: Current Riverine Flood Risk with and without Green Infrastructure

The first group of scenarios estimated potential riverine flood damage and loss in the Upper North Newport River Watershed for the 10, 25, 50, 100 and 500 year return periods. These scenarios reflected present day flood risk with and without considering the impacts of green infrastructure in the analysis. Using the US Geological Survey's (USGS) StreamStats application the discharges that correspond to the

10, 25, 50, 100, and 500 year return period floods were calculated for the Mills Creek, Peacock Canal, and Alligator Creek around Hinesville, Georgia. A total of 16 discharge points were determined along the three streams /canals. The 24hr, 50 year rainfall event and the impervious surface percentage of the upstream drainage areas for each discharge point were calculated by StreamStats and used as inputs to the hydrologic calculations. The damages and losses were calculated using the current (2018) building inventory developed by the Polis Center.

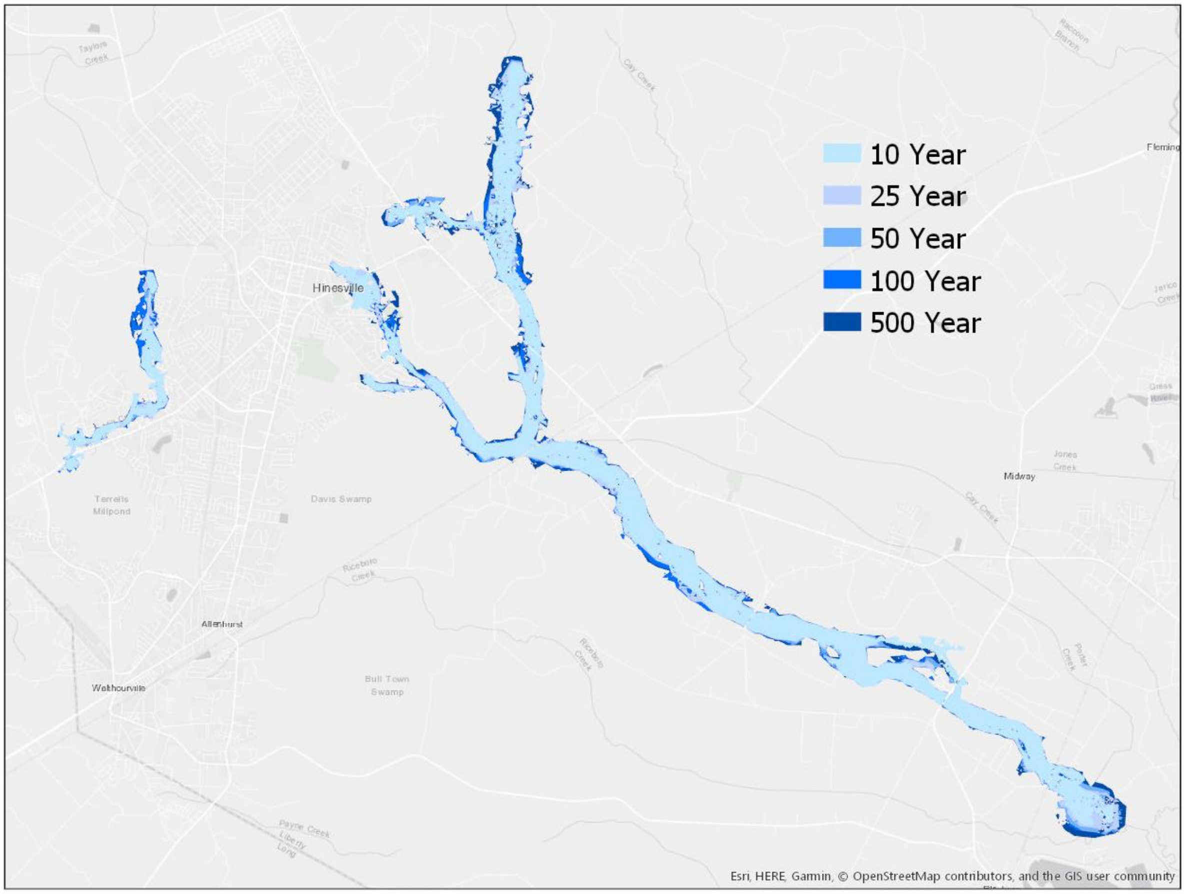

Figure 16: Estimated Hinesville Study Area Flood Extents for Present Day 10, 25, 50 and 100 Year Frequency Events without Green Infrastructure

The flood hazard data that included green infrastructure were performed using a similar methodology. Using the US Geological Survey's (USGS) StreamStats application the discharges that correspond to the 10, 25, 50, 100, and 500 year return period floods that included a reduction of flood water from the implementation of green infrastructure were calculated for the Mills Creek, Peacock Canal, and Alligator Creek around Hinesville, Georgia. While specific green infrastructure projects are not highlighted in this analysis the total volumes of water reduction could be used in the development of future green infrastructure projects. A total of 16 discharge points were determined along the three streams /canals. The 24hr, 50 year rainfall event and the upstream drainage areas for each discharge point were calculated by StreamStats and used as inputs to the hydrologic calculations. The rainfall data was reduced for the green infrastructure data calculations. The damages and losses were calculated using the current (2018) building inventory.

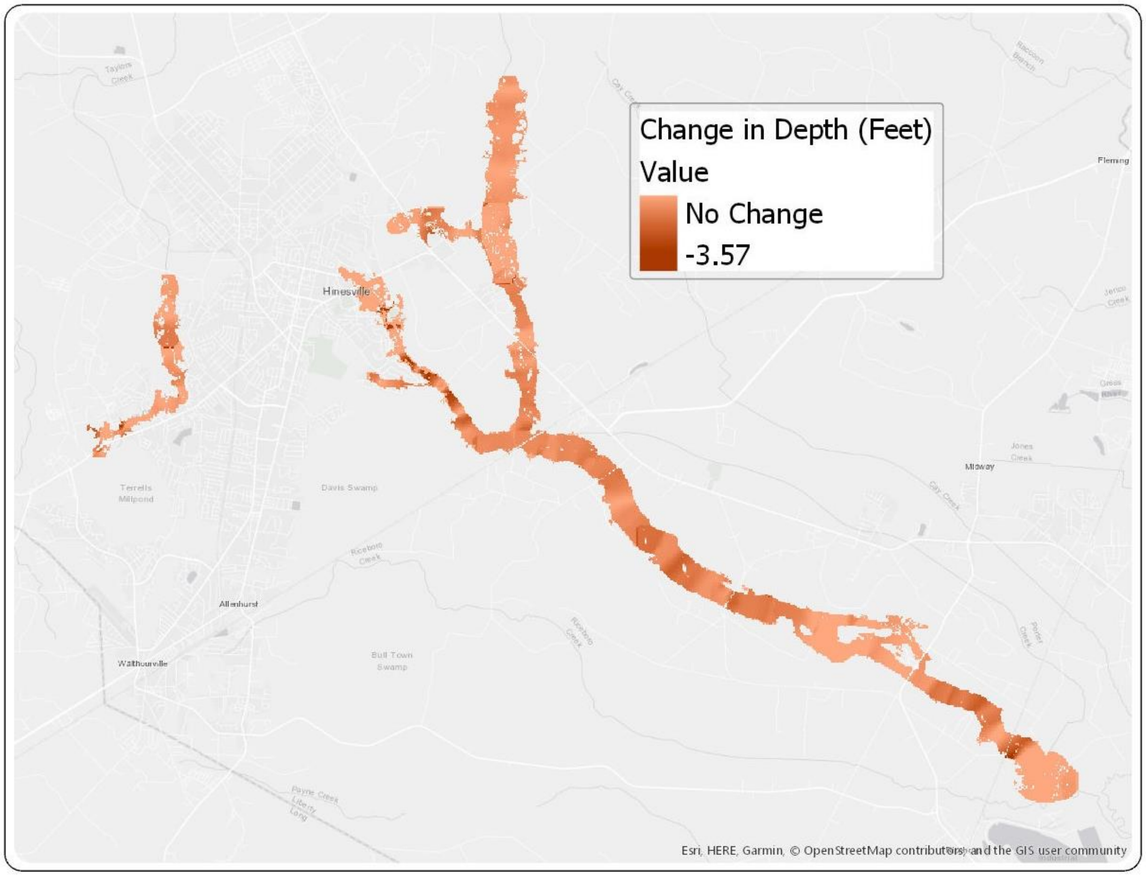

Figure 17: illustrates the reduction in water depth of the 500-year flood event resulting from the addition of green infrastructure.

Scenarios 11 through 18: Current Coastal Flooding Related Flood Risk with and without Green Infrastructure

In this group of ten scenarios, we evaluated potential coastal flood damage and loss estimations for Tybee Island resulting from Category 1 through 4 hurricane storm surges. For each storm category we evaluated impacts due to present day flood risk both with and without the addition of green infrastructure.

The hazard data for these scenarios were developed by leveraging the geospatial datasets within the national flood hazard layer (NFHL). These data layers were then loaded into Hazus-MH’s Flood Information Tool (FIT). A DEM provided by the Georgia Department of Natural Resources was used for the elevation data to derive each flood depth grid. No changes to the DEM were made to the non-green infrastructure simulation. To simulate the impacts of green infrastructure, the DEM was modified to simulate the addition of an 8ft high dune along the barrier front of the island. This dune was placed along the projected locations for current and future dune construction on Tybee Island provided by the City of Tybee Island. The 8ft high dune is high enough to protect against the 10 year return period flood which equates to the Category 1 hurricane storm surge scenario. The current (2018) building inventory was used for the damage and analyses for all 10 scenarios.

3.2.2 Present day wind scenarios

Scenarios 19 through 26: Present Day Hurricane Wind Related Risk with and without Mitigation

We analyzed eight scenarios to evaluate the impacts of coastal wind on Tybee Island resulting from categories 1 through 4 hurricanes. One of the key objectives of this analysis was to ascertain the impact of building codes on mitigating the effects of hurricane winds. To assess this impact we modeled the first four wind scenarios based on default assumptions about building inventory applied by Hazus-MH release 4.2.1. In Hazus-MH 4.2.1, building characteristics of the General Building Stock are described in terms of percentages. One of these characteristics reflects the presence or absence of hurricane shutters that have met the ASTM Standard 7. The following table documents the assumptions applied to Tybee Island for each hurricane specific building occupancy category. [5]

Hurricane Specific Building Occupancy	Percentage with Shutters Before Mitigation	Percentage with Shutters After Mitigation
Wood		
WSF1 – Single Family Homes – 1 Story	5	10
WSF2 – Single Family Homes – 2 or more Stories	5	10
WMUH1 – Multi-Unit Hotel/Motel – 1 Story	0	5
WMUH2 – Multi-Unit Hotel/Motel – 2 Story	0	5
WMUH3 – Multi-Unit Hotel/Motel – 3 or more Stories	0	0
Masonry		
MSF1- Single Family Homes – 1 Story	5	10
MSF2 - Single Family Homes – 2 or more Stories	5	10
MMUH1 – Multi-Unit Hotel/Motel – 1 Story	0	5
MMUH2 – Multi-Unit Hotel/Motel – 2 Story	0	5
MMUH3 – Multi-Unit Hotel/Motel – 3 or more Stories	0	0
MLRM1 – Low Rise MAS Strip Mall up to 15 feet high	0	0
MLRM2 – Low Rise MAS Strip Mall more than 15 feet high	0	0
MLRI – Low Rise Mas Warehouse/Factory – 20 ft high	0	0
MERBL – Masonry Engineered Residential Buildings – 1 to 2 stories	0	0
MERBM - Masonry Engineered Residential Buildings – 3 to 5 stories	0	0
MERBH - Masonry Engineered Residential Buildings – 6 or more stories	0	0
MECBL – Masonry Engineered Commercial Buildings – 1 to 2 stories	0	0
MECBM – Masonry Engineered Commercial Buildings – 3 to 5 stories	0	0
MECBH - – Masonry Engineered Commercial Buildings – 6 or more stories	0	0
Concrete		
CERBL – Concrete Engineered Residential Buildings – 1 to 2 stories	0	0
CERBM - Concrete Engineered Residential Buildings – 3 to 5 stories	0	0
CERBH - Concrete Engineered Residential Buildings – 6 or more stories	0	0
CECBL – Concrete Engineered Commercial Buildings – 1 to 2 stories	0	0
CECBM - Concrete Engineered Commercial Buildings – 3 to 5 stories	0	0

[5] Tybee Island default building characteristics in Hazus-MH 4.2.1 are assigned using the Hazus Southeast Coastal mapping scheme. Details about this mapping scheme can be found in the Hazus-MH technical documentation.

Hurricane Specific Building Occupancy	Percentage with Shutters Before Mitigation	Percentage with Shutters After Mitigation
CECBH - Concrete Engineered Commercial Buildings – 6 or more stories	0	0
Steel		
SPMBS – Pre-Engineered Metal Building - Small	0	0
SPMBM – Pre-Engineered Metal Building – Medium	0	0
SPMBL – Pre-Engineered Metal Building – Large	0	0
SERBL – Engineered Residential Building – 1 to 2 stories	0	0
SERBM – Engineered Residential Building – 3 to 5 stories	0	0
SERBH – Engineered Residential Building – 6 or more stories	0	0
SECBL – Engineered Commercial Buildings – 1 to 2 stories	0	0
SECBM – Engineered Commercial Buildings – 3 to 5 stories	0	0
SECBH – Engineered Commercial Buildings – 6 or more stories	0	0
Manufactured Housing		
MHPHUD – Manufactured Home – Before 1976	0	0
MH76UD – Manufactured Home – 1976 to 1994	0	0
MH94HUD1 – Manufactured Homes, After, 1994 Zone 1	0	0
MH94HUDII – Manufactured Homes, After, 1994 Zone 2	0	0
MH94HUDIII – Manufactured Homes, After, 1994 Zone 3	0	0

Table 7: Default Hurricane Shutters Distribution by Hazus-MH 4.2.1 and the modified building distributions for Hurricane Specific Building Types for Tybee Island.

The direction of approach, size of the wind field, duration of time required for the hurricane to pass through an area and a variety of other factors play a significant role in determining the impact of hurricane winds. For these scenarios we developed hurricane wind scenarios that reflect the climatological characteristics of hurricane events for coastal Georgia. Category 1 – 4 hurricane wind scenarios were computed and used in the simulations.

3.2.3 Future condition flood scenarios

Future Rainfall Climate for Coastal Georgia Near Hinesville, Georgia

The observed estimate of the 50-year (average recurrence interval), 24-hour (duration) precipitation for Liberty County, Georgia was retrieved from NOAA Atlas 14 for a representative city, Midway, Georgia. This historical value is 9.39”, based on data for 1941-2011.

Global Historical Climate Network (GHCN) daily precipitation data was downloaded for Fort Stewart, Georgia in Liberty County for 1965-2016. For each year, the maximum daily total was determined. These values were then inflated by a multiplicative factor of 1.12 to convert between maximum daily totals and maximum 24-hour (potentially across-day) totals by applying observation-based estimates from Hershfield (1961) and Villarini et al. (2011). The mean value of these yearly maximum 24-hour totals was 4.03” for Fort Stewart.

Generalized Extreme Value (GEV) theory (Coles 2001) was applied to these corrected (maximum 24-hour) totals per year, using the National Center for Atmospheric Research (NCAR) Command Language (NCL). The NCL function, extval_mlegev, estimates the location (related to the mean of the distribution), scale (representative of the variance), and shape (representative of the tails) parameters for the GEV distribution using the maximum-likelihood estimation. The observed GEV location, scale, and shape parameters were 3.18, 0.90, and 0.28, respectively. According to GEV theory, the return level is computed as:

$$Return\ Level = \frac{Scale}{Shape}\left[Coeff^{-1*Shape} - 1\right] + Location$$

where $Coeff = -1 * log\left[1 - \frac{1}{50}\right]$.

The resulting 50-year, 24-hour return level based on GHCN data was 9.47”, highly consistent with the NOAA Atlas 14 estimate. This demonstrated our accurate application of GEV theory in NCL, so we used 9.39” for the observed historical return level for Liberty County, Georgia.

The Wisconsin Initiative on Climate Change Impacts (WICCI), Multivariate Adaptive Constructed Analogs (MACA), and Localized Constructed Analogs (LOCA) statistically downscaled datasets were downloaded for the late 20th (1961-2000), mid-21st (2046-2065), and late 21st (2081-2100) centuries and the closest grid cell to Fort Stewart, Georgia was extracted from each dataset using either the NCAR Command Operators (NCO) or website data extraction. For each product and each year, the maximum daily total was determined, and these values were then inflated by a multiplicative factor of 1.12 to convert between maximum daily totals and maximum 24-hour totals. The average value of the 24-hour maximum total per year was 3.88”, 2.87”, and 2.84” for the WICCI, MACA, and LOCA products, respectively, compared to the observed value of 4.03”.

The GEV return level was computed for each individual global climate model within each of the three statistically downscaled products. The late 20th century mean return level was 8.05”, 5.90”, and 5.57” for the WICCI, MACA, and LOCA products, respectively, all underestimating the observed value of 9.39”. Therefore, the projected return levels, for the mid- and late 21st century, were then debiased by multiplying by 9.39” and dividing by the simulated late 20th century return levels per model. For example, a model that simulated a late-20th century return level of 6.00” and a future return level of 8.00” would have a debiased future return level of 9.39” x (8.00”/6.00”) = 12.52”.

The key findings are summarized below and illustrated in Figure 18 and Table 19.

(1) Aggregate estimates for the 25th percentile, median, and 75th percentile of the 50-year, 24-hour precipitation return level for Liberty County, Georgia are 9.37”, 10.90”, and 12.79” for the mid-21st century and 9.57”, 10.92”, and 12.75” for the late 21st century, respectively. These values are based on averaging across the results from seven data sources: the WICCI product for three emission scenarios, LOCA product for two emission scenarios, and MACA product for two emission scenarios.

(2) The low-end return level (25th percentile) estimate of 9.37” is close to the observed historical value (9.39”). The median return level estimate is 16% higher than the observed historical value. The high-end return level (75th percentile) estimate is 36% higher than the observed historical value. An amplification of 24-hour precipitation extremes is therefore likely for Liberty County.

(3) These projected return level magnitudes for the mid- and late 21st century, are very similar, suggesting an enhancement of extreme rainfall between the late 20th century and mid-21st century, but no further amplification later in the 21st century.

(4) Some of the models produce exceedingly high extreme precipitation totals during the 21st century that may be skewed by the debiasing method (in particular, models that vastly under-simulate precipitation extremes and thus require a large correction factor), leading to the recommendation to consider the 25th percentile, median, and 75th percentile but not the minimum and maximum values among models.

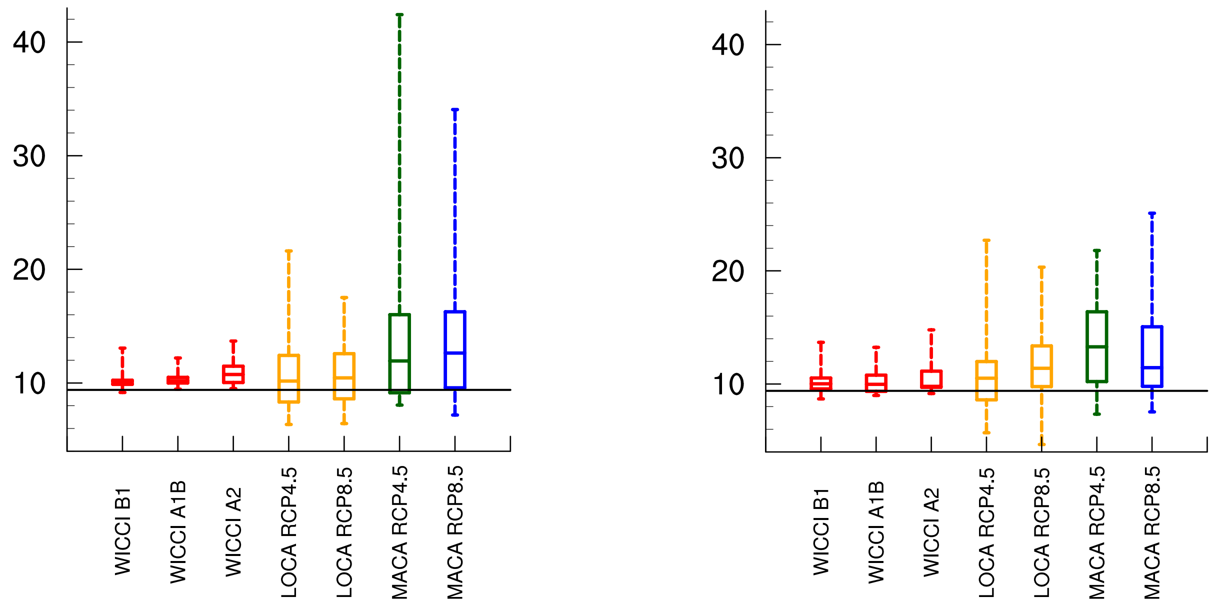

Figure 18: The mid- (left) and late (right) 21st century projected 50-year, 24-hour precipitation return levels in inches are shown for the WICCI (9 models according to the B1, A1B, and A2 scenarios), LOCA (32 models according to the RCP4.5 and RCP8.5 scenarios), and MACA (20 models according to the RCP4.5 and RCP8.5 scenarios) products for Fort Stewart, Georgia. The box and whiskers plots represent the minimum, 25th percentile, median, 75th percentile, and maximum values across the models. The black line represents the observed historical return level.

Mid-21st Century	Minimum	25th Percentile	Median	75th Percentile	Maximum
WICCI B1	9.17”	9.88”	10.18”	10.24”	13.07”
WICCI A1B	9.46”	10.00”	10.19”	10.50”	12.20”
WICCI A2	9.50”	10.05”	10.75”	11.48”	13.69”
LOCA RCP4.5	6.35”	8.33”	10.17”	12.43”	21.62”
LOCA RCP8.5	6.44”	8.61”	10.45”	12.58”	17.52”
MACA RCP4.5	8.05”	9.14”	11.94”	16.01”	42.41”
MACA RCP8.5	7.18”	9.58”	12.63”	16.26”	34.06”

Late 21st Century	Minimum	25th Percentile	Median	75th Percentile	Maximum

WICCI B1	8.68”	9.56”	10.02”	10.53”	13.68”
WICCI A1B	8.99”	9.35”	9.97”	10.78”	13.24”
WICCI A2	9.16”	9.71”	9.79”	11.13”	14.79”
LOCA RCP4.5	5.69”	8.60”	10.51”	11.99”	22.70”
LOCA RCP8.5	4.65”	9.77”	11.39”	13.36”	20.33”
MACA RCP4.5	7.33”	10.21”	13.29”	16.38”	21.80”
MACA RCP8.5	7.53”	9.80”	11.44”	15.06”	25.10”

Table 8: Minimum 25th percentile, median, 75th percentile, and maximum values, among the analyzed set of models, of 50-year, 24-hour precipitation return level in inches for Fort Stewart, Georgia, according to the WICCI (9 models according to the B1, A1B, and A2 scenarios), LOCA (32 models according to the RCP4.5 and RCP8.5 scenarios), and MACA (20 models according to the RCP4.5 and RCP8.5 scenarios) products. Results are shown for the (top) mid-21st and (bottom) late 21st century.

Scenarios 27 through 56: Future Riverine Flood Risk with and without Green Infrastructure and a Future Projected Building Stock

In Scenarios 27 through 56 we evaluated riverine flood damage and loss estimation in the Upper North Newport River Watershed under future rainfall conditions. These included the 10, 25, 50, 100 and 500 year return periods each with 3 projections (25th, 50th, and 75th percentile) of rainfall estimates that represented changes to riverine flood hazards due to increases in precipitation in the future. We also evaluated the impacts to each depth grid with a 10% reduction in water volume from green infrastructure. Each scenario also incorporated changes to the building stock resulting from expected future population changes.

Scenarios 57 through 86: Future Riverine Flood Risk with and without Green Infrastructure and a the Current (2018) Building Stock

In Scenarios 57 through 86 we evaluated riverine flood damage and loss estimation in the Upper North Newport River Watershed under future rainfall conditions. These included the 10, 25, 50, 100 and 500 year return periods each with 3 projections (25th, 50th, and 75th percentile) of rainfall estimates that represented changes to riverine flood hazards due to increases in precipitation in the future. We also evaluated the impacts to each depth grid with a 10% reduction in water volume from green infrastructure. Each scenario used the current (2018) building stock.

Scenarios 87 through 94: Future Coastal Flood Risk with and without Green Infrastructure using a Simulated Future Building Stock

Scenarios 87 through 94 are future coastal flood damage and loss estimations for Tybee Island for each of four hurricane scenarios (Categories 1 through 4). These scenarios represented changes to coastal flooding hazards due to changes in hurricane intensity and frequency with projected population growth with and without green infrastructure targeting coastal protection. The relationship between wind intensity and storm surge was used to simulate future increases in wind intensity and associated coastal flooding.

The original NFHL geospatial datasets were modified to include future flood hazard information. A modified DEM produced by Georgia Southern University that captures a 1m sea level rise was used as an input for estimating future flooding hazard potential. The still water elevations and DEM were used as inputs into Hazus-MH's Flood Information Tool (FIT). For the green infrastructure scenarios, the DEM was further modified to include a sand dune that protects against the 100 year (1% annual chance) coastal flood. The damage and loss analyses were calculated using a projected (2080) future building stock.

Scenarios 95 through 102: Future Coastal Flood Risk with and without Green Infrastructure using the Current Building Stock

Scenarios 95 through 102 are future coastal flood damage and loss estimations for Tybee Island for each of four hurricane scenarios (Categories 1 through 4). These scenarios represented changes to coastal flooding hazards due to changes in hurricane intensity and frequency with projected population growth with and without green infrastructure targeting coastal protection. The relationship between wind intensity and storm surge was used to simulate future increases in wind intensity and associated coastal flooding.

The original NFHL geospatial datasets were modified to include future flood hazard information. A modified DEM produced by Georgia Southern University that captures a 1m sea level rise was used as an input for estimating future flooding hazard potential. The still water elevations and DEM were used as inputs into Hazus-MH's Flood Information Tool (FIT). For the green infrastructure scenarios the DEM was further modified to include a sand dune that protects against the 100 year (1% annual chance) coastal flood. The damage and loss analyses were calculated using a projected (2018) future building stock.

3.2.4 Future condition wind scenarios

Scenarios 103 through 118: Future Hurricane Wind Related Risk with and without Mitigation

In Scenarios 103 to 118 we considered coastal wind hazard damage and losses for Tybee Island for each of four hurricane scenarios (Categories 1 through 4). These scenarios represented changes in hurricane intensity and frequency. Scenarios 103 to 118 considered a business-as-usual population growth and with a business-as-usual set of building construction requirements that keep existing building codes (e.g., hurricane shutters) for hurricane wind protection for new and old construction. Scenarios 103 to 118 also assumed business as usual population growth. However, to represent the impact of improved building codes, all structures in the scenario, all structure built after 2018 were assumed to be built with hurricane shutters for hurricane wind protection.

The hazard data for these scenarios were developed by individual reconstruction of the windfields of each hypothetical hurricane. For the future windspeeds each scenario was increased by 10% over the analogous current hurricane wind scenarios. The forward speed was also lowered by 5%. Both of these changes are cited in recent literature. Hazus-MH was used to model the final windfields for each scenario.

Section 4 Risk Assessment Methodology

The following material provides an overview of the key aspects of the analysis methodology employed in Hazus-MH. For additional information on this methodology the reader is encouraged to consult the Hazus-MH technical and user manuals available from FEMA's Map Service Center[6].

4.1 Flood Building Damage Analysis

In the Hazus-MH flood model, General Building Stock is reported by 2010 census block geographies. As described previously, a key assumption associated with the General Building Stock is that all structures are evenly distributed. Clearly, this is not always the case. Figure 19 illustrates an example in which the actual location of two of the four structures are in areas of three feet of water while the other two structures are entirely outside of the flooded area. Hazus-MH would assume, however, that three of the four structures are impacted and that only one is in three feet of water while the others are in relatively shallow water and potentially unscathed.

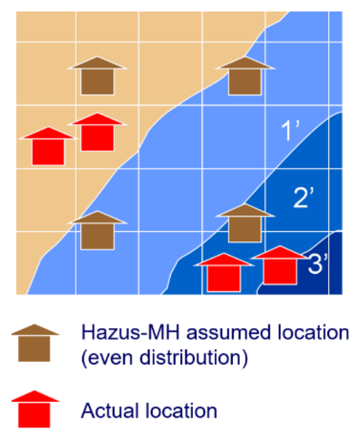

Figure 19: Hazus-MH Interpretation of Locations of Structures within the General Building Stock Inventory

As mentioned previously, the assumption of even distribution of structures is partially mitigated by the use of clipped census block polygons from which unpopulated areas such as forests, vacant land and water have been removed. However, there is still considerable potential for error to be introduced in loss estimations due to the even distribution assumption. In order to mitigate this issue, we elected to take advantage of the Hazus-MH User Defined Facility inventory where possible to refine the building loss estimations for this study.

[6] Hazus-MH technical and user manuals can be obtained from FEMA's Map Service Center at https://www.fema.gov/hazus-mh-user-technical-manuals.

User Defined Facilities outputs used for this study included the number of damaged buildings based on their occupancy. It also included for each building the losses to the building itself, its contents and, where applicable, its inventory due to flooding. As is the case for the General Building Stock, the User Defined Facility inventory categorizes buildings based on seven General Occupancies (residential, commercial, industrial, agricultural, government, religion and education) and 33 specific occupancies (e.g. single family residential, multifamily residential, etc.). It further defines buildings by the type of material from which they are constructed. In the Hazus-MH flood model materials include wood, concrete, steel, masonry and manufactured homes. Additionally, critical attributes for user-defined facilities include first floor elevation and the number of stories of each structure.

Damages to individual user defined facilities are assessed using depth damage curves. Figure 20 provides an example of damage curves associated with single-family residential homes with one story and no basement. The sample curves reflect estimated damage percentages for the building itself as well as the contents of the building.

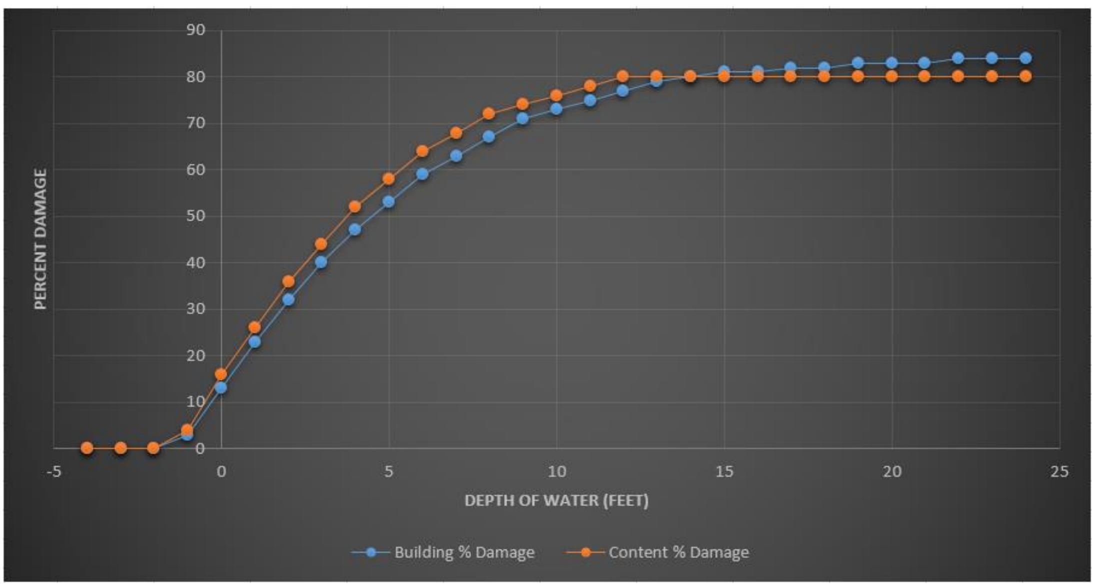

Figure 20: Building Damage and Content Damage Curves for Single Family Residential Home with 1-Story and No Basement

4.2 Hurricane Wind Building Damage Analysis

While the Hazus-MH hurricane wind model supports user defined facility analysis, it produces only probabilities of building damage. No economic loss is available in the current Hazus-MH release. Therefore, all hurricane wind related impacts associated with this study are based on exposure defined in the Hazus-MH General Building Stock inventory. The only exception to this is estimated damage related to Hazus-MH Essential Facilities. As noted earlier, the Hazus-MH General Building Stock inventory contains information that describes characteristics of buildings aggregated to 2010 census boundaries. In the Hurricane model, aggregation is by 2010 census tracts. Factors considered by Hazus-MH for estimating wind impacts include wind pressures, wind-borne debris, tree blow-down, rainfall, and storm duration. The model explicitly accounts for the impacts of wind on various structure components including roof cover, roof deck, whole roof failures, window and door failures and wall damage.

Hazus-MH includes over 300,000 hurricane wind damage functions that are applied to the building inventory to assess impacts. Figure 21 provides an example of the probability of various damage states to a single family home one story in height and constructed of wood. This outcome reflects a hip shaped roof, the presence of secondary water resistance measures, toe-nail roof-wall connections, and open terrain. It also assumes the presence of hurricane shutters. Note, for example, that at a 140 MPH peak gust wind speed the probability of destruction would be less than 0.1 (or a 10% chance).

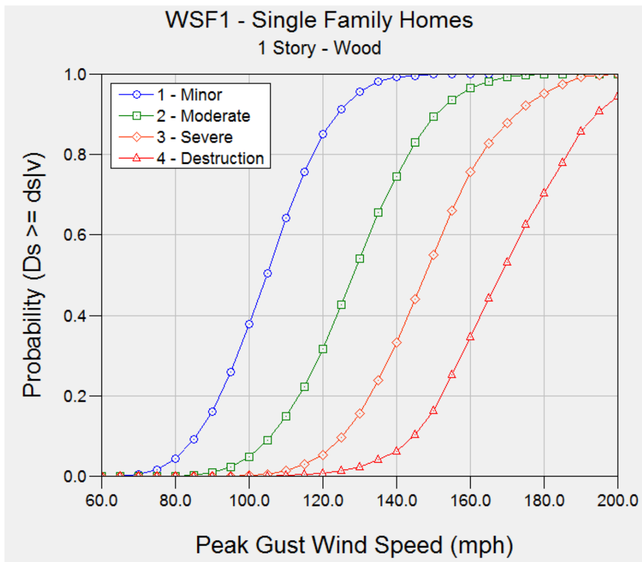

Figure 21: Hurricane Wind Damage Curves for Single Family Home with Hurricane Shutters.

Figure 22 reflects the same conditions, but adjusted to assume that no hurricane shutters are present. In this situation, the same peak gust wind speed would yield a probability of destruction that exceeds 0.5 (or a 50% chance).

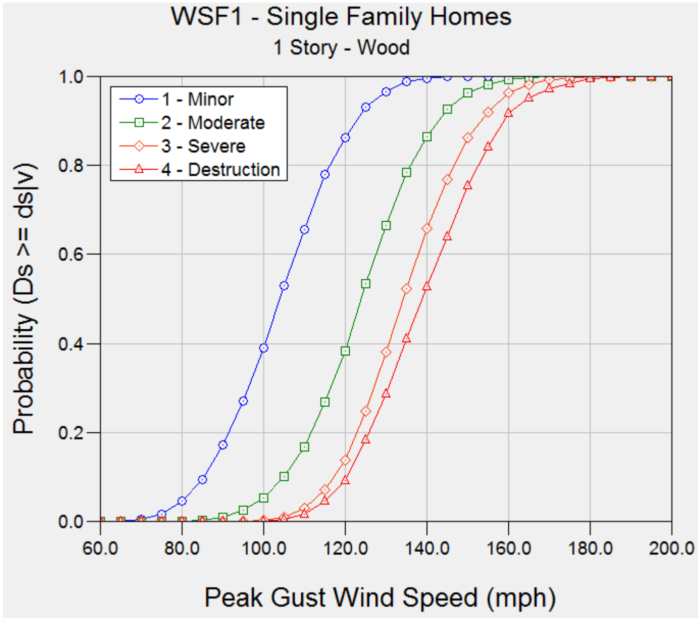

Figure 22: Hurricane Wind Damage Curves for Single Family Home without Hurricane Shutters.

4.3 Hurricane and Flood Debris Analysis

The hurricane wind debris model is based on the damage states for structural and non-structural components of several model building types. For each damaged component, the debris generated in each building type category (wood, masonry, metal and other) is calculated based on the component's damage state and weight statistics. Then, by adding up the debris produced by all the damaged components, the total debris weight for each model building type can be estimated. The debris volume is simply estimated by dividing the debris weight by its density. Specific assumptions about each modeled building type as they related to debris generation are provided in the Hazus-MH documentation.[7]

In addition to building related damage, the Hazus-MH Hurricane Wind model provides an estimation of tree debris reported in this study for each hurricane wind scenario. This estimate considers the density of trees as well as their height. It also considers the type of trees grouped by deciduous, coniferous and mixed based on root systems and resistance to wind. The tree database that comes with Hazus-MH was not modified for this study. Hazus-MH provides an estimate of total tree debris as well as debris eligible for removal at the public's expense as a result of being located on roadways for instance.

The Hazus-MH flood model reports building debris in terms of estimated tons of building finishes, structural components and foundation materials. It is important to note that this is not an all-inclusive representation of flood related debris. For examples, it does not consider debris from vegetation, sediment or building contents. Flood debris estimations are evaluated based upon a combination of

[7] See Hazus-MH 4.2 Hurricane User Manual Section 7.4: Building Debris Functions and Hazus-MH 2.1 Hurricane Technical Module Chapter 10: Debris Generated from Damaged Buildings.

building occupancies and foundation types. Default assumptions about building foundation type weights are pre-populated in Hazus-MH and were not modified for this study.

4.4 Hurricane and Flood Essential Facility Analysis

Essential facilities consist of police stations, fire stations, schools, hospitals and emergency operation centers. Of these, fire stations, schools and hospitals have been explicitly modeled in the Hazus-MH hurricane wind model methodology. Fire stations and schools are often low-rise structures and are modeled in Hazus-MH as such, while hospitals can be low-rise or high-rise in nature. In the Hazus-MH methodology essential facility damage is limited to entry doors and windows, overhead doors (fire station only), and metal roof systems. All essential facilities were modeled assuming that whole wall failure and roof framing member failure would not occur. Detailed information on the assumptions associated with various damage states for each essential facility type is provided in the Hazus-MH documentation.[8]

As is the case for most damage estimations in the Hazus-MH flood model, Essential Facility loss estimates are based on the use of depth damage functions. Input required to estimate losses includes the building height, presence/absence of a basement and first floor elevation. The methodology applied to assess Essential Facility impacts is similar to that of the General Building Stock except that Essential Facilities are assessed at the location of the facility – a point with latitude and longitude coordinates.

4.5 Hurricane and Flood Social Vulnerability

This study did not attempt to quantify social impacts of which there are many. However, it is important to consider that they exist and that there is an associated cost. Quantification of the societal benefits of hazard mitigation when determining the benefits and costs of hazard mitigation is a relatively recent phenomena. A significant recent report that quantified societal impacts is the Natural Hazard Mitigation Saves: 2017 Interim Report[9]. This report updated the often cited 2005 Mitigation Saves report by evaluating a wider range of federal grants as well as analyzing the benefits of building beyond minimum code requirements. One of the most significant additions to the 2017 report was the consideration of the cost of post-traumatic stress disorder (PTSD), one of several potential societal impacts. Consideration of PTSD and other factors in the 2017 study resulting in increasing the often quoted average of $4 saved for every $1 spent on hazard mitigation to a new higher average of $6 saved for every $1 spent on mitigation.

[8] Hazus-MH 2.1 Hurricane Technical Manual page 6-140 to 6-158.

[9] Multihazard Mitigation Council (2017) Natural Hazard Mitigation Saves 2017 Interim Report: An Independent Study – Summary of Findings. Principal Investigator Porter, K.; co-Principal Investigators Scawthorn, C.; Dash, N.; Santos, J.; Investigators: Eguchi, M., Ghosh., S., Huyck, C., Isteita, M., Mickey, K., Rashed, T.; Project Manager P. Schneider, Director, MMC. National Institute of Building Sciences, Washington.

In addition to PTSD and other public health impacts, there are a variety of other potential social impacts. For example, one potential immediate impact can be injury or loss of life. A less immediate, but important impact may be loss of livelihoods of the impacted population. With destruction of communication links and infrastructure such as roads and bridges, economic activities can be reduced or come to a standstill. This can result in the dislocation of populations and disruption in normal life that can extend well past the actual flood or hurricane event.

Section

5

Scenario Results

As indicated previously, this study modeled 118 scenarios. Sections 5.1 thru 5.5 describe selected potential hurricane wind and flood related economic and social impacts to the built and social environment in the study area.

5.1 Present Day Flood Scenarios

5.1.1: Current Riverine Flood Risk with and without Green Infrastructure

Table 9 provides a summary of the expected damages from riverine flood risk. Total Buildings Damaged reflects the total number of buildings in any state of damage from minor damage to destruction. Building loss refers to damage to the structure only. Content loss is an estimate of loss to furniture, equipment that is not integral with the structure, computers and other supplies. Contents do not include inventory or nonstructural components such as lighting, ceilings, mechanical and electrical equipment and other fixtures. Things within a commercial or industrial structure than can be sold are considered Inventory. Thus, they do not apply to many occupancies. Note that the numbers in the following table do not account for potential impacts such as business interruption.

Occupancy Classification	Total Buildings Damaged	Building Loss	Content Loss	Inventory Loss
Scenario 1: Current Riverine Flood Risk with Green Infrastructure (10 Year)				
Residential	31	$620,104	$384,548	No Damages
Commercial	12	$426,268	$1,263,696	$86,886
Industrial	1	$3,296	$7,740	$1,479
Agricultural	No Damages	No Damages	No Damages	No Damages
Religious	No Damages	No Damages	No Damages	No Damages
Government	No Damages	No Damages	No Damages	No Damages
Education	No Damages	No Damages	No Damages	No Damages
Total	**44**	**$1,049,669**	**$1,655,984**	**$88,365**
Scenario 6: Current Riverine Flood Risk without Green Infrastructure (10 Year)				
Residential	31	$733,475	$449,358	No Damages
Commercial	12	$426,268	$1,263,696	$86,886
Industrial	1	$3,296	$7,740	$1,479
Agricultural	No Damages	No Damages	No Damages	No Damages
Religious	No Damages	No Damages	No Damages	No Damages
Government	No Damages	No Damages	No Damages	No Damages
Education	No Damages	No Damages	No Damages	No Damages
Total	**44**	**$1,163,040**	**$1,720,795**	**$88,365**
Scenario 2: Current Riverine Flood Risk with Green Infrastructure (25 Year)				
Residential	56	$1,278,955	$772,002	No Damages

Occupancy Classification	Total Buildings Damaged	Building Loss	Content Loss	Inventory Loss
Commercial	17	$545,420	$1,648,423	$94,086
Industrial	1	$3,512	$8,189	$1,557
Agricultural	No Damages	No Damages	No Damages	No Damages
Religious	No Damages	No Damages	No Damages	No Damages
Government	No Damages	No Damages	No Damages	No Damages
Education	No Damages	No Damages	No Damages	No Damages
Total	**74**	**$1,827,887**	**$2,428,614**	**$95,643**
Scenario 7: Current Riverine Flood Risk without Green Infrastructure (25 Year)				
Residential	56	$1,407,361	$846,063	No Damages
Commercial	17	$693,887	$2,103,533	$113,047
Industrial	1	$3,922	$10,445	$2,061
Agricultural	No Damages	No Damages	No Damages	No Damages
Religious	No Damages	No Damages	No Damages	No Damages
Government	No Damages	No Damages	No Damages	No Damages
Education	No Damages	No Damages	No Damages	No Damages
Total	**74**	**$2,105,170**	**$2,960,041**	**$115,108**
Scenario 3: Current Riverine Flood Risk with Green Infrastructure (50 Year)				
Residential	64	$1,525,235	$920,187	No Damages
Commercial	17	$693,887	$2,103,533	$113,047
Industrial	1	$3,922	$10,445	$2,061
Agricultural	No Damages	No Damages	No Damages	No Damages
Religious	No Damages	No Damages	No Damages	No Damages
Government	No Damages	No Damages	No Damages	No Damages
Education	No Damages	No Damages	No Damages	No Damages
Total	82	$2,223,044	$3,034,165	$115,108
Scenario 8: Current Riverine Flood Risk without Green Infrastructure (50 Year)				
Residential	64	$1,659,571	$998,717	No Damages
Commercial	17	$693,887	$2,103,533	$113,047
Industrial	1	$3,922	$10,445	$2,061
Agricultural	No Damages	No Damages	No Damages	No Damages
Religious	1	$15,339	$194,378	No Damages
Government	No Damages	No Damages	No Damages	No Damages
Education	No Damages	No Damages	No Damages	No Damages
Total	**83**	**$2,372,719**	**$3,307,072**	**$115,108**
Scenario 4: Current Riverine Flood Risk with Green Infrastructure (100 Year)				
Residential	94	$2,015,755	$1,222,852	No Damages
Commercial	17	$693,887	$2,103,533	$113,047
Industrial	1	$3,922	$10,445	$2,061
Agricultural	No Damages	No Damages	No Damages	No Damages
Religious	1	$15,339	$194,378	No Damages
Government	No Damages	No Damages	No Damages	No Damages
Education	No Damages	No Damages	No Damages	No Damages
Total	**113**	**$2,728,903**	**$3,531,208**	**$115,108**
Scenario 9: Current Riverine Flood Risk without Green Infrastructure (100 Year)				
Residential	94	$2,252,829	$1,358,378	No Damages
Commercial	20	$733,643	$2,337,630	$117,202
Industrial	1	$3,934	$10,828	$2,156
Agricultural	No Damages	No Damages	No Damages	No Damages

Occupancy Classification	Total Buildings Damaged	Building Loss	Content Loss	Inventory Loss
Religious	1	$15,339	$194,378	No Damages
Government	No Damages	No Damages	No Damages	No Damages
Education	No Damages	No Damages	No Damages	No Damages
Total	**116**	**$3,005,745**	**$3,901,214**	**$119,358**
Scenario 5: Current Riverine Flood Risk with Green Infrastructure (500 Year)				
Residential	117	$2,798,203	$1,688,562	No Damages
Commercial	21	$749,089	$2,337,630	$117,202
Industrial	1	$3,934	$10,828	$2,156
Agricultural	No Damages	No Damages	No Damages	No Damages
Religious	1	$15,339	$194,378	No Damages
Government	No Damages	No Damages	No Damages	No Damages
Education	No Damages	No Damages	No Damages	No Damages
Total	**140**	**$3,566,564**	**$4,231,398**	**$119,358**
Scenario 10: Current Riverine Flood Risk without Green Infrastructure (500 Year)				
Residential	117	$3,087,158	$1,850,446	No Damages
Commercial	21	$749,089	$2,337,630	$117,202
Industrial	1	$3,934	$10,828	$2,156
Agricultural	No Damages	No Damages	No Damages	No Damages
Religious	1	$15,339	$194,378	No Damages
Government	No Damages	No Damages	No Damages	No Damages
Education	No Damages	No Damages	No Damages	No Damages
Total	**140**	**$3,855,520**	**$4,393,282**	**$119,358**

Table 9: Potential Building Economic Loss and Total Damaged Buildings with and without Green Infrastructure Resulting from Present Day Riverine Flood Risk

Table 10 provides an estimate of building debris based on current riverine flood related damages for each of the modeled scenarios.

	Finishes (Tons)	Structures (Tons)	Foundations (Tons)	Total (Tons)
Scenario 1: Current Riverine Flood Risk with Green Infrastructure (10 Year)	115	8	19	142
Scenario 6: Current Riverine Flood Risk without Green Infrastructure (10 Year)	133	9	21	163
Scenario 2: Current Riverine Flood Risk with Green Infrastructure (25 Year)	196	10	24	230
Scenario 7: Current Riverine Flood Risk without Green Infrastructure (25 Year)	248	14	33	295

	Finishes (Tons)	Structures (Tons)	Foundations (Tons)	Total (Tons)
Scenario 3: Current Riverine Flood Risk with Green Infrastructure (50 Year)	250	14	33	297
Scenario 8: Current Riverine Flood Risk without Green Infrastructure (50 Year)	261	15	36	312
Scenario 4: Current Riverine Flood Risk with Green Infrastructure (100 Year)	269	15	37	321
Scenario 9: Current Riverine Flood Risk without Green Infrastructure (100 Year)	300	16	39	355
Scenario 5: Current Riverine Flood Risk with Green Infrastructure (500 Year)	321	19	45	385
Scenario 10: Current Riverine Flood Risk without Green Infrastructure (500 Year)	340	19	47	406

Table 10: Potential Building Related Debris Resulting from Present Day Riverine Flood Risk

Table 11 describes potential impacts to essential facilities based on current riverine flood related damages for each of the modeled scenarios.

	Number of Facilities Slightly Damaged (1 – 10%)	Number of Facilities Moderately Damaged (11 – 30%)	Number of Facilities Severely Damaged or greater (>30%)
Scenario 1: Current Riverine Flood Risk with Green Infrastructure (10 Year)			
Fire	0	0	0
Police	0	0	0
Care	0	0	0
Emergency Operation Centers	0	0	0
Schools	0	0	0
Scenario 6: Current Riverine Flood Risk without Green Infrastructure (10 Year)			
Fire	0	0	0
Police	0	0	0
Care	0	0	0
Emergency Operation Centers	0	0	0
Schools	0	0	0

	Number of Facilities Slightly Damaged (1 – 10%)	**Number of Facilities Moderately Damaged (11 – 30%)**	**Number of Facilities Severely Damaged or greater (>30%)**
Scenario 2: Current Riverine Flood Risk with Green Infrastructure (25 Year)			
Fire	0	0	0
Police	0	0	0
Care	0	0	0
Emergency Operation Centers	0	0	0
Schools	0	0	0
Scenario 7: Current Riverine Flood Risk without Green Infrastructure (25 Year)			
Fire	0	0	0
Police	0	0	0
Care	0	0	0
Emergency Operation Centers	0	0	0
Schools	0	0	0
Scenario 3: Current Riverine Flood Risk with Green Infrastructure (50 Year)			
Fire	0	0	0
Police	0	0	0
Care	0	0	0
Emergency Operation Centers	0	0	0
Schools	0	0	0
Scenario 8: Current Riverine Flood Risk without Green Infrastructure (50 Year)			
Fire	0	0	0
Police	0	0	0
Care	0	0	0
Emergency Operation Centers	0	0	0
Schools	0	0	0
Scenario 4: Current Riverine Flood Risk with Green Infrastructure (100 Year)			
Fire	0	0	0
Police	0	0	0
Care	0	0	0
Emergency Operation Centers	0	0	0
Schools	0	0	0
Scenario 9: Current Riverine Flood Risk without Green Infrastructure (100 Year)			
Fire	0	0	0
Police	0	0	0
Care	0	0	0
Emergency Operation Centers	0	0	0
Schools	0	0	0
Scenario 5: Current Riverine Flood Risk with Green Infrastructure (500 Year)			
Fire	0	0	0
Police	0	0	0
Care	0	0	0
Emergency Operation Centers	0	0	0
Schools	0	0	0

	Number of Facilities Slightly Damaged (1 – 10%)	Number of Facilities Moderately Damaged (11 – 30%)	Number of Facilities Severely Damaged or greater (>30%)
Scenario 10: Current Riverine Flood Risk without Green Infrastructure (500 Year)			
Fire	0	0	0
Police	0	0	0
Care	0	0	0
Emergency Operation Centers	0	0	0
Schools	0	0	0

Table 11: Potential Essential Facilities Impacted Based on Current Condition Riverine Scenarios

5.1.2: Current Coastal Flood Risk with and without Green Infrastructure

Table 12 provides a summary of the expected damages from coastal flooding risk. Total Buildings Damaged reflects the total number of buildings in any state of damage from minor damage to destruction. Building loss refers to damage to the structure only. Content loss is an estimate of loss to furniture, equipment that is not integral with the structure, computers and other supplies. Contents do not include inventory or nonstructural components such as lighting, ceilings, mechanical and electrical equipment and other fixtures. Inventory losses are things within a structure that can be sold. Thus, they do not apply to many occupancies. Note that the numbers in the following table do not account for potential impacts such as business interruption.

Also, note that the losses for the each scenario are identical for analysis with and without green infrastructure except for the Category 1 storm which equates to an approximately 10 year return period. The reason for this is that there is no impact variation in coastal flooding extent based upon the modeled green infrastructure option for the Category 2, 3 or 4 scenarios.

Occupancy Classification	Total Buildings Damaged	Building Loss	Content Loss	Inventory Loss
Scenario 11: Current Coastal Flood Risk with Green Infrastructure (Category 1 Hurricane)				
Residential	188	$4,304,590	$2,083,946	No Damages
Commercial	16	$171,433	$522,405	$47,194
Industrial	No Damages	No Damages	No Damages	No Damages
Agricultural	No Damages	No Damages	No Damages	No Damages
Religious	No Damages	No Damages	No Damages	No Damages
Government	No Damages	No Damages	No Damages	No Damages
Education	No Damages	No Damages	No Damages	No Damages
Total	**188**	**$4,304,590**	**$2,083,946**	**$0.00**
Scenario 15: Current Coastal Flood Risk without Green Infrastructure (Category 1 Hurricane)				
Residential	806	$24,243,838	$12,382,233	No Damages
Commercial	51	$468,398	$1,868,928	$81,383
Industrial	2	$28,402	$25,820	$6,267
Agricultural	No Damages	No Damages	No Damages	No Damages
Religious	No Damages	No Damages	No Damages	No Damages
Government	No Damages	No Damages	No Damages	No Damages
Education	No Damages	No Damages	No Damages	No Damages

Occupancy Classification	**Total Buildings Damaged**	**Building Loss**	**Content Loss**	**Inventory Loss**
Total	**859**	**$ 24,740,638**	**$14,276,982**	**$87,650**
Scenario 12: Current Coastal Flood Risk with Green Infrastructure (Category 2 Hurricane)				
Residential	806	$24,243,838	$12,382,233	No Damages
Commercial	51	$468,398	$1,868,928	$81,383
Industrial	2	$28,402	$25,820	$6,267
Agricultural	No Damages	No Damages	No Damages	No Damages
Religious	No Damages	No Damages	No Damages	No Damages
Government	No Damages	No Damages	No Damages	No Damages
Education	No Damages	No Damages	No Damages	No Damages
Total	**859**	**$24,740,638**	**$14,276,982**	**$87,650**
Scenario 16: Current Coastal Flood Risk without Green Infrastructure (Category 2 Hurricane)				
Residential	806	$24,243,838	$12,382,233	No Damages
Commercial	51	$468,398	$1,868,928	$81,383
Industrial	2	$28,402	$25,820	$6,267
Agricultural	No Damages	No Damages	No Damages	No Damages
Religious	No Damages	No Damages	No Damages	No Damages
Government	No Damages	No Damages	No Damages	No Damages
Education	No Damages	No Damages	No Damages	No Damages
Total	**859**	**$24,740,638**	**$14,276,982**	**$87,650**
Scenario 13: Current Coastal Flood Risk with Green Infrastructure (Category 3 Hurricane)				
Residential	2130	$150,178,384	$78,061,542	No Damages
Commercial	95	$3,430,294	$11,482,437	$459,560
Industrial	2	$156,168	$197,313	$35,681
Agricultural	No Damages	No Damages	No Damages	No Damages
Religious	6	$416,247	$2,426,996	No Damages
Government	No Damages	No Damages	No Damages	No Damages
Education	3	$113,148	$610,999	No Damages
Total	**2236**	**$154,294,240**	**$92,779,287**	**$495,241**
Scenario 17: Current Coastal Flood Risk without Green Infrastructure (Category 3 Hurricane)				
Residential	2130	$150,178,384	$78,061,542	No Damages
Commercial	95	$3,430,294	$11,482,437	$459,560
Industrial	2	$156,168	$197,313	$35,681
Agricultural	No Damages	No Damages	No Damages	No Damages
Religious	6	$416,247	$2,426,996	No Damages
Government	No Damages	No Damages	No Damages	No Damages
Education	3	$113,148	$610,999	No Damages
Total	**2236**	**$154,294,240**	**$92,779,287**	**$495,241**
Scenario 14: Current Coastal Flood Risk with Green Infrastructure (Category 4 Hurricane)				
Residential	2570	$249,914,364	$129,392,535	No Damages
Commercial	114	$5,425,849	$17,372,513	$704,158
Industrial	2	$187,667	$241,927	$40,902
Agricultural	0	No Damages	No Damages	No Damages
Religious	7	$568,495	$3,904,432	No Damages
Government	No Damages	No Damages	No Damages	No Damages
Education	3	$224,231	$1,221,608	No Damages
Total	**2696**	**$256,320,605**	**$152,133,015**	**$745,060**

Occupancy Classification	Total Buildings Damaged	Building Loss	Content Loss	Inventory Loss
Scenario 18: Current Coastal Flood Risk without Green Infrastructure (Category 4 Hurricane)				
Residential	2570	$249,914,364	$129,392,535	No Damages
Commercial	114	$5,425,849	$17,372,513	$704,158
Industrial	2	$187,667	$241,927	$40,902
Agricultural	0	No Damages	No Damages	No Damages
Religious	7	$568,495	$3,904,432	No Damages
Government	No Damages	No Damages	No Damages	No Damages
Education	3	$224,231	$1,221,608	No Damages
Total	**2696**	**$256,320,605**	**$152,133,015**	**$745,060**

Table 12: Potential Building Economic Loss and Total Damaged Buildings with and without Green Infrastructure Resulting from Present Day Coastal Flood Risk

Table 13 provides an estimate of building debris based on coastal flooding related damages for each of the modeled scenarios.

Scenario	Finishes (Tons)	Structures (Tons)	Foundations (Tons)	Total (Tons)
Scenario 11: Current Coastal Flooding Related Flood Risk with Green Infrastructure (10 Year)	1,213	51	32	1,296
Scenario 15: Current Coastal Flooding Related Flood Risk without Green Infrastructure (10 Year)	3,191	125	80	3,396
Scenario 12: Current Coastal Flooding Related Flood Risk with Green Infrastructure (25 Year)	3,191	125	80	3,396
Scenario 16: Current Coastal Flooding Related Flood Risk without Green Infrastructure (25 Year)	3,191	125	80	3,396
Scenario 13: Current Coastal Flooding Related Flood Risk with Green Infrastructure (50 Year)	10,975	1,869	1,196	14,040
Scenario 17: Current Coastal Flooding Related Flood Risk without Green Infrastructure (50 Year)	10,975	1,869	1,196	14,040
Scenario 14: Current Coastal Flooding Related Flood Risk with	16,741	5,080	3,357	25,178

Scenario	Finishes (Tons)	Structures (Tons)	Foundations (Tons)	Total (Tons)
Green Infrastructure (100 Year)				
Scenario 18: Current Coastal Flooding Related Flood Risk without Green Infrastructure (100 Year)	16,741	5,080	3,357	25,178

Table 13: Potential Building Related Debris Resulting from Present Day Coastal Flooding

Table 14 describes potential impacts to essential facilities based on current coastal flood related damages for each of the modeled scenarios.

	Number of Facilities Slightly Damaged (1 – 10%)	Number of Facilities Moderately Damaged (11 – 30%)	Number of Facilities Severely Damaged or greater (>30%)
Scenario 11: Current Coastal Flood Risk with Green Infrastructure (Category 1 Hurricane)			
Fire	0	0	0
Police	0	0	0
Care	0	0	0
Emergency Operation Centers	0	0	0
Schools	11	0	0
Scenario 15: Current Coastal Flood Risk without Green Infrastructure (Category 1 Hurricane)			
Fire	0	0	0
Police	0	0	0
Care	0	0	0
Emergency Operation Centers	0	0	0
Schools	12	0	0
Scenario 12: Current Coastal Flood Risk with Green Infrastructure (Category 2 Hurricane)			
Fire	0	0	0
Police	0	0	0
Care	0	0	0
Emergency Operation Centers	0	0	0
Schools	12	0	0
Scenario 16: Current Coastal Flood Risk without Green Infrastructure (Category 2 Hurricane)			
Fire	0	0	0
Police	0	0	0
Care	0	0	0
Emergency Operation Centers	0	0	0
Schools	12	0	0
Scenario 13: Current Coastal Flood Risk with Green Infrastructure (Category 3 Hurricane)			
Fire	1	0	0
Police	0	0	0
Care	0	0	0
Emergency Operation Centers	0	0	0

	Number of Facilities Slightly Damaged (1 – 10%)	Number of Facilities Moderately Damaged (11 – 30%)	Number of Facilities Severely Damaged or greater (>30%)
Schools	10	3	0
Scenario 17: Current Coastal Flood Risk without Green Infrastructure (Category 3 Hurricane)			
Fire	1	0	0
Police	0	0	0
Care	0	0	0
Emergency Operation Centers	0	0	0
Schools	10	3	0
Scenario 14: Current Coastal Flood Risk with Green Infrastructure (Category 4 Hurricane)			
Fire	1	0	0
Police	0	0	0
Care	0	0	0
Emergency Operation Centers	0	0	0
Schools	2	11	0
Scenario 18: Current Coastal Flood Risk without Green Infrastructure (Category 4 Hurricane)			
Fire	1	0	0
Police	0	0	0
Care	0	0	0
Emergency Operation Centers	0	0	0
Schools	2	11	0

Table 14: Potential Essential Facilities Impacted Based on Current Condition Coastal Scenarios

5.2 Present Day Coastal Wind Scenarios

Table 15 provides a summary of the expected damages from present day coastal wind only risk. This table reports expected coastal wind only building, content and inventory losses for each of the modeled scenarios. The number of buildings damaged column reflects the total of all buildings that have experienced any amount of damage from minor to total destruction.

Scenario	Number of Buildings Damaged	Building Loss	Content Loss	Inventory Loss
Scenario 19: Category 1 Hurricane without Mitigation	1,192	$16,346,092	$3,879,001	$9,074
Scenario 23: Category 1 Hurricane with Mitigation	1,185	$16,160,740	$37,777,809	$9,056
Scenario 20: Category 2 Hurricane without Mitigation	2,830	$118,153,089	$46,358,839	$134,753
Scenario 24: Category 2 Hurricane with Mitigation	2,819	$115,686,862	$44,820,964	$134,608
Scenario 21: Category 3 Hurricane without Mitigation	3,336	$341,721,502	$151,567,734	$458,014
Scenario 25: Category 3 Hurricane with Mitigation	3,333	$335,931,551	$147,502,225	$457,296
Scenario 22: Category 4 Hurricane without Mitigation	3,384	$560,149,242	$272,632,579	$991,398

Scenario	Number of Buildings Damaged	Building Loss	Content Loss	Inventory Loss
Scenario 26: Category 4 Hurricane with Mitigation	3,384	$555,555,485	$268,686,963	$990,208

Table 15: Present Day Coastal Wind Estimated Building Damages

Table 16 provides an estimate of building and tree related debris based on coastal wind related damages for each of the modeled scenarios.

Scenario	Brick, Wood and Other (Tons)	Reinforced Concrete Steel (Tons)	Tree Debris Eligible for Removal with Public Funds (Tons)	Other Tree Debris (Tons)
Scenario 19: Category 1 Hurricane without Mitigation	2,658	3	1,693	1,187
Scenario 23: Category 1 Hurricane with Mitigation	2,630	3	1,693	1,187
Scenario 20: Category 2 Hurricane without Mitigation	16,956	242	3,720	2,631
Scenario 24: Category 2 Hurricane with Mitigation	16,593	230	3,720	2,631
Scenario 21: Category 3 Hurricane without Mitigation	50,498	1,127	5,550	3,980
Scenario 25: Category 3 Hurricane with Mitigation	49,535	1,091	5,550	3,980
Scenario 22: Category 4 Hurricane without Mitigation	91,901	2,872	7,139	5,186
Scenario 26: Category 4 Hurricane with Mitigation	91,021	2,827	7,139	5,186

Table 16: Present Day Coastal Wind Estimated Building and Tree Debris Impacts

Table 17 describes potential impacts to essential facilities based on current coastal wind related damages for each of the modeled scenarios.

	Probability of Least Moderate Damage >50%	Probability of Least Substantial Damage >50%	Number of Facilities with Expected Loss of Use <1 day
Scenario 19: Category 1 Hurricane without Mitigation			
Fire	0	0	1
Police	0	0	1
Care	0	0	0

	Probability of Least Moderate Damage >50%	Probability of Least Substantial Damage >50%	Number of Facilities with Expected Loss of Use <1 day
Emergency Operation Centers	0	0	0
Schools	0	0	0
Scenario 23: Category 1 Hurricane with Mitigation			
Fire	0	0	1
Police	0	0	1
Care	0	0	0
Emergency Operation Centers	0	0	0
Schools	0	0	0
Scenario 20: Category 2 Hurricane without Mitigation			
Fire	0	0	1
Police	1	0	0
Care	0	0	0
Emergency Operation Centers	0	0	0
Schools	13	0	0
Scenario 24: Category 2 Hurricane with Mitigation			
Fire	0	0	1
Police	1	0	0
Care	0	0	0
Emergency Operation Centers	0	0	0
Schools	13	0	0
Scenario 21: Category 3 Hurricane without Mitigation			
Fire	1	0	1
Police	1	0	0
Care	0	0	0
Emergency Operation Centers	0	0	0
Schools	13	0	0
Scenario 25: Category 3 Hurricane with Mitigation			
Fire	1	0	1
Police	1	0	0
Care	0	0	0
Emergency Operation Centers	0	0	0
Schools	13	0	0
Scenario 22: Category 4 Hurricane without Mitigation			
Fire	1	0	1
Police	1	0	0
Care	0	0	0
Emergency Operation Centers	0	0	0
Schools	13	0	0
Scenario 26: Category 4 Hurricane with Mitigation			
Fire	1	0	0
Police	1	0	0
Care	0	0	0

	Probability of Least Moderate Damage >50%	Probability of Least Substantial Damage >50%	Number of Facilities with Expected Loss of Use <1 day
Emergency Operation Centers	0	0	0
Schools	13	13	0

Table 17: Present Day Coastal Wind Estimated Essential Facility Damage

5.3 Future Condition Flood Scenarios

5.3.1 Future Condition Riverine Flood Risk with and without Green Infrastructure and Future Building Stock

Table 18 reports on estimates of damage to buildings, contents and inventory resulting from predicted future condition riverine flood risk both with and without green infrastructure and a future predicted building stock.

Occupancy Classification	Total Buildings Damaged	Building Loss	Content Loss	Inventory Loss
Scenario 27: Future condition riverine flood risk without green infrastructure (10 year, 25th percentile) with "business as usual" projection of impervious surface area				
Residential	359	$13,076,963	$7,588,361	No Damages
Commercial	27	$1,059,690	$3,535,068	$162,281
Industrial	1	$4,108	$16,303	$3,510
Agricultural	No Damages	No Damages	No Damages	No Damages
Religious	1	$132,655	$729,788	No Damages
Government	No Damages	No Damages	No Damages	No Damages
Education	No Damages	No Damages	No Damages	No Damages
Total	**388**	**$14,273,416**	**$11,869,520**	**$165,791**
Scenario 42: Future condition riverine flood risk with green infrastructure (10 year, 25th percentile) reduction of impervious surface area				
Residential	314	$10,930,426	$6,345,173	No Damages
Commercial	26	$1,045,207	$3,448,331	$161,854
Industrial	1	$4,108	$16,303	$3,510
Agricultural	No Damages	No Damages	No Damages	No Damages
Religious	1	$128,275	$668,711	No Damages
Government	No Damages	No Damages	No Damages	No Damages
Education	No Damages	No Damages	No Damages	No Damages
Total	**342**	**$12,108,016**	**$10,478,519**	**$165,365**
Scenario 28: Future condition riverine flood risk without green infrastructure (10 year, 50th percentile) with "business as usual" projection of impervious surface area				
Residential	457	$17,608,046	$10,272,635	No Damages
Commercial	34	$1,631,549	$5,483,203	$175,818
Industrial	1	$4,108	$16,303	$3,510
Agricultural	No Damages	No Damages	No Damages	No Damages
Religious	1	$136,856	$813,797	No Damages
Government	No Damages	No Damages	No Damages	No Damages
Education	No Damages	No Damages	No Damages	No Damages

Occupancy Classification	Total Buildings Damaged	Building Loss	Content Loss	Inventory Loss
Total	**493**	**$19,380,559**	**$16,585,939**	**$179,328**
Scenario 43: Future condition riverine flood risk with green infrastructure (10 year, 50th percentile) reduction of impervious surface area				
Residential	372	$13,550,352	$7,868,850	No Damages
Commercial	27	$1,065,831	$3,575,113	$162,565
Industrial	1	$4,108	$16,303	$3,510
Agricultural	No Damages	No Damages	No Damages	No Damages
Religious	1	$133,608	$748,834	No Damages
Government	No Damages	No Damages	No Damages	No Damages
Education	No Damages	No Damages	No Damages	No Damages
Total	**401**	**$14,753,898**	**$12,209,101**	**$166,076**
Scenario 29: Future condition riverine flood risk without green infrastructure (10 year, 75th percentile) with "business as usual" projection of impervious surface area				
Residential	570	$21,746,048	$12,652,263	No Damages
Commercial	35	$1,800,518	$6,192,310	$181,826
Industrial	1	$4,119	$16,664	$3,600
Agricultural	No Damages	No Damages	No Damages	No Damages
Religious	5	$364,363	$2,257,480	No Damages
Government	No Damages	No Damages	No Damages	No Damages
Education	No Damages	No Damages	No Damages	No Damages
Total	**611**	**$23,915,049**	**$21,118,717**	**$185,425**
Scenario 44: Future condition riverine flood risk with green infrastructure (10 year, 75th percentile) reduction of impervious surface area				
Residential	493	$18,570,561	$10,808,574	No Damages
Commercial	32	$1,559,185	$5,249,613	$172,494
Industrial	1	$4,108	$16,303	$3,510
Agricultural	No Damages	No Damages	No Damages	No Damages
Religious	1	$138,465	$845,973	No Damages
Government	No Damages	No Damages	No Damages	No Damages
Education	No Damages	No Damages	No Damages	No Damages
Total	**527**	**$20,272,318**	**$16,920,463**	**$176,004**
Scenario 30: Future condition riverine flood risk without green infrastructure (25 year, 25th percentile) with "business as usual" projection of impervious surface area				
Residential	433	$16,074,226	$9,324,017	No Damages
Commercial	30	$1,266,475	$4,346,104	$182,850
Industrial	1	$4,332	$18,806	$4,079
Agricultural	No Damages	No Damages	No Damages	No Damages
Religious	1	$133,003	$736,742	No Damages
Government	No Damages	No Damages	No Damages	No Damages
Education	No Damages	No Damages	No Damages	No Damages
Total	**465**	**$17,478,037**	**$14,425,670**	**$186,929**
Scenario 45: Future condition riverine flood risk with green infrastructure (25 year, 25th percentile) reduction of impervious surface area				
Residential	372	$13,579,903	$7,872,284	No Damages
Commercial	27	$1,046,501	$3,465,155	$161,854
Industrial	1	$4,108	$16,303	$3,510
Agricultural	No Damages	No Damages	No Damages	No Damages
Religious	1	$130,638	$689,449	No Damages
Government	No Damages	No Damages	No Damages	No Damages

Occupancy Classification	Total Buildings Damaged	Building Loss	Content Loss	Inventory Loss
Education	No Damages	No Damages	No Damages	No Damages
Total	**401**	**$14,761,151**	**$12,043,192**	**$165,365**
Scenario 31: Future condition riverine flood risk without green infrastructure (25 year, 50th percentile) with "business as usual" projection of impervious surface area				
Residential	577	$22,078,240	$12,835,807	No Damages
Commercial	36	$1,915,152	$6,633,885	$198,048
Industrial	1	$4,332	$18,806	$4,079
Agricultural	No Damages	No Damages	No Damages	No Damages
Religious	5	$364,363	$2,257,480	No Damages
Government	No Damages	No Damages	No Damages	No Damages
Education	No Damages	No Damages	No Damages	No Damages
Total	**619**	**$24,362,087**	**$21,745,978**	**$202,127**
Scenario 46: Future condition riverine flood risk with green infrastructure (25 year, 50th percentile) reduction of impervious surface area				
Residential	497	$19,006,329	$11,065,354	No Damages
Commercial	34	$1,737,171	$5,922,068	$182,023
Industrial	1	$4,138	$17,262	$3,748
Agricultural	No Damages	No Damages	No Damages	No Damages
Religious	1	$138,465	$845,973	No Damages
Government	No Damages	No Damages	No Damages	No Damages
Education	No Damages	No Damages	No Damages	No Damages
Total	**533**	**$20,886,102**	**$17,850,656**	**$185,771**
Scenario 32: Future condition riverine flood risk without green infrastructure (25 year, 75th percentile) with "business as usual" projection of impervious surface area				
Residential	675	$27,171,069	$15,794,333	No Damages
Commercial	39	$2,172,642	$7,534,342	$223,539
Industrial	1	$4,378	$18,944	$4,098
Agricultural	No Damages	No Damages	No Damages	No Damages
Religious	5	$376,367	$2,322,866	No Damages
Government	No Damages	No Damages	No Damages	No Damages
Education	No Damages	No Damages	No Damages	No Damages
Total	**720**	**$29,724,455**	**$25,670,484**	**$227,637**
Scenario 47: Future condition riverine flood risk with green infrastructure (25 year, 75th percentile) reduction of impervious surface area				
Residential	544	$21,354,312	$12,412,584	No Damages
Commercial	34	$1,770,776	$6,034,644	$183,181
Industrial	1	$4,138	$17,262	$3,748
Agricultural	No Damages	No Damages	No Damages	No Damages
Religious	3	$147,067	$1,041,568	No Damages
Government	No Damages	No Damages	No Damages	No Damages
Education	No Damages	No Damages	No Damages	No Damages
Total	**582**	**$23,276,293**	**$19,506,057**	**$186,929**
Scenario 33: Future condition riverine flood risk without green infrastructure (50 year, 25th percentile) with "business as usual" projection of impervious surface area				
Residential	477	$18,594,182	$10,784,120	No Damages
Commercial	34	$1,804,661	$6,192,636	$193,273
Industrial	1	$4,332	$18,806	$4,079
Agricultural	No Damages	No Damages	No Damages	No Damages
Religious	1	$133,114	$738,965	No Damages

Occupancy Classification	Total Buildings Damaged	Building Loss	Content Loss	Inventory Loss
Government	No Damages	No Damages	No Damages	No Damages
Education	No Damages	No Damages	No Damages	No Damages
Total	**513**	**$20,536,289**	**$17,734,527**	**$197,352**
Scenario 48: Future condition riverine flood risk with green infrastructure (50 year, 25th percentile) reduction of impervious surface area				
Residential	392	$14,795,723	$8,561,891	No Damages
Commercial	27	$1,052,329	$3,481,985	$162,153
Industrial	1	$4,108	$16,303	$3,510
Agricultural	No Damages	No Damages	No Damages	No Damages
Religious	1	$130,638	$689,449	No Damages
Government	No Damages	No Damages	No Damages	No Damages
Education	No Damages	No Damages	No Damages	No Damages
Total	**421**	**$15,982,798**	**$12,749,629**	**$165,664**
Scenario 34: Future condition riverine flood risk without green infrastructure (50 year, 50th percentile) with “business as usual” projection of impervious surface area				
Residential	675	$27,217,495	$15,819,437	No Damages
Commercial	39	$2,172,642	$7,534,342	$223,539
Industrial	1	$4,378	$18,944	$4,098
Agricultural	No Damages	No Damages	No Damages	No Damages
Religious	5	$376,367	$2,322,866	No Damages
Government	No Damages	No Damages	No Damages	No Damages
Education	No Damages	No Damages	No Damages	No Damages
Total	**720**	**$29,770,881**	**$25,695,589**	**$227,637**
Scenario 49: Future condition riverine flood risk with green infrastructure (50 year, 50th percentile) reduction of impervious surface area				
Residential	545	$21,410,664	$12,443,590	No Damages
Commercial	34	$1,770,776	$6,034,644	$183,181
Industrial	1	$4,138	$17,262	$3,748
Agricultural	No Damages	No Damages	No Damages	No Damages
Religious	3	$147,067	$1,041,568	No Damages
Government	No Damages	No Damages	No Damages	No Damages
Education	No Damages	No Damages	No Damages	No Damages
Total	**583**	**$23,332,645**	**$19,537,063**	**$186,929**
Scenario 35: Future condition riverine flood risk without green infrastructure (50 year, 75th percentile) with “business as usual” projection of impervious surface area				
Residential	723	$30,334,510	$17,619,551	No Damages
Commercial	39	$2,348,026	$8,232,204	$242,269
Industrial	1	$4,758	$20,086	$4,260
Agricultural	No Damages	No Damages	No Damages	No Damages
Religious	5	$418,548	$2,552,731	No Damages
Government	No Damages	No Damages	No Damages	No Damages
Education	No Damages	No Damages	No Damages	No Damages
Total	**768**	**$33,105,842**	**$28,424,573**	**$246,530**
Scenario 50: Future condition riverine flood risk with green infrastructure (50 year, 75th percentile) reduction of impervious surface area				
Residential	611	$24,380,081	$14,130,977	No Damages
Commercial	35	$1,806,898	$6,188,440	$183,417
Industrial	1	$4,138	$17,262	$3,748
Agricultural	No Damages	No Damages	No Damages	No Damages
Religious	4	$335,130	$2,026,490	No Damages

Occupancy Classification	Total Buildings Damaged	Building Loss	Content Loss	Inventory Loss
Government	No Damages	No Damages	No Damages	No Damages
Education	No Damages	No Damages	No Damages	No Damages
Total	**651**	**$26,526,248**	**$22,363,168**	**$187,165**
Scenario 36: Future condition riverine flood risk without green infrastructure (100 year, 25th percentile) with "business as usual" projection of impervious surface area				
Residential	498	$19,865,943	$11,496,054	No Damages
Commercial	34	$1,815,088	$6,218,953	$193,517
Industrial	1	$4,332	$18,806	$4,079
Agricultural	No Damages	No Damages	No Damages	No Damages
Religious	2	$258,129	$1,443,199	No Damages
Government	No Damages	No Damages	No Damages	No Damages
Education	No Damages	No Damages	No Damages	No Damages
Total	**535**	**$21,943,492**	**$19,177,013**	**$197,596**
Scenario 51: Future condition riverine flood risk with green infrastructure (100 year, 25th percentile) reduction of impervious surface area				
Residential	421	$16,093,628	$9,305,242	No Damages
Commercial	27	$1,052,360	$3,482,400	$162,153
Industrial	1	$4,108	$16,303	$3,510
Agricultural	No Damages	No Damages	No Damages	No Damages
Religious	1	$130,670	$690,078	No Damages
Government	No Damages	No Damages	No Damages	No Damages
Education	No Damages	No Damages	No Damages	No Damages
Total	**450**	**$17,280,766**	**$13,494,023**	**$165,664**
Scenario 37: Future condition riverine flood risk without green infrastructure (100 year, 50th percentile) with "business as usual" projection of impervious surface area				
Residential	723	$30,339,402	$17,622,173	No Damages
Commercial	39	$2,349,469	$8,235,178	$242,269
Industrial	1	$4,758	$20,086	$4,260
Agricultural	No Damages	No Damages	No Damages	No Damages
Religious	5	$418,548	$2,552,731	No Damages
Government	No Damages	No Damages	No Damages	No Damages
Education	No Damages	No Damages	No Damages	No Damages
Total	**768**	**$33,112,177**	**$28,430,169**	**$246,530**
Scenario 52: Future condition riverine flood risk with green infrastructure (100 year, 50th percentile) reduction of impervious surface area				
Residential	612	$24,467,580	$14,182,624	No Damages
Commercial	35	$1,820,537	$6,229,759	$184,303
Industrial	1	$4,138	$17,262	$3,748
Agricultural	No Damages	No Damages	No Damages	No Damages
Religious	4	$335,130	$2,026,490	No Damages
Government	No Damages	No Damages	No Damages	No Damages
Education	No Damages	No Damages	No Damages	No Damages
Total	**652**	**$26,627,385**	**$22,456,135**	**$188,051**
Scenario 38: Future condition riverine flood risk without green infrastructure (100 year,75th percentile) with "business as usual" projection of impervious surface area				
Residential	807	$34,831,982	$20,177,203	No Damages
Commercial	41	$2,636,320	$9,423,875	$265,055
Industrial	1	$5,179	$21,347	$4,439
Agricultural	No Damages	No Damages	No Damages	No Damages

Occupancy Classification	**Total Buildings Damaged**	**Building Loss**	**Content Loss**	**Inventory Loss**
Religious	6	$448,219	$2,909,852	No Damages
Government	No Damages	No Damages	No Damages	No Damages
Education	No Damages	No Damages	No Damages	No Damages
Total	**855**	**$37,921,700**	**$32,532,277**	**$269,494**
Scenario 53: Future condition riverine flood risk with green infrastructure (100 year, 75th percentile) reduction of impervious surface area				
Residential	648	$26,698,910	$15,436,172	No Damages
Commercial	36	$1,857,356	$6,360,670	$185,289
Industrial	1	$4,138	$17,262	$3,748
Agricultural	No Damages	No Damages	No Damages	No Damages
Religious	4	$343,920	$2,094,157	No Damages
Government	No Damages	No Damages	No Damages	No Damages
Education	No Damages	No Damages	No Damages	No Damages
Total	**689**	**$28,904,324**	**$23,908,261**	**$189,036**
Scenario 39: Future condition riverine flood risk without green infrastructure (500 year, 25th percentile) with "business as usual" projection of impervious surface area				
Residential	568	$23,925,208	$13,806,566	No Damages
Commercial	36	$1,834,705	$6,278,524	$194,516
Industrial	1	$4,332	$18,806	$4,079
Agricultural	No Damages	No Damages	No Damages	No Damages
Religious	2	$258,129	$1,443,199	No Damages
Government	No Damages	No Damages	No Damages	No Damages
Education	No Damages	No Damages	No Damages	No Damages
Total	607	$26,022,373	$21,547,096	$198,594
Scenario 54: Future condition riverine flood risk with green infrastructure (500 year, 25th percentile) reduction of impervious surface area				
Residential	477	$19,377,907	$11,163,671	No Damages
Commercial	28	$1,244,183	$4,212,861	$180,656
Industrial	1	$4,291	$18,683	$4,061
Agricultural	No Damages	No Damages	No Damages	No Damages
Religious	1	$130,670	$690,078	No Damages
Government	No Damages	No Damages	No Damages	No Damages
Education	No Damages	No Damages	No Damages	No Damages
Total	507	$20,757,050	$16,085,293	$184,718
Scenario 40: Future condition riverine flood risk without green infrastructure (500 year, 50th percentile) with "business as usual" projection of impervious surface area				
Residential	816	$35,130,195	$20,346,026	No Damages
Commercial	41	$2,641,978	$9,439,590	$265,055
Industrial	1	$5,179	$21,347	$4,439
Agricultural	No Damages	No Damages	No Damages	No Damages
Religious	6	$448,219	$2,909,852	No Damages
Government	No Damages	No Damages	No Damages	No Damages
Education	No Damages	No Damages	No Damages	No Damages
Total	864	$38,225,571	$32,716,815	$269,494
Scenario 55: Future condition riverine flood risk with green infrastructure (500 year, 50th percentile) reduction of impervious surface area				
Residential	650	$26,866,200	$15,533,602	No Damages
Commercial	37	$1,984,000	$6,891,506	$195,876
Industrial	1	$4,291	$18,683	$4,061
Agricultural	No Damages	No Damages	No Damages	No Damages

Occupancy Classification	Total Buildings Damaged	Building Loss	Content Loss	Inventory Loss
Religious	4	$343,920	$2,094,157	No Damages
Government	No Damages	No Damages	No Damages	No Damages
Education	No Damages	No Damages	No Damages	No Damages
Total	692	$29,198,411	$24,537,948	$199,937
Scenario 41: Future condition riverine flood risk without green infrastructure (500 year,75th percentile) with "business as usual" projection of impervious surface area				
Residential	969	$46,361,376	$26,893,914	No Damages
Commercial	53	$3,435,679	$11,885,637	$321,505
Industrial	1	$5,360	$21,890	$4,516
Agricultural	No Damages	No Damages	No Damages	No Damages
Religious	6	$451,082	$2,962,421	No Damages
Government	No Damages	No Damages	No Damages	No Damages
Education	No Damages	No Damages	No Damages	No Damages
Total	1029	$50,253,497	$41,763,862	$326,020
Scenario 56: Future condition riverine flood risk with green infrastructure (500 year, 75th percentile) reduction of impervious surface area				
Residential	773	$34,295,398	$19,827,801	No Damages
Commercial	40	$2,459,619	$8,599,868	$243,636
Industrial	1	$4,732	$20,007	$4,249
Agricultural	No Damages	No Damages	No Damages	No Damages
Religious	4	$343,920	$2,094,157	No Damages
Government	No Damages	No Damages	No Damages	No Damages
Education	No Damages	No Damages	No Damages	No Damages
Total	818	$37,103,669	$30,541,832	$247,885

Table 18: Future Condition Riverine Flood Related Impacts on Building Damage with and without Green Infrastructure.

Table 19 provides a summary of the expected building debris from future condition riverine flooding for each of the modeled scenarios.

Scenario	Finishes (Tons)	Structures (Tons)	Foundations (Tons)	Total (Tons)
Scenario 27: Future condition riverine flood risk without green infrastructure (10 year, 25th percentile) with "business as usual" projection of impervious surface area	674	112	276	1,062
Scenario 42: Future condition riverine flood risk with green infrastructure (10 year, 25th percentile) reduction of impervious surface area	576	52	127	755
Scenario 28: Future condition riverine flood	882	137	339	1,358

Scenario	Finishes (Tons)	Structures (Tons)	Foundations (Tons)	Total (Tons)
risk without green infrastructure (10 year, 50th percentile) with "business as usual" projection of impervious surface area				
Scenario 43: Future condition riverine flood risk with green infrastructure (10 year, 50th percentile) reduction of impervious surface area	695	113	278	1,086
Scenario 29: Future condition riverine flood risk without green infrastructure (10 year, 75th percentile) with "business as usual" projection of impervious surface area	1,033	184	453	1,670
Scenario 44: Future condition riverine flood risk with green infrastructure (10 year, 75th percentile) reduction of impervious surface area	893	174	430	1,497
Scenario 30: Future condition riverine flood risk without green infrastructure (25 year, 25th percentile) with "business as usual" projection of impervious surface area	791	114	282	1,187
Scenario 45: Future condition riverine flood risk with green infrastructure (25 year, 25th percentile) reduction of impervious surface area	647	91	224	962
Scenario 31: Future condition riverine flood	1,050	184	453	1,687

Scenario	**Finishes (Tons)**	**Structures (Tons)**	**Foundations (Tons)**	**Total (Tons)**
risk without green infrastructure (25 year, 50th percentile) with "business as usual" projection of impervious surface area				
Scenario 46: Future condition riverine flood risk with green infrastructure (25 year, 50th percentile) reduction of impervious surface area	948	175	433	1,556
Scenario 32: Future condition riverine flood risk without green infrastructure (25 year, 75th percentile) with "business as usual" projection of impervious surface area	1,204	189	464	1,857
Scenario 47: Future condition riverine flood risk with green infrastructure (25 year, 75th percentile) reduction of impervious surface area	1,038	180	445	1,663
Scenario 33: Future condition riverine flood risk without green infrastructure (50 year, 25th percentile) with "business as usual" projection of impervious surface area	901	117	286	1,304
Scenario 48: Future condition riverine flood risk with green infrastructure (50 year, 25th percentile) reduction of impervious surface area	680	92	227	999
Scenario 34: Future condition riverine flood	1,204	189	464	1,857

Scenario	Finishes (Tons)	Structures (Tons)	Foundations (Tons)	Total (Tons)
risk without green infrastructure (50 year, 50th percentile) with "business as usual" projection of impervious surface area				
Scenario 49: Future condition riverine flood risk with green infrastructure (50 year, 50th percentile) reduction of impervious surface area	1,039	180	445	1,664
Scenario 35: Future condition riverine flood risk without green infrastructure (50 year, 75th percentile) with "business as usual" projection of impervious surface area	1,331	213	520	2,064
Scenario 50: Future condition riverine flood risk with green infrastructure (50 year, 75th percentile) reduction of impervious surface area	1,115	184	453	1,752
Scenario 36: Future condition riverine flood risk without green infrastructure (100 year, 25th percentile) with "business as usual" projection of impervious surface area	929	118	290	1,337
Scenario 51: Future condition riverine flood risk with green infrastructure (100 year, 25th percentile) reduction of impervious surface area	710	94	231	1,035
Scenario 37: Future condition riverine flood	1,332	213	520	2,065

Scenario	Finishes (Tons)	Structures (Tons)	Foundations (Tons)	Total (Tons)
risk without green infrastructure (100 year, 50th percentile) with "business as usual" projection of impervious surface area				
Scenario 52: Future condition riverine flood risk with green infrastructure (100 year, 50th percentile) reduction of impervious surface area	1,115	184	453	1,752
Scenario 38: Future condition riverine flood risk without green infrastructure (100 year,75th percentile) with "business as usual" projection of impervious surface area	1,482	219	533	2,234
Scenario 53: Future condition riverine flood risk with green infrastructure (100 year, 75th percentile) reduction of impervious surface area	1,147	186	458	1,791
Scenario 39: Future condition riverine flood risk without green infrastructure (500 year, 25th percentile) with "business as usual" projection of impervious surface area	1,003	122	298	1,423
Scenario 54: Future condition riverine flood risk with green infrastructure (500 year, 25th percentile) reduction of impervious surface area	814	98	239	1,151
Scenario 40: Future condition riverine flood	1,492	219	534	2,245

Scenario	Finishes (Tons)	Structures (Tons)	Foundations (Tons)	Total (Tons)
risk without green infrastructure (500 year, 50th percentile) with "business as usual" projection of impervious surface area				
Scenario 55: Future condition riverine flood risk with green infrastructure (500 year, 50th percentile) reduction of impervious surface area	1,167	188	460	1,815
Scenario 41: Future condition riverine flood risk without green infrastructure (500 year,75th percentile) with "business as usual" projection of impervious surface area	1,710	235	564	2,509
Scenario 56: Future condition riverine flood risk with green infrastructure (500 year, 75th percentile) reduction of impervious surface area	1,357	195	475	2,027

Table 19: Future Condition Riverine Flood Related Impacts on Building Debris with and without Green Infrastructure.

Table 20 provides a summary of the expected essential facility damage from future condition riverine flooding for each of the modeled scenarios.

	Number of Facilities at least Moderately Damaged	Number of Facilities at Least Substantially Damaged	Number of Facilities with Expected Loss of Use <1 day
Scenario 27: Future condition riverine flood risk without green infrastructure (10 year, 25th percentile) with "business as usual" projection of impervious surface area			
Fire	0	0	0
Police	0	0	0
Care	0	0	0
Emergency Operation Centers	0	0	0
Schools	0	0	0
Scenario 42: Future condition riverine flood risk with green infrastructure (10 year, 25th percentile) reduction of impervious surface area			
Fire	0	0	0

	Number of Facilities at least Moderately Damaged	**Number of Facilities at Least Substantially Damaged**	**Number of Facilities with Expected Loss of Use <1 day**
Police	0	0	0
Care	0	0	0
Emergency Operation Centers	0	0	0
Schools	0	0	0
Scenario 28: Future condition riverine flood risk without green infrastructure (10 year, 50th percentile) with "business as usual" projection of impervious surface area			
Fire	0	0	0
Police	0	0	0
Care	0	0	0
Emergency Operation Centers	0	0	0
Schools	0	0	0
Scenario 43: Future condition riverine flood risk with green infrastructure (10 year, 50th percentile) reduction of impervious surface area			
Fire	0	0	0
Police	0	0	0
Care	0	0	0
Emergency Operation Centers	0	0	0
Schools	0	0	0
Scenario 29: Future condition riverine flood risk without green infrastructure (10 year, 75th percentile) with "business as usual" projection of impervious surface area			
Fire	0	0	0
Police	0	0	0
Care	0	0	0
Emergency Operation Centers	0	0	0
Schools	0	0	0
Scenario 44: Future condition riverine flood risk with green infrastructure (10 year, 75th percentile) reduction of impervious surface area			
Fire	0	0	0
Police	0	0	0
Care	0	0	0
Emergency Operation Centers	0	0	0
Schools	0	0	0
Scenario 30: Future condition riverine flood risk without green infrastructure (25 year, 25th percentile) with "business as usual" projection of impervious surface area			
Fire	0	0	0
Police	0	0	0
Care	0	0	0
Emergency Operation Centers	0	0	0
Schools	0	0	0
Scenario 45: Future condition riverine flood risk with green infrastructure (25 year, 25th percentile) reduction of impervious surface area			
Fire	0	0	0
Police	0	0	0

	Number of Facilities at least Moderately Damaged	**Number of Facilities at Least Substantially Damaged**	**Number of Facilities with Expected Loss of Use <1 day**
Care	0	0	0
Emergency Operation Centers	0	0	0
Schools	0	0	0
Scenario 31: Future condition riverine flood risk without green infrastructure (25 year, 50th percentile) with "business as usual" projection of impervious surface area			
Fire	0	0	0
Police	0	0	0
Care	0	0	0
Emergency Operation Centers	0	0	0
Schools	0	0	0
Scenario 46: Future condition riverine flood risk with green infrastructure (25 year, 50th percentile) reduction of impervious surface area			
Fire	0	0	0
Police	0	0	0
Care	0	0	0
Emergency Operation Centers	0	0	0
Schools	0	0	0
Scenario 32: Future condition riverine flood risk without green infrastructure (25 year, 75th percentile) with "business as usual" projection of impervious surface area			
Fire	0	0	0
Police	0	0	0
Care	0	0	0
Emergency Operation Centers	0	0	0
Schools	0	0	0
Scenario 47: Future condition riverine flood risk with green infrastructure (25 year, 75th percentile) reduction of impervious surface area			
Fire	0	0	0
Police	0	0	0
Care	0	0	0
Emergency Operation Centers	0	0	0
Schools	0	0	0
Scenario 33: Future condition riverine flood risk without green infrastructure (50 year, 25th percentile) with "business as usual" projection of impervious surface area			
Fire	0	0	0
Police	0	0	0
Care	0	0	0
Emergency Operation Centers	0	0	0
Schools	0	0	0
Scenario 48: Future condition riverine flood risk with green infrastructure (50 year, 25th percentile) reduction of impervious surface area			
Fire	0	0	0
Police	0	0	0
Care	0	0	0

	Number of Facilities at least Moderately Damaged	Number of Facilities at Least Substantially Damaged	Number of Facilities with Expected Loss of Use <1 day
Emergency Operation Centers	0	0	0
Schools	0	0	0
Scenario 34: Future condition riverine flood risk without green infrastructure (50 year, 50th percentile) with "business as usual" projection of impervious surface area			
Fire	0	0	0
Police	0	0	0
Care	0	0	0
Emergency Operation Centers	0	0	0
Schools	0	0	0
Scenario 49: Future condition riverine flood risk with green infrastructure (50 year, 50th percentile) reduction of impervious surface area			
Fire	0	0	0
Police	0	0	0
Care	0	0	0
Emergency Operation Centers	0	0	0
Schools	0	0	0
Scenario 35: Future condition riverine flood risk without green infrastructure (50 year, 75th percentile) with "business as usual" projection of impervious surface area			
Fire	0	0	0
Police	0	0	0
Care	0	0	0
Emergency Operation Centers	0	0	0
Schools	0	0	0
Scenario 50: Future condition riverine flood risk with green infrastructure (50 year, 75th percentile) reduction of impervious surface area			
Fire	0	0	0
Police	0	0	0
Care	0	0	0
Emergency Operation Centers	0	0	0
Schools	0	0	0
Scenario 36: Future condition riverine flood risk without green infrastructure (100 year, 25th percentile) with "business as usual" projection of impervious surface area			
Fire	0	0	0
Police	0	0	0
Care	0	0	0
Emergency Operation Centers	0	0	0
Schools	0	0	0
Scenario 51: Future condition riverine flood risk with green infrastructure (100 year, 25th percentile) reduction of impervious surface area			
Fire	0	0	0
Police	0	0	0
Care	0	0	0

	Number of Facilities at least Moderately Damaged	Number of Facilities at Least Substantially Damaged	Number of Facilities with Expected Loss of Use <1 day
Emergency Operation Centers	0	0	0
Schools	0	0	0
Scenario 37: Future condition riverine flood risk without green infrastructure (100 year, 50th percentile) with “business as usual” projection of impervious surface area			
Fire	0	0	0
Police	0	0	0
Care	0	0	0
Emergency Operation Centers	0	0	0
Schools	0	0	0
Scenario 52: Future condition riverine flood risk with green infrastructure (100 year, 50th percentile) reduction of impervious surface area			
Fire	0	0	0
Police	0	0	0
Care	0	0	0
Emergency Operation Centers	0	0	0
Schools	0	0	0
Scenario 38: Future condition riverine flood risk without green infrastructure (100 year,75th percentile) with “business as usual” projection of impervious surface area			
Fire	0	0	0
Police	0	0	0
Care	0	0	0
Emergency Operation Centers	0	0	0
Schools	0	0	0
Scenario 53: Future condition riverine flood risk with green infrastructure (100 year, 75th percentile) reduction of impervious surface area			
Fire	0	0	0
Police	0	0	0
Care	0	0	0
Emergency Operation Centers	0	0	0
Schools	0	0	0
Scenario 39: Future condition riverine flood risk without green infrastructure (500 year, 25th percentile) with “business as usual” projection of impervious surface area			
Fire	0	0	0
Police	0	0	0
Care	0	0	0
Emergency Operation Centers	0	0	0
Schools	0	0	0
Scenario 54: Future condition riverine flood risk with green infrastructure (500 year, 25th percentile) reduction of impervious surface area			
Fire	0	0	0
Police	0	0	0
Care	0	0	0

	Number of Facilities at least Moderately Damaged	Number of Facilities at Least Substantially Damaged	Number of Facilities with Expected Loss of Use <1 day
Emergency Operation Centers	0	0	0
Schools	0	0	0
Scenario 40: Future condition riverine flood risk without green infrastructure (500 year, 50th percentile) with "business as usual" projection of impervious surface area			
Fire	0	0	0
Police	0	0	0
Care	0	0	0
Emergency Operation Centers	0	0	0
Schools	0	0	0
Scenario 55: Future condition riverine flood risk with green infrastructure (500 year, 50th percentile) reduction of impervious surface area			
Fire	0	0	0
Police	0	0	0
Care	0	0	0
Emergency Operation Centers	0	0	0
Schools	0	0	0
Scenario 41: Future condition riverine flood risk without green infrastructure (500 year, 75th percentile) with "business as usual" projection of impervious surface area			
Fire	0	0	0
Police	0	0	0
Care	0	0	0
Emergency Operation Centers	0	0	0
Schools	0	0	0
Scenario 56: Future condition riverine flood risk with green infrastructure (500 year, 75th percentile) reduction of impervious surface area			
Fire	0	0	0
Police	0	0	0
Care	0	0	0
Emergency Operation Centers	0	0	0
Schools	0	0	0

Table 20: Potential Essential Facilities Impacted Based on Future Condition Riverine Flood Scenarios

5.3.2 Future Condition Riverine Flood Risk with and without Green Infrastructure and Current Buildings

Table 21 reports on estimates of damage to buildings, contents and inventory resulting from predicted future condition riverine flood risk both with and without green infrastructure and 2018 building stock.

Occupancy Classification	Total Buildings Damaged	Building Loss	Content Loss	Inventory Loss
Scenario57: Future condition riverine flood risk without green infrastructure (10 year, 25th percentile) with "business as usual" projection of impervious surface area				
Residential	238	$6,741,295	$4,015,742	No Damages
Commercial	28	$1,141,231	$3,824,420	$162,281

Occupancy Classification	Total Buildings Damaged	Building Loss	Content Loss	Inventory Loss
Industrial	1	$4,108	$16,303	$3,510
Agricultural	No Damages	No Damages	No Damages	No Damages
Religious	1	$132,655	$729,788	No Damages
Government	No Damages	No Damages	No Damages	No Damages
Education	No Damages	No Damages	No Damages	No Damages
Total	**268**	**$8,019,289**	**$8,586,254**	**$165,791**
Scenario 72: Future condition riverine flood risk with green infrastructure (10 year, 25th percentile) reduction of impervious surface area				
Residential	200	$5,294,283	$3,157,840	No Damages
Commercial	27	$1,126,748	$3,737,684	$161,854
Industrial	1	$4,108	$16,303	$3,510
Agricultural	No Damages	No Damages	No Damages	No Damages
Religious	1	$128,275	$668,711	No Damages
Government	No Damages	No Damages	No Damages	No Damages
Education	No Damages	No Damages	No Damages	No Damages
Total	**229**	**$6,553,415**	**$7,580,538**	**$165,364**
Scenario 58: Future condition riverine flood risk without green infrastructure (10 year, 50th percentile) with "business as usual" projection of impervious surface area				
Residential	301	$9,826,363	$5,872,664	No Damages
Commercial	35	$1,713,090	$5,772,555	$175,818
Industrial	1	$4,108	$16,303	$3,510
Agricultural	No Damages	No Damages	No Damages	No Damages
Religious	1	$136,856	$813,797	No Damages
Government	No Damages	No Damages	No Damages	No Damages
Education	No Damages	No Damages	No Damages	No Damages
Total	**338**	**$11,680,416**	**$12,475,320**	**$179,328**
Scenario 73: Future condition riverine flood risk with green infrastructure (10 year, 50th percentile) reduction of impervious surface area				
Residential	244	$7,020,152	$4,184,742	No Damages
Commercial	28	$1,147,372	$3,864,465	$162,565
Industrial	1	$4,108	$16,303	$3,510
Agricultural	No Damages	No Damages	No Damages	No Damages
Religious	1	$133,608	$748,834	No Damages
Government	No Damages	No Damages	No Damages	No Damages
Education	No Damages	No Damages	No Damages	No Damages
Total	**274**	**$8,305,240**	**$8,814,345**	**$166,076**
Scenario 59: Future condition riverine flood risk without green infrastructure (10 year, 75th percentile) with "business as usual" projection of impervious surface area				
Residential	397	$12,727,627	$7,569,259	No Damages
Commercial	36	$1,908,057	$6,605,539	$181,826
Industrial	1	$4,119	$16,664	$3,600
Agricultural	No Damages	No Damages	No Damages	No Damages
Religious	5	$364,363	$2,257,480	No Damages
Government	No Damages	No Damages	No Damages	No Damages
Education	No Damages	No Damages	No Damages	No Damages
Total	**439**	**$15,004,167**	**$16,448,942**	**$185,425**
Scenario 74: Future condition riverine flood risk with green infrastructure (10 year, 75th percentile) reduction of impervious surface area				
Residential	334	$10,630,589	$6,324,926	No Damages
Commercial	33	$1,647,330	$5,569,782	$172,494

Occupancy Classification	Total Buildings Damaged	Building Loss	Content Loss	Inventory Loss
Industrial	1	$4,108	$16,303	$3,510
Agricultural	No Damages	No Damages	No Damages	No Damages
Religious	1	$138,465	$845,973	No Damages
Government	No Damages	No Damages	No Damages	No Damages
Education	No Damages	No Damages	No Damages	No Damages
Total	**369**	**$12,420,492**	**$12,756,984**	**$176,004**

Scenario 60: Future condition riverine flood risk without green infrastructure (25 year, 25th percentile) with "business as usual" projection of impervious surface area				
Residential	284	$8,433,546	$5,027,278	No Damages
Commercial	31	$1,348,017	$4,635,456	$182,850
Industrial	1	$4,332	$18,806	$4,079
Agricultural	No Damages	No Damages	No Damages	No Damages
Religious	1	$133,003	$736,742	No Damages
Government	No Damages	No Damages	No Damages	No Damages
Education	No Damages	No Damages	No Damages	No Damages
Total	**317**	**$9,918,897**	**$10,418,283**	**$186,929**
Scenario 75: Future condition riverine flood risk with green infrastructure (25 year, 25th percentile) reduction of impervious surface area				
Residential	236	$6,803,369	$4,039,231	No Damages
Commercial	28	$1,128,042	$3,754,508	$161,854
Industrial	1	$4,108	$16,303	$3,510
Agricultural	No Damages	No Damages	No Damages	No Damages
Religious	1	$130,638	$689,449	No Damages
Government	No Damages	No Damages	No Damages	No Damages
Education	No Damages	No Damages	No Damages	No Damages
Total	**266**	**$8,066,157**	**$8,499,491**	**$165,365**
Scenario 61: Future condition riverine flood risk without green infrastructure (25 year, 50th percentile) with "business as usual" projection of impervious surface area				
Residential	403	$12,933,181	$7,692,423	No Damages
Commercial	37	$2,022,691	$7,047,114	$198,048
Industrial	1	$4,332	$18,806	$4,079
Agricultural	No Damages	No Damages	No Damages	No Damages
Religious	5	$364,363	$2,257,480	No Damages
Government	No Damages	No Damages	No Damages	No Damages
Education	No Damages	No Damages	No Damages	No Damages
Total	**446**	**$15,324,567**	**$17,015,823**	**$202,127**
Scenario 76: Future condition riverine flood risk with green infrastructure (25 year, 50th percentile) reduction of impervious surface area				
Residential	336	$10,938,229	$6,508,951	No Damages
Commercial	35	$1,825,316	$6,242,237	$182,023
Industrial	1	$4,138	$17,262	$3,748
Agricultural	No Damages	No Damages	No Damages	No Damages
Religious	1	$138,465	$845,973	No Damages
Government	No Damages	No Damages	No Damages	No Damages
Education	No Damages	No Damages	No Damages	No Damages
Total	**373**	**$12,906,148**	**$13,614,423**	**$185,771**
Scenario 62: Future condition riverine flood risk without green infrastructure (25 year, 75th percentile) with "business as usual" projection of impervious surface area				
Residential	473	$16,111,146	$9,582,096	No Damages
Commercial	40	$2,280,593	$7,961,792	$223,539
Industrial	1	$4,378	$18,943	$4,098
Agricultural	No Damages	No Damages	No Damages	No Damages
Religious	5	$376,367	$2,322,866	No Damages
Government	No Damages	No Damages	No Damages	No Damages
Education	No Damages	No Damages	No Damages	No Damages
Total	**519**	**$18,772,483**	**$19,885,697**	**$227,637**

Scenario 77: Future condition riverine flood risk with green infrastructure (25 year, 75th percentile) reduction of impervious surface area				
Residential	369	$12,253,629	$7,282,905	No Damages
Commercial	35	$1,864,180	$6,379,353	$183,181
Industrial	1	$4,138	$17,262	$3,748
Agricultural	No Damages	No Damages	No Damages	No Damages
Religious	3	$147,067	$1,041,568	No Damages
Government	No Damages	No Damages	No Damages	No Damages
Education	No Damages	No Damages	No Damages	No Damages
Total	**408**	**$14,269,013**	**$14,721,087**	**$186,929**
Scenario 63: Future condition riverine flood risk without green infrastructure (50 year, 25th percentile) with "business as usual" projection of impervious surface area				
Residential	312	$10,074,305	$5,993,254	No Damages
Commercial	35	$1,886,202	$6,481,988	$193,273
Industrial	1	$4,332	$18,806	$4,079
Agricultural	No Damages	No Damages	No Damages	No Damages
Religious	1	$133,114	$738,965	No Damages
Government	No Damages	No Damages	No Damages	No Damages
Education	No Damages	No Damages	No Damages	No Damages
Total	**349**	**$12,097,953**	**$13,233,014**	**$197,352**
Scenario 78: Future condition riverine flood risk with green infrastructure (50 year, 25th percentile) reduction of impervious surface area				
Residential	247	$7,418,658	$4,392,489	No Damages
Commercial	28	$1,133,870	$3,771,338	$162,153
Industrial	1	$4,108	$16,303	$3,510
Agricultural	No Damages	No Damages	No Damages	No Damages
Religious	1	$130,638	$689,449	No Damages
Government	No Damages	No Damages	No Damages	No Damages
Education	No Damages	No Damages	No Damages	No Damages
Total	**277**	**$8,687,274**	**$8,869,580**	**$165,664**
Scenario 64: Future condition riverine flood risk without green infrastructure (50 year, 50th percentile) with "business as usual" projection of impervious surface area				
Residential	473	$16,154,263	$9,605,219	No Damages
Commercial	40	$2,280,593	$7,961,792	$223,539
Industrial	1	$4,378	$18,944	$4,098
Agricultural	No Damages	No Damages	No Damages	No Damages
Religious	5	$376,367	$2,322,866	No Damages
Government	No Damages	No Damages	No Damages	No Damages
Education	No Damages	No Damages	No Damages	No Damages
Total	**519**	**$18,815,601**	**$19,908,821**	**$227,637**
Scenario 79: Future condition riverine flood risk with green infrastructure (50 year, 50th percentile) reduction of impervious surface area				
Residential	370	$12,276,277	$7,295,197	No Damages
Commercial	35	$1,864,180	$6,379,353	$183,181
Industrial	1	$4,138	$17,262	$3,748
Agricultural	No Damages	No Damages	No Damages	No Damages
Religious	3	$147,067	$1,041,568	No Damages
Government	No Damages	No Damages	No Damages	No Damages
Education	No Damages	No Damages	No Damages	No Damages
Total	**409**	**$14,291,661**	**$14,733,379**	**$186,929**

Scenario 65: Future condition riverine flood risk without green infrastructure (50 year, 75th percentile) with “business as usual” projection of impervious surface area				
Residential	505	$17,827,907	$10,607,032	No Damages
Commercial	40	$2,456,403	$8,674,341	$242,269
Industrial	1	$4,758	$20,086	$4,260
Agricultural	No Damages	No Damages	No Damages	No Damages
Religious	5	$418,548	$2,552,731	No Damages
Government	No Damages	No Damages	No Damages	No Damages
Education	No Damages	No Damages	No Damages	No Damages
Total	**551**	**$20,707,617**	**$21,854,190**	**$246,530**
Scenario 80: Future condition riverine flood risk with green infrastructure (50 year, 75th percentile) reduction of impervious surface area				
Residential	422	$14,094,258	$8,348,548	No Damages
Commercial	36	$1,900,302	$6,533,149	$183,417
Industrial	1	$4,138	$17,262	$3,748
Agricultural	No Damages	No Damages	No Damages	No Damages
Religious	4	$335,130	$2,026,490	No Damages
Government	No Damages	No Damages	No Damages	No Damages
Education	No Damages	No Damages	No Damages	No Damages
Total	**463**	**$16,333,828**	**$16,925,448**	**$187,165**
Scenario 66: Future condition riverine flood risk without green infrastructure (100 year, 25th percentile) with “business as usual” projection of impervious surface area				
Residential	328	$10,811,734	$6,411,014	No Damages
Commercial	35	$1,896,629	$6,508,306	$193,517
Industrial	1	$4,332	$18,806	$4,079
Agricultural	No Damages	No Damages	No Damages	No Damages
Religious	2	$258,129	$1,443,200	No Damages
Government	No Damages	No Damages	No Damages	No Damages
Education	No Damages	No Damages	No Damages	No Damages
Total	**366**	**$12,970,824**	**$14,381,325**	**$197,596**
Scenario 81: Future condition riverine flood risk with green infrastructure (100 year, 25th percentile) reduction of impervious surface area				
Residential	266	$8,125,078	$4,803,148	No Damages
Commercial	28	$1,133,902	$3,771,752	$162,153
Industrial	1	$4,108	$16,303	$3,510
Agricultural	No Damages	No Damages	No Damages	No Damages
Religious	1	$130,670	$690,078	No Damages
Government	No Damages	No Damages	No Damages	No Damages
Education	No Damages	No Damages	No Damages	No Damages
Total	**296**	**$9,393,757**	**$9,281,282**	**$165,664**
Scenario 67: Future condition riverine flood risk without green infrastructure (100 year, 50th percentile) with “business as usual” projection of impervious surface area				
Residential	505	$17,827,908	$10,607,032	No Damages
Commercial	40	$2,457,846	$8,677,315	$242,269
Industrial	1	$4,759	$20,086	$4,260
Agricultural	No Damages	No Damages	No Damages	No Damages
Religious	5	$418,548	$2,552,731	No Damages
Government	No Damages	No Damages	No Damages	No Damages
Education	No Damages	No Damages	No Damages	No Damages
Total	**551**	**$20,709,060**	**$21,857,164**	**$246,530**

Scenario 82: Future condition riverine flood risk with green infrastructure (100 year, 50th percentile) reduction of impervious surface area				
Residential	423	$14,179,197	$8,398,670	No Damages
Commercial	36	$1,913,940	$6,574,469	$184,303
Industrial	1	$4,138	$17,262	$3,748
Agricultural	No Damages	No Damages	No Damages	No Damages
Religious	4	$335,130	$2,026,490	No Damages
Government	No Damages	No Damages	No Damages	No Damages
Education	No Damages	No Damages	No Damages	No Damages
Total	**464**	**$16,432,406**	**$17,016,891**	**$188,051**
Scenario 68: Future condition riverine flood risk without green infrastructure (100 year,75th percentile) with "business as usual" projection of impervious surface area				
Residential	566	$20,615,549	$12,222,574	No Damages
Commercial	42	$2,744,697	$9,866,012	$265,055
Industrial	1	$5,179	$21,347	$4,439
Agricultural	No Damages	No Damages	No Damages	No Damages
Religious	6	$448,219	$2,909,852	No Damages
Government	No Damages	No Damages	No Damages	No Damages
Education	No Damages	No Damages	No Damages	No Damages
Total	**615**	**$23,813,644**	**$25,019,785**	**$269,494**
Scenario 83: Future condition riverine flood risk with green infrastructure (100 year, 75th percentile) reduction of impervious surface area				
Residential	442	$15,151,502	$8,956,992	No Damages
Commercial	37	$1,954,144	$6,721,174	$185,289
Industrial	1	$4,138	$17,262	$3,748
Agricultural	No Damages	No Damages	No Damages	No Damages
Religious	4	$343,920	$2,094,157	No Damages
Government	No Damages	No Damages	No Damages	No Damages
Education	No Damages	No Damages	No Damages	No Damages
Total	**484**	**$17,453,704**	**$17,789,585**	**$189,036**
Scenario 69: Future condition riverine flood risk without green infrastructure (500 year, 25th percentile) with "business as usual" projection of impervious surface area				
Residential	373	$12,894,368	$7,625,327	No Damages
Commercial	37	$1,916,246	$6,567,876	$194,516
Industrial	1	$4,332	$18,806	$4,079
Agricultural	No Damages	No Damages	No Damages	No Damages
Religious	2	$258,129	$1,443,200	No Damages
Government	No Damages	No Damages	No Damages	No Damages
Education	No Damages	No Damages	No Damages	No Damages
Total	**413**	**$15,073,075**	**$15,655,209**	**$198,595**
Scenario 84: Future condition riverine flood risk with green infrastructure (500 year, 25th percentile) reduction of impervious surface area				
Residential	308	$10,046,174	$5,929,341	No Damages
Commercial	29	$1,325,724	$4,502,213	$180,656
Industrial	1	$4,291	$18,683	$4,061
Agricultural	No Damages	No Damages	No Damages	No Damages
Religious	1	$130,670	$690,078	No Damages
Government	No Damages	No Damages	No Damages	No Damages
Education	No Damages	No Damages	No Damages	No Damages
Total	**339**	**$11,506,858**	**$11,140,315**	**$184,718**

Scenario 70: Future condition riverine flood risk without green infrastructure (500 year, 50th percentile) with "business as usual" projection of impervious surface area				
Residential	571	$20,764,745	$12,304,933	No Damages
Commercial	42	$2,750,355	$9,881,727	$265,055
Industrial	1	$5,179	$21,347	$4,439
Agricultural	No Damages	No Damages	No Damages	No Damages
Religious	6	$448,219	$2,909,852	No Damages
Government	No Damages	No Damages	No Damages	No Damages
Education	No Damages	No Damages	No Damages	No Damages
Total	**620**	**$23,968,497**	**$25,117,859**	**$269,494**
Scenario 85: Future condition riverine flood risk with green infrastructure (500 year, 50th percentile) reduction of impervious surface area				
Residential	445	$15,239,727	$9,013,951	No Damages
Commercial	38	$2,080,788	$7,252,010	$195,876
Industrial	1	$4,291	$18,683	$4,061
Agricultural	No Damages	No Damages	No Damages	No Damages
Religious	4	$343,920	$2,094,157	No Damages
Government	No Damages	No Damages	No Damages	No Damages
Education	No Damages	No Damages	No Damages	No Damages
Total	**488**	**$17,668,725**	**$18,378,800**	**$199,937**
Scenario 71: Future condition riverine flood risk without green infrastructure (500 year,75th percentile) with "business as usual" projection of impervious surface area				
Residential	613	$24,130,907	$14,482,491	No Damages
Commercial	48	$3,436,807	$12,124,265	$301,067
Industrial	1	$5,360	$21,890	$4,516
Agricultural	No Damages	No Damages	No Damages	No Damages
Religious	6	$451,082	$2,962,421	No Damages
Government	No Damages	No Damages	No Damages	No Damages
Education	No Damages	No Damages	No Damages	No Damages
Total	**668**	**$28,024,156**	**$29,591,067**	**$305,583**
Scenario 86: Future condition riverine flood risk with green infrastructure (500 year, 75th percentile) reduction of impervious surface area				
Residential	508	$18,522,546	$10,989,308	No Damages
Commercial	41	$2,556,407	$8,960,372	$243,636
Industrial	1	$4,732	$20,007	$4,250
Agricultural	No Damages	No Damages	No Damages	No Damages
Religious	4	$343,920	$2,094,157	No Damages
Government	No Damages	No Damages	No Damages	No Damages
Education	No Damages	No Damages	No Damages	No Damages
Total	**554**	**$21,427,604**	**$22,063,843**	**$247,885**

Table 21: Future Condition Riverine Flood Related Impacts on Building Damage with and without Green Infrastructure.

Table 22 provides a summary of the expected building debris from future condition riverine flooding for each of the modeled scenarios.

Scenario	Finishes (Tons)	Structures (Tons)	Foundations (Tons)	Total (Tons)
Scenario 57: Future condition riverine flood risk without green infrastructure (10 year, 25th percentile) with "business as usual" projection of impervious surface area	568	114	280	962
Scenario 72: Future condition riverine flood risk with green infrastructure (10 year, 25th percentile) reduction of impervious surface area	480	54	131	665
Scenario 58: Future condition riverine flood risk without green infrastructure (10 year, 50th percentile) with "business as usual" projection of impervious surface area	737	139	343	1,219
Scenario 73: Future condition riverine flood risk with green infrastructure (10 year, 50th percentile) reduction of impervious surface area	582	115	282	979
Scenario 59: Future condition riverine flood risk without green infrastructure (10 year, 75th percentile) with "business as usual" projection of impervious surface area	873	186	458	1,517
Scenario 74: Future condition riverine flood risk with green infrastructure (10 year, 75th percentile)	760	176	435	1,371

Scenario	Finishes (Tons)	Structures (Tons)	Foundations (Tons)	Total (Tons)
reduction of impervious surface area				
Scenario 60: Future condition riverine flood risk without green infrastructure (25 year, 25th percentile) with "business as usual" projection of impervious surface area	664	116	286	1,066
Scenario 75: Future condition riverine flood risk with green infrastructure (25 year, 25th percentile) reduction of impervious surface area	538	93	228	859
Scenario 61: Future condition riverine flood risk without green infrastructure (25 year, 50th percentile) with "business as usual" projection of impervious surface area	881	186	458	1,525
Scenario 76: Future condition riverine flood risk with green infrastructure (25 year, 50th percentile) reduction of impervious surface area	791	178	438	1,407
Scenario 62: Future condition riverine flood risk without green infrastructure (25 year, 75th percentile) with "business as usual" projection of impervious surface area	1,005	192	471	1,668
Scenario 77: Future condition riverine flood risk with green infrastructure (25 year, 75th percentile)	866	183	450	1,499

Scenario	Finishes (Tons)	Structures (Tons)	Foundations (Tons)	Total (Tons)
reduction of impervious surface area				
Scenario 63: Future condition riverine flood risk without green infrastructure (50 year, 25th percentile) with "business as usual" projection of impervious surface area	744	119	291	1,154
Scenario 78: Future condition riverine flood risk with green infrastructure (50 year, 25th percentile) reduction of impervious surface area	563	94	231	888
Scenario 64: Future condition riverine flood risk without green infrastructure (50 year, 50th percentile) with "business as usual" projection of impervious surface area	1,005	192	471	1,668
Scenario 79: Future condition riverine flood risk with green infrastructure (50 year, 50th percentile) reduction of impervious surface area	867	183	450	1,500
Scenario 65: Future condition riverine flood risk without green infrastructure (50 year, 75th percentile) with "business as usual" projection of impervious surface area	1,101	215	527	1,843
Scenario 80: Future condition riverine flood risk with green infrastructure (50 year, 75th percentile)	927	187	459	1,573

Scenario	Finishes (Tons)	Structures (Tons)	Foundations (Tons)	Total (Tons)
reduction of impervious surface area				
Scenario 66: Future condition riverine flood risk without green infrastructure (100 year, 25th percentile) with “business as usual” projection of impervious surface area	764	121	295	1,180
Scenario 81: Future condition riverine flood risk with green infrastructure (100 year, 25th percentile) reduction of impervious surface area	589	96	235	920
Scenario 67: Future condition riverine flood risk without green infrastructure (100 year, 50th percentile) with “business as usual” projection of impervious surface area	1,101	215	527	1,843
Scenario 82: Future condition riverine flood risk with green infrastructure (100 year, 50th percentile) reduction of impervious surface area	668	101	244	1,013
Scenario 68: Future condition riverine flood risk without green infrastructure (100 year,75th percentile) with “business as usual” projection of impervious surface area	1,213	222	540	1,975
Scenario 83: Future condition riverine flood risk with green infrastructure (100 year, 75th percentile)	947	189	465	1,601

Scenario	**Finishes (Tons)**	**Structures (Tons)**	**Foundations (Tons)**	**Total (Tons)**
reduction of impervious surface area				
Scenario 69: Future condition riverine flood risk without green infrastructure (500 year, 25th percentile) with "business as usual" projection of impervious surface area	816	125	304	1,245
Scenario 84: Future condition riverine flood risk with green infrastructure (500 year, 25th percentile) reduction of impervious surface area	668	101	244	1,013
Scenario 70: Future condition riverine flood risk without green infrastructure (500 year, 50th percentile) with "business as usual" projection of impervious surface area	1,222	222	541	1,985
Scenario 85: Future condition riverine flood risk with green infrastructure (500 year, 50th percentile) reduction of impervious surface area	958	190	466	1,613
Scenario 71: Future condition riverine flood risk without green infrastructure (500 year,75th percentile) with "business as usual" projection of impervious surface area	1,366	239	573	2,178
Scenario 86: Future condition riverine flood risk with green infrastructure (500 year, 75th percentile)	1,084	197	482	1,763

Scenario	Finishes (Tons)	Structures (Tons)	Foundations (Tons)	Total (Tons)
reduction of impervious surface area				

Table 22: Future Condition Riverine Flood Related Impacts on Building Debris with and without Green Infrastructure.

Table 23 provides a summary of the expected essential facility damage from future condition riverine flooding for each of the modeled scenarios.

	Number of Facilities Slightly Damaged (1 – 10%)	Number of Facilities Moderately Damaged (11 – 30%)	Number of Facilities Severely Damaged or greater (>30%)
Scenario 57: Future condition riverine flood risk without green infrastructure (10 year, 25th percentile) with "business as usual" projection of impervious surface area			
Fire	0	0	0
Police	0	0	0
Care	0	0	0
Emergency Operation Centers	0	0	0
Schools	0	0	0
Scenario 72: Future condition riverine flood risk with green infrastructure (10 year, 25th percentile) reduction of impervious surface area			
Fire	0	0	0
Police	0	0	0
Care	0	0	0
Emergency Operation Centers	0	0	0
Schools	0	0	0
Scenario 58: Future condition riverine flood risk without green infrastructure (10 year, 50th percentile) with "business as usual" projection of impervious surface area			
Fire	0	0	0
Police	0	0	0
Care	0	0	0
Emergency Operation Centers	0	0	0
Schools	0	0	0
Scenario 73: Future condition riverine flood risk with green infrastructure (10 year, 50th percentile) reduction of impervious surface area			
Fire	0	0	0
Police	0	0	0
Care	0	0	0
Emergency Operation Centers	0	0	0
Schools	0	0	0
Scenario 59: Future condition riverine flood risk without green infrastructure (10 year, 75th percentile) with "business as usual" projection of impervious surface area			
Fire	0	0	0
Police	0	0	0
Care	0	0	0
Emergency Operation Centers	0	0	0

	Number of Facilities Slightly Damaged (1 – 10%)	**Number of Facilities Moderately Damaged (11 – 30%)**	**Number of Facilities Severely Damaged or greater (>30%)**
Schools	0	0	0
Scenario 74: Future condition riverine flood risk with green infrastructure (10 year, 75th percentile) reduction of impervious surface area			
Fire	0	0	0
Police	0	0	0
Care	0	0	0
Emergency Operation Centers	0	0	0
Schools	0	0	0
Scenario 60: Future condition riverine flood risk without green infrastructure (25 year, 25th percentile) with “business as usual” projection of impervious surface area			
Fire	0	0	0
Police	0	0	0
Care	0	0	0
Emergency Operation Centers	0	0	0
Schools	0	0	0
Scenario 75: Future condition riverine flood risk with green infrastructure (25 year, 25th percentile) reduction of impervious surface area			
Fire	0	0	0
Police	0	0	0
Care	0	0	0
Emergency Operation Centers	0	0	0
Schools	0	0	0
Scenario 61: Future condition riverine flood risk without green infrastructure (25 year, 50th percentile) with “business as usual” projection of impervious surface area			
Fire	0	0	0
Police	0	0	0
Care	0	0	0
Emergency Operation Centers	0	0	0
Schools	0	0	0
Scenario 76: Future condition riverine flood risk with green infrastructure (25 year, 50th percentile) reduction of impervious surface area			
Fire	0	0	0
Police	0	0	0
Care	0	0	0
Emergency Operation Centers	0	0	0
Schools	0	0	0
Scenario 62: Future condition riverine flood risk without green infrastructure (25 year, 75th percentile) with “business as usual” projection of impervious surface area			
Fire	0	0	0
Police	0	0	0
Care	0	0	0
Emergency Operation Centers	0	0	0
Schools	0	0	0

	Number of Facilities Slightly Damaged (1 – 10%)	**Number of Facilities Moderately Damaged (11 – 30%)**	**Number of Facilities Severely Damaged or greater (>30%)**
Scenario 77: Future condition riverine flood risk with green infrastructure (25 year, 75th percentile) reduction of impervious surface area			
Fire	0	0	0
Police	0	0	0
Care	0	0	0
Emergency Operation Centers	0	0	0
Schools	0	0	0
Scenario 63: Future condition riverine flood risk without green infrastructure (50 year, 25th percentile) with “business as usual” projection of impervious surface area			
Fire	0	0	0
Police	0	0	0
Care	0	0	0
Emergency Operation Centers	0	0	0
Schools	0	0	0
Scenario 78: Future condition riverine flood risk with green infrastructure (50 year, 25th percentile) reduction of impervious surface area			
Fire	0	0	0
Police	0	0	0
Care	0	0	0
Emergency Operation Centers	0	0	0
Schools	0	0	0
Scenario 64: Future condition riverine flood risk without green infrastructure (50 year, 50th percentile) with “business as usual” projection of impervious surface area			
Fire	0	0	0
Police	0	0	0
Care	0	0	0
Emergency Operation Centers	0	0	0
Schools	0	0	0
Scenario 79: Future condition riverine flood risk with green infrastructure (50 year, 50th percentile) reduction of impervious surface area			
Fire	0	0	0
Police	0	0	0
Care	0	0	0
Emergency Operation Centers	0	0	0
Schools	0	0	0
Scenario 65: Future condition riverine flood risk without green infrastructure (50 year, 75th percentile) with “business as usual” projection of impervious surface area			
Fire	0	0	0
Police	0	0	0
Care	0	0	0
Emergency Operation Centers	0	0	0
Schools	0	0	0

	Number of Facilities Slightly Damaged (1 – 10%)	**Number of Facilities Moderately Damaged (11 – 30%)**	**Number of Facilities Severely Damaged or greater (>30%)**
Scenario 80: Future condition riverine flood risk with green infrastructure (50 year, 75th percentile) reduction of impervious surface area			
Fire	0	0	0
Police	0	0	0
Care	0	0	0
Emergency Operation Centers	0	0	0
Schools	0	0	0
Scenario 66: Future condition riverine flood risk without green infrastructure (100 year, 25th percentile) with “business as usual” projection of impervious surface area			
Fire	0	0	0
Police	0	0	0
Care	0	0	0
Emergency Operation Centers	0	0	0
Schools	0	0	0
Scenario 81: Future condition riverine flood risk with green infrastructure (100 year, 25th percentile) reduction of impervious surface area			
Fire	0	0	0
Police	0	0	0
Care	0	0	0
Emergency Operation Centers	0	0	0
Schools	0	0	0
Scenario 67: Future condition riverine flood risk without green infrastructure (100 year, 50th percentile) with “business as usual” projection of impervious surface area			
Fire	0	0	0
Police	0	0	0
Care	0	0	0
Emergency Operation Centers	0	0	0
Schools	0	0	0
Scenario 82: Future condition riverine flood risk with green infrastructure (100 year, 50th percentile) reduction of impervious surface area			
Fire	0	0	0
Police	0	0	0
Care	0	0	0
Emergency Operation Centers	0	0	0
Schools	0	0	0
Scenario 68: Future condition riverine flood risk without green infrastructure (100 year,75th percentile) with “business as usual” projection of impervious surface area			
Fire	0	0	0
Police	0	0	0
Care	0	0	0
Emergency Operation Centers	0	0	0
Schools	0	0	0

	Number of Facilities Slightly Damaged (1 – 10%)	Number of Facilities Moderately Damaged (11 – 30%)	Number of Facilities Severely Damaged or greater (>30%)
Scenario 83: Future condition riverine flood risk with green infrastructure (100 year, 75th percentile) reduction of impervious surface area			
Fire	0	0	0
Police	0	0	0
Care	0	0	0
Emergency Operation Centers	0	0	0
Schools	0	0	0
Scenario 69: Future condition riverine flood risk without green infrastructure (500 year, 25th percentile) with "business as usual" projection of impervious surface area			
Fire	0	0	0
Police	0	0	0
Care	0	0	0
Emergency Operation Centers	0	0	0
Schools	0	0	0
Scenario 84: Future condition riverine flood risk with green infrastructure (500 year, 25th percentile) reduction of impervious surface area			
Fire	0	0	0
Police	0	0	0
Care	0	0	0
Emergency Operation Centers	0	0	0
Schools	0	0	0
Scenario 70: Future condition riverine flood risk without green infrastructure (500 year, 50^{th} percentile) with "business as usual" projection of impervious surface area			
Fire	0	0	0
Police	0	0	0
Care	0	0	0
Emergency Operation Centers	0	0	0
Schools	0	0	0
Scenario 85: Future condition riverine flood risk with green infrastructure (500 year, 50^{th} percentile) reduction of impervious surface area			
Fire	0	0	0
Police	0	0	0
Care	0	0	0
Emergency Operation Centers	0	0	0
Schools	0	0	0
Scenario 71: Future condition riverine flood risk without green infrastructure (500 year,75th percentile) with "business as usual" projection of impervious surface area			
Fire	0	0	0
Police	0	0	0
Care	0	0	0
Emergency Operation Centers	0	0	0
Schools	1	0	0

	Number of Facilities Slightly Damaged (1 – 10%)	Number of Facilities Moderately Damaged (11 – 30%)	Number of Facilities Severely Damaged or greater (>30%)
Scenario 86: Future condition riverine flood risk with green infrastructure (500 year, 75th percentile) reduction of impervious surface area			
Fire	0	0	0
Police	0	0	0
Care	0	0	0
Emergency Operation Centers	0	0	0
Schools	0	0	0

Table 23: Potential Essential Facilities Impacted Based on Future Condition Riverine Flood Scenarios

5.3.3 Future Coastal Flood Risk with and without Green Infrastructure and a Future Building Stock

Table 24 reports on estimates of building, content and inventory losses resulting from future coastal flood hazards both with and without the presence of green infrastructure and a future predicted building stock.

Occupancy Classification	Total Buildings Damaged	Building Loss	Content Loss	Inventory Loss
Scenario 87: Future Coastal Flood Risk with Green Infrastructure (Category 1 Hurricane)				
Residential	2,766	$71,693,872	$36,397,670	$0
Commercial	75	$1,465,321	$4,871,734	$182,097
Industrial	2	$126,682	$140,136	$28,708
Agricultural	No Damages	No Damages	No Damages	No Damages
Religious	No Damages	No Damages	No Damages	No Damages
Government	No Damages	No Damages	No Damages	No Damages
Education	No Damages	No Damages	No Damages	No Damages
Total	2,843	$73,285,876	$41,409,542	$210,805
Scenario 91: Future Coastal Flood Risk without Green Infrastructure (Category 1 Hurricane)				
Residential	3,015	$107,674,865	$54,925,987	$0
Commercial	76	$1,741,748	$5,967,080	$211,124
Industrial	2	$107,052	$107,418	$23,926
Agricultural	No Damages	No Damages	No Damages	No Damages
Religious	No Damages	No Damages	No Damages	No Damages
Government	No Damages	No Damages	No Damages	No Damages
Education	No Damages	No Damages	No Damages	No Damages
Total	3,093	$ 109,523,666	$ 61,000,487	$ 235,050
Scenario 88: Future Coastal Flood Risk with Green Infrastructure (Category 2 Hurricane)				
Residential	2,766	$71,693,872	$36,397,670	$0
Commercial	75	$126,682	$140,136	$28,708
Industrial	2	$126,682	$140,136	$28,708
Agricultural	No Damages	No Damages	No Damages	No Damages
Religious	No Damages	No Damages	No Damages	No Damages
Government	No Damages	No Damages	No Damages	No Damages
Education	No Damages	No Damages	No Damages	No Damages
Total	2,843	$73,285,876	$41,409,542	$210,805
Scenario 92: Future Coastal Flood Risk without Green Infrastructure (Category 2 Hurricane)				

Occupancy Classification	Total Buildings Damaged	Building Loss	Content Loss	Inventory Loss
Residential	3,015	$ 107,674,865	$ 54,925,987	$0
Commercial	76	$ 1,741,748	$ 5,967,080	$ 211,124
Industrial	2	$ 107,052	$ 107,418	$ 23,926
Agricultural	No Damages	No Damages	No Damages	No Damages
Religious	No Damages	No Damages	No Damages	No Damages
Government	No Damages	No Damages	No Damages	No Damages
Education	No Damages	No Damages	No Damages	No Damages
Total	3,093	$ 109,523,666	$ 61,000,487	$ 235,050
Scenario 89: Future Coastal Flood Risk with Green Infrastructure (Category 3 Hurricane)				
Residential	3,524	$ 349,934,012	$ 182,267,324	$0
Commercial	110	$ 5,331,239	$ 17,082,639	$ 671,319
Industrial	2	$ 203,031	$ 257,896	$ 44,093
Agricultural	No Damages	No Damages	No Damages	No Damages
Religious	No Damages	No Damages	No Damages	No Damages
Government	1	$ 41,828	$ 279,849	$0
Education	No Damages	No Damages	No Damages	No Damages
Total	3,637	$355,510,112	$199,887,710	$715,412
Scenario 93: Future Coastal Flood Risk without Green Infrastructure (Category 3 Hurricane)				
Residential	3,662	$ 418,026,682	$ 217,494,442	$0
Commercial	119	$ 6,349,453	$ 19,969,205	$ 782,953
Industrial	3	$ 192,237	$ 245,397	$ 41,803
Agricultural	No Damages	No Damages	No Damages	No Damages
Religious	No Damages	No Damages	No Damages	No Damages
Government	1	$ 23,176	$ 139,058	$0
Education	No Damages	No Damages	No Damages	No Damages
Total	3,785	$ 424,591,550	$ 237,848,103	$ 824,757
Scenario 90: Future Coastal Flood Risk with Green Infrastructure (Category 4 Hurricane)				
Residential	3,704	$524,951,014	$274,797,969	$0
Commercial	130	$7,965,048	$24,140,638	$927,600
Industrial	3	$230,083	$294,253	$49,482
Agricultural	No Damages	No Damages	No Damages	No Damages
Religious	No Damages	No Damages	No Damages	No Damages
Government	1	$88,730	$506,574	$0
Education	No Damages	No Damages	No Damages	No Damages
Total	3,838	$533,234,876	$299,739,436	$977,082
Scenario 94: Future Coastal Flood Risk without Green Infrastructure (Category 4 Hurricane)				
Residential	3,736	$ 568,921,467	$ 297,959,734	$0
Commercial	134	$ 9,410,647	$ 28,185,367	$ 1,068,572
Industrial	3	$ 222,204	$ 290,814	$ 48,664
Agricultural	No Damages	No Damages	No Damages	No Damages
Religious	No Damages	No Damages	No Damages	No Damages
Government	1	$ 63,376	$ 427,800	$0
Education	No Damages	No Damages	No Damages	No Damages
Total	3,874	$ 578,617,695	$ 326,863,717	$ 1,117,237

Table 24: Future Condition Coastal Flood Related Building Losses with and without Green Infrastructure by Occupancy Type

Table 25 provides a summary of the expected building debris from future condition coastal flooding for each of the modeled scenarios.

Scenario	Finishes (Tons)	Structures (Tons)	Foundations (Tons)	Total (Tons)
Scenario 87: Future Coastal Flooding Risk with Green Infrastructure (Category 1 Hurricane)	7,916	1,287	921	10,124
Scenario 91: Future Coastal Flooding Risk without Green Infrastructure (Category 1 Hurricane)	9,498	1,435	1,006	11,940
Scenario 88: Future Coastal Flooding Risk with Green Infrastructure (Category 2 Hurricane)	7,916	1,287	921	10,124
Scenario 92: Future Coastal Flooding Risk without Green Infrastructure (Category 2 Hurricane)	9,498	1,435	1,006	11,940
Scenario 89: Future Coastal Flooding Risk with Green Infrastructure (Category 3 Hurricane)	22,417	8,632	6,748	37,796
Scenario 93: Future Coastal Flooding Risk without Green Infrastructure (Category 3 Hurricane)	26,505	10,822	8,305	45,632
Scenario 90: Future Coastal Flooding Risk with Green Infrastructure (Category 4 Hurricane)	32,456	18,085	14,259	64,799
Scenario 94: Future Coastal Flooding Risk without Green Infrastructure (Category 4 Hurricane)	38,274	21,160	17,477	76,910

Table 25: Future Condition Coastal Flood Related Impacts on Building Debris with and without Green Infrastructure.

Table 26 provides a summary of the expected essential facility damage from future condition coastal flooding for each of the modeled scenarios.

	Number of Facilities at least Moderately Damaged	Number of Facilities at Least Substantially Damaged	Number of Facilities with Expected Loss of Use <1 day
Scenario 87: Future Coastal Flood Risk with Green Infrastructure (Category 1 Hurricane)			
Fire	1	0	0
Police	0	0	0

	Number of Facilities at least Moderately Damaged	Number of Facilities at Least Substantially Damaged	Number of Facilities with Expected Loss of Use <1 day
Care	0	0	0
Emergency Operation Centers	0	0	0
Schools	13	0	13
Scenario 91: Future Coastal Flood Risk without Green Infrastructure (Category 1 Hurricane)			
Fire	0	0	0
Police	0	0	0
Care	0	0	0
Emergency Operation Centers	0	0	0
Schools	13	0	12
Scenario 88: Future Coastal Flood Risk with Green Infrastructure (Category 2 Hurricane)			
Fire	1	0	0
Police	0	0	0
Care	0	0	0
Emergency Operation Centers	0	0	0
Schools	13	0	13
Scenario 92: Future Coastal Flood Risk without Green Infrastructure (Category 2 Hurricane)			
Fire	0	0	0
Police	0	0	0
Care	0	0	0
Emergency Operation Centers	0	0	0
Schools	13	0	12
Scenario 89: Future Coastal Flood Risk with Green Infrastructure (Category 3 Hurricane)			
Fire	1	0	1
Police	1	0	0
Care	0	0	0
Emergency Operation Centers	0	0	0
Schools	13	0	13
Scenario 93: Future Coastal Flood Risk without Green Infrastructure (Category 3 Hurricane)			
Fire	1	0	1
Police	1	0	1
Care	0	0	0
Emergency Operation Centers	0	0	0
Schools	13	0	13
Scenario 90: Future Coastal Flood Risk with Green Infrastructure (Category 4 Hurricane)			
Fire	1	0	1
Police	1	0	1
Care	0	0	0
Emergency Operation Centers	0	0	0
Schools	13	0	13
Scenario 94: Future Coastal Flood Risk without Green Infrastructure (Category 4 Hurricane)			
Fire	1	0	1
Police	1	0	1

	Number of Facilities at least Moderately Damaged	Number of Facilities at Least Substantially Damaged	Number of Facilities with Expected Loss of Use <1 day
Care	0	0	0
Emergency Operation Centers	0	0	0
Schools	13	0	13

Table 26: Potential Essential Facilities Impacted Based on Future Condition Coastal Flood Scenarios

5.3.4 Future Coastal Flood Risk with and without Green Infrastructure and 2018 Buildings

Table 27 reports on estimates of building, content and inventory losses resulting from future coastal flood hazards both with and without the presence of green infrastructure with current (2018) buildings.

Occupancy Classification	Total Buildings Damaged	Building Loss	Content Loss	Inventory Loss
Scenario 99: Future Coastal Flood Risk with Green Infrastructure (Category 1 Hurricane)				
Residential	1182	$32,734,899	$17,004,036	No Damages
Commercial	71	$1,465,321	$4,867,361	$182,097
Industrial	2	$126,683	$140,136	$28,708
Agricultural	0	No Damages	No Damages	No Damages
Religious	4	$111,707	$725,451	No Damages
Government	0	No Damages	No Damages	No Damages
Education	0	No Damages	No Damages	No Damages
Total	**1259**	**$34,438,610**	**$22,736,984**	**$210,805**
Scenario 95: Future Coastal Flood Risk without Green Infrastructure (Category 1 Hurricane)				
Residential	1605	$74,202,934	$38,379,972	No Damages
Commercial	74	$1,953,068	$6,579,935	$236,405
Industrial	2	$126,683	$140,136	$28,708
Agricultural	0	No Damages	No Damages	No Damages
Religious	4	$111,707	$725,451	No Damages
Government	0	No Damages	No Damages	No Damages
Education	0	No Damages	No Damages	No Damages
Total	**1685**	**$76,394,392**	**$45,825,493**	**$265,113**
Scenario 100: Future Coastal Flood Risk with Green Infrastructure (Category 2 Hurricane)				
Residential	1182	$32,734,899	$17,004,037	No Damages
Commercial	71	$1,465,321	$4,867,361	$182,097
Industrial	2	$126,683	$140,136	$28,708
Agricultural	0	No Damages	No Damages	No Damages
Religious	4	$111,707	$725,451	No Damages
Government	0	No Damages	No Damages	No Damages
Education	0	No Damages	No Damages	No Damages
Total	**1259**	**$34,438,610**	**$22,736,984**	**$210,805**
Scenario 96: Future Coastal Flood Risk without Green Infrastructure (Category 2 Hurricane)				
Residential	1605	$74,202,934	$38,379,972	No Damages
Commercial	74	$1,953,068	$6,579,935	$236,405
Industrial	2	$126,683	$140,136	$28,708
Agricultural	0	No Damages	No Damages	No Damages
Religious	4	$111,707	$725,451	No Damages

Occupancy Classification	Total Buildings Damaged	Building Loss	Content Loss	Inventory Loss
Government	0	No Damages	No Damages	No Damages
Education	0	No Damages	No Damages	No Damages
Total	**1685**	**$76,394,392**	**$45,825,493**	**$265,113**
Scenario 101: Future Coastal Flood Risk with Green Infrastructure (Category 3 Hurricane)				
Residential	2597	$233,089,213	$119,682,187	No Damages
Commercial	111	$5,482,290	$17,535,712	$710,413
Industrial	2	$203,032	$257,896	$44,093
Agricultural	0	No Damages	No Damages	No Damages
Religious	7	$611,608	$4,650,927	No Damages
Government	1	$41,829	$279,850	No Damages
Education	3	$285,593	$1,807,379	No Damages
Total	**2721**	**$239,713,565**	**$144,213,951**	**$754,506**
Scenario 97: Future Coastal Flood Risk without Green Infrastructure (Category 3 Hurricane)				
Residential	2780	$309,993,768	$160,120,677	No Damages
Commercial	120	$6,733,151	$21,148,898	$846,581
Industrial	3	$203,298	$258,138	$44,152
Agricultural	0	No Damages	No Damages	No Damages
Religious	7	$611,608	$4,650,927	No Damages
Government	1	$41,829	$279,850	No Damages
Education	3	$285,593	$1,807,379	No Damages
Total	**2914**	**$317,869,247**	**$188,265,869**	**$890,733**
Scenario 102: Future Coastal Flood Risk with Green Infrastructure (Category 4 Hurricane)				
Residential	2885	$388,284,218	$200,851,782	No Damages
Commercial	131	$8,309,452	$25,216,670	$988,975
Industrial	3	$230,084	$294,254	$49,482
Agricultural	0	No Damages	No Damages	No Damages
Religious	7	$655,864	$5,085,941	No Damages
Government	1	$88,730	$506,574	No Damages
Education	3	$318,585	$2,160,331	No Damages
Total	**3030**	**$397,886,933**	**$234,115,553**	**$1,038,458**
Scenario 98: Future Coastal Flood Risk without Green Infrastructure (Category 4 Hurricane)				
Residential	3024	$427,264,457	$223,975,102	No Damages
Commercial	135	$9,779,005	$29,271,468	$1,140,297
Industrial	3	$235,837	$301,039	$50,799
Agricultural	0	No Damages	No Damages	No Damages
Religious	7	$655,864	$5,085,941	No Damages
Government	1	$88,730	$506,574	No Damages
Education	3	$318,585	$2,160,331	No Damages
Total	**3173**	**$438,342,478**	**$261,300,456**	**$1,191,096**

Table 27: Future Condition Coastal Flood Related Building Losses with and without Green Infrastructure by Occupancy Type

Table 28 provides a summary of the expected building debris from future condition coastal flooding for each of the modeled scenarios.

Scenario	Finishes (Tons)	Structures (Tons)	Foundations (Tons)	Total (Tons)
Scenario 99: Future Coastal Flooding Risk	4,906	430	282	5,618

Scenario	Finishes (Tons)	Structures (Tons)	Foundations (Tons)	Total (Tons)
with Green Infrastructure (Category 1 Hurricane)				
Scenario 95: Future Coastal Flooding Risk without Green Infrastructure (Category 1 Hurricane)	6,714	603	391	7,708
Scenario 100: Future Coastal Flooding Risk with Green Infrastructure (Category 2 Hurricane)	4,906	430	282	5,618
Scenario 96: Future Coastal Flooding Risk without Green Infrastructure (Category 2 Hurricane)	6,714	603	391	7,708
Scenario 101: Future Coastal Flooding Risk with Green Infrastructure (Category 3 Hurricane)	16,064	5,326	3,797	25,187
Scenario 97: Future Coastal Flooding Risk without Green Infrastructure (Category 3 Hurricane)	20,821	8,055	5,599	34,475
Scenario 102: Future Coastal Flooding Risk with Green Infrastructure (Category 4 Hurricane)	26,809	12,971	9,210	48,990
Scenario 98: Future Coastal Flooding Risk without Green Infrastructure (Category 4 Hurricane)	32,042	15,882	12,043	59,967

Table 28: Future Condition Coastal Flood Related Impacts on Building Debris with and without Green Infrastructure.

Table 29 provides a summary of the expected essential facility damage from future condition coastal flooding for each of the modeled scenarios.

	Number of Facilities Slightly Damaged (1 – 10%)	Number of Facilities Moderately Damaged (11 – 30%)	Number of Facilities Severely Damaged or greater (>30%)
Scenario 99: Future Coastal Flood Risk with Green Infrastructure (Category 1 Hurricane)			
Fire	1	0	0
Police	0	0	0
Care	0	0	0

	Number of Facilities Slightly Damaged (1 – 10%)	**Number of Facilities Moderately Damaged (11 – 30%)**	**Number of Facilities Severely Damaged or greater (>30%)**
Emergency Operation Centers	0	0	0
Schools	13	0	0
Scenario 95: Future Coastal Flood Risk without Green Infrastructure (Category 1 Hurricane)			
Fire	1	0	0
Police	0	0	0
Care	0	0	0
Emergency Operation Centers	0	0	0
Schools	13	0	0
Scenario 100: Future Coastal Flood Risk with Green Infrastructure (Category 2 Hurricane)			
Fire	1		
Police	0	0	0
Care	0	0	0
Emergency Operation Centers	0	0	0
Schools	13	0	0
Scenario 96: Future Coastal Flood Risk without Green Infrastructure (Category 2 Hurricane)			
Fire	1	0	0
Police	0	0	0
Care	0	0	0
Emergency Operation Centers	0	0	0
Schools	13	0	0
Scenario 101: Future Coastal Flood Risk with Green Infrastructure (Category 3 Hurricane)			
Fire	0	1	0
Police	1	0	0
Care	0	0	0
Emergency Operation Centers	0	0	0
Schools	2	11	0
Scenario 97: Future Coastal Flood Risk without Green Infrastructure (Category 3 Hurricane)			
Fire	0	1	0
Police	1	0	0
Care	0	0	0
Emergency Operation Centers	0	0	0
Schools	2	11	0
Scenario 102: Future Coastal Flood Risk with Green Infrastructure (Category 4 Hurricane)			
Fire	0	1	0
Police	1	0	0
Care	0	0	0
Emergency Operation Centers	0	0	0
Schools	0	13	0
Scenario 98: Future Coastal Flood Risk without Green Infrastructure (Category 4 Hurricane)			
Fire	0	1	0
Police	1	0	0
Care	0	0	0

	Number of Facilities Slightly Damaged (1 – 10%)	Number of Facilities Moderately Damaged (11 – 30%)	Number of Facilities Severely Damaged or greater (>30%)
Emergency Operation Centers	0	0	0
Schools	0	13	0

Table 29: Potential Essential Facilities Impacted Based on Future Condition Coastal Flood Scenarios

5.4 Future Condition Coastal Wind Scenarios

5.4.1 Future Condition Coastal Wind Scenarios with a Future Predicted Building Stock

Table 30 provides a summary of the expected Coastal wind only building, content and inventory losses for each of the modeled scenarios. The number of buildings damaged column reflects the total of all buildings that have experienced any amount of damage from minor to total destruction.

Scenario	Number of Buildings Damaged	Building Loss	Content Loss	Inventory Loss
Scenario 103: Category 1 Hurricane without Mitigation	2,265	52,629,849	16,142,622	34,560
Scenario 107: Category 1 Hurricane with Mitigation	2,215	49,415,293	14,320,399	34,552
Scenario 104: Category 2 Hurricane without Mitigation	3,586	246,798,901	102,608,144	216,353
Scenario 108: Category 2 Hurricane with Mitigation	3,549	227,829,586	90,376,745	215,726
Scenario 105: Category 3 Hurricane without Mitigation	3,837	556,003,121	254,591,567	574,697
Scenario 109: Category 3 Hurricane with Mitigation	3,833	526,119,820	232,496,174	573,055
Scenario 106: Category 4 Hurricane without Mitigation	3,850	766,020,062	386,416,412	1,009,760
Scenario 110: Category 4 Hurricane with Mitigation	3,850	748,784,921	370,530,296	1,097,868

Table 30: Future Coastal Wind Estimated Building Damages

Table 31 provides an estimate of building and tree related debris based on coastal wind related damages for each of the modeled scenarios.

Scenario	Brick, Wood and Other (Tons)	Reinforced Concrete Steel (Tons)	Tree Debris Eligible for Removal with Public Funds (Tons)	Other Tree Debris (Tons)
Scenario 103: Category 1 Hurricane	7,847	40	1,600	1,845

Scenario	Brick, Wood and Other (Tons)	Reinforced Concrete Steel (Tons)	Tree Debris Eligible for Removal with Public Funds (Tons)	Other Tree Debris (Tons)
without Mitigation				
Scenario 107: Category 1 Hurricane with Mitigation	7,440	25	1,600	1,845
Scenario 104: Category 2 Hurricane without Mitigation	34,965	563	2,940	3,358
Scenario 108: Category 2 Hurricane with Mitigation	32,214	482	2,940	3,358
Scenario 105: Category 3 Hurricane without Mitigation	83,491	1,951	4,134	4,697
Scenario 109: Category 3 Hurricane with Mitigation	78,629	1,765	4,134	4,697
Scenario 106: Category 4 Hurricane without Mitigation	129,191	4,206	5,246	5,946
Scenario 110: Category 4 Hurricane with Mitigation	125,910	4,064	5,246	5,946

Table 31: Future Coastal Wind Estimated Building and Tree Debris Impacts

Table 32 provides a summary of the expected essential facility damage from future condition hurricane winds for each of the modeled scenarios.

	Probability of Least Moderate Damage >50%	Probability of Least Substantial Damage >50%	Number of Facilities with Expected Loss of Use <1 day
Scenario 103: Category 1 Hurricane without Mitigation			
Fire	0	0	1
Police	1	0	1
Care	0	0	0
Emergency Operation Centers	0	0	0
Schools	13	0	0

	Probability of Least Moderate Damage >50%	Probability of Least Substantial Damage >50%	Number of Facilities with Expected Loss of Use <1 day
Scenario 107: Category 1 Hurricane with Mitigation			
Fire	0	0	1
Police	1	0	1
Care	0	0	0
Emergency Operation Centers	0	0	0
Schools	13	0	0
Scenario 104: Category 2 Hurricane without Mitigation			
Fire	1	0	1
Police	1	0	0
Care	0	0	0
Emergency Operation Centers	0	0	0
Schools	13	0	0
Scenario 108: Category 2 Hurricane with Mitigation			
Fire	1	0	0
Police	1	0	0
Care	0	0	0
Emergency Operation Centers	0	0	0
Schools	13	0	0
Scenario 105: Category 3 Hurricane without Mitigation			
Fire	1	0	0
Police	1	0	0
Care	0	0	0
Emergency Operation Centers	0	0	0
Schools	13	0	0
Scenario 109: Category 3 Hurricane with Mitigation			
Fire	1	0	0
Police	1	0	0
Care	0	0	0
Emergency Operation Centers	0	0	0
Schools	13	0	0
Scenario 106: Category 4 Hurricane without Mitigation			
Fire	1	1	0
Police	1	0	0
Care	0	0	0
Emergency Operation Centers	0	0	0
Schools	13	13	0
Scenario 110: Category 4 Hurricane with Mitigation			
Fire	1	1	0
Police	1	0	0
Care	0	0	0
Emergency Operation Centers	0	0	0

	Probability of Least Moderate Damage >50%	Probability of Least Substantial Damage >50%	Number of Facilities with Expected Loss of Use <1 day
Schools	13	13	0

Table 32: Potential Essential Facilities Impacted Based on Future Condition Coastal Wind Scenarios

5.4.2 Future Condition Coastal Wind Scenarios with Current Building Stock

Table 33 provides a summary of the expected Coastal wind only building, content and inventory losses for each of the modeled scenarios. The number of buildings damaged column reflects the total of all buildings that have experienced any amount of damage from minor to total destruction.

Scenario	Number of Buildings Damaged	Building Loss	Content Loss	Inventory Loss
Scenario 111: Category 1 Hurricane without Mitigation	2,120	$43,650	$13,029	$40
Scenario 115: Category 1 Hurricane with Mitigation	2,076	$40,937	$11,551	$40
Scenario 112: Category 2 Hurricane without Mitigation	3,357	$214,224	$89,941	$259
Scenario 116: Category 2 Hurricane with Mitigation	3,322	$198,202	$79,453	$258
Scenario 113: Category 3 Hurricane without Mitigation	3,584	$485,328	$223,511	$695
Scenario 117: Category 3 Hurricane with Mitigation	3,580	$460,711	$204,955	$691
Scenario 114: Category 4 Hurricane without Mitigation	3,595	$666,368	$341,365	$1,323
Scenario 118: Category 4 Hurricane with Mitigation	3,595	$652,950	$328,479	$1,319

Table 33: Future Coastal Wind Estimated Building Damages

Table 34 provides an estimate of building and tree related debris based on coastal wind related damages for each of the modeled scenarios.

Scenario	Brick, Wood and Other (Tons)	Reinforced Concrete Steel (Tons)	Tree Debris Eligible for Removal with Public Funds (Tons)	Other Tree Debris (Tons)
Scenario 111: Category 1 Hurricane without Mitigation	6,580	17	1,746	17,459
Scenario 115: Category 1 Hurricane with Mitigation	6,254	9	1,746	17,459

Scenario	Brick, Wood and Other (Tons)	Reinforced Concrete Steel (Tons)	Tree Debris Eligible for Removal with Public Funds (Tons)	Other Tree Debris (Tons)
Scenario 112: Category 2 Hurricane without Mitigation	30,012	174	2,698	26,982
Scenario 116: Category 2 Hurricane with Mitigation	27,703	146	2,698	26,982
Scenario 113: Category 3 Hurricane without Mitigation	71,379	582	3,095	30,950
Scenario 117: Category 3 Hurricane with Mitigation	67,425	539	3,095	30,950
Scenario 114: Category 4 Hurricane without Mitigation	109,150	1,194	3,333	33,330
Scenario 118: Category 4 Hurricane with Mitigation	106,616	1,152	3,333	33,330

Table 34: Future Coastal Wind Estimated Building and Tree Debris Impacts

Table 35 provides a summary of the expected essential facility damage from future condition hurricane winds for each of the modeled scenarios.

	Probability of Least Moderate Damage >50%	Probability of Least Substantial Damage >50%	Number of Facilities with Expected Loss of Use >1 day
Scenario 111: Category 1 Hurricane without Mitigation			
Fire	0	0	0
Police	0	0	0
Care	0	0	0
Emergency Operation Centers	0	0	0
Schools	13	0	0
Scenario 115: Category 1 Hurricane with Mitigation			
Fire	0	0	0
Police	0	0	0
Care	0	0	0
Emergency Operation Centers	0	0	0

	Probability of Least Moderate Damage >50%	Probability of Least Substantial Damage >50%	Number of Facilities with Expected Loss of Use >1 day
Schools	13	0	0
Scenario 112: Category 2 Hurricane without Mitigation			
Fire	0	0	0
Police	1	0	1
Care	0	0	0
Emergency Operation Centers	0	0	0
Schools	13	0	13
Scenario 116: Category 2 Hurricane with Mitigation			
Fire	0	0	0
Police	1	0	1
Care	0	0	0
Emergency Operation Centers	0	0	0
Schools	13	0	13
Scenario 113: Category 3 Hurricane without Mitigation			
Fire	1	0	1
Police	1	0	1
Care	0	0	0
Emergency Operation Centers	0	0	0
Schools	13	0	13
Scenario 117: Category 3 Hurricane with Mitigation			
Fire	1	0	1
Police	1	0	1
Care	0	0	0
Emergency Operation Centers	0	0	0
Schools	13	0	13
Scenario 114: Category 4 Hurricane without Mitigation			
Fire	1	0	1
Police	1	0	1
Care	0	0	0
Emergency Operation Centers	0	0	0
Schools	13	0	13
Scenario 118: Category 4 Hurricane with Mitigation			
Fire	1	0	1
Police	1	0	1
Care	0	0	0
Emergency Operation Centers	0	0	0
Schools	13	0	13

Table 35: Potential Essential Facilities Impacted Based on Future Condition Coastal Wind Scenarios

5.5 Average Annualized Losses for Current and Future Condition Flood Scenarios

Scenario	AAL Loss
Current Riverine Flooding without green infrastructure (Scenarios 1 through 5)	$416,498.66
Current Riverine Flooding with green infrastructure (Scenarios 6 through 10)	$367.933.46
Current Coastal Flooding with green infrastructure (Scenarios 11 through 14)	$9,152,186.52
Current Coastal Flooding without green infrastructure (Scenarios 15 through 18)	$10,133,688.54
Current Hurricane Wind Related Risk without building mitigation (Scenarios 19 through 22)	$22,103,059.97
Current Hurricane Wind Related Risk with building mitigation (Scenarios 23 through 26)	$22,729,585.49
Future Riverine Risk with 25th percentile future rainfall without green infrastructure and a future building stock (Scenarios 27 through 56)	$3,021,772.68
Future Riverine Risk with 50th percentile future rainfall without green infrastructure and a future building stock (Scenarios 27 through 56)	$4,328,293.95
Future Riverine Risk with 75th percentile future rainfall without green infrastructure and a future building stock (Scenarios 27 through 56)	$5,144,644.18
Future Riverine Risk with 25th percentile future rainfall with green infrastructure and a future building stock (Scenarios 27 through 56)	$2,473,280.76
Future Riverine Risk with 50th percentile future rainfall with green infrastructure and a future building stock (Scenarios 27 through 56)	$3,460,067.10
Future Riverine Risk with 75th percentile future rainfall with green infrastructure and a future building stock (Scenarios 27 through 56)	$4,052,998.01
Future Riverine Risk with 25th percentile future rainfall without green infrastructure and the current building stock (Scenarios 57 through 86)	$1,954,976.87
Future Riverine Risk with 50th percentile future rainfall without green infrastructure and the current building stock (Scenarios 57 through 86)	$3,001,348.27
Future Riverine Risk with 75th percentile future rainfall without green infrastructure and the current building stock (Scenarios 57 through 86)	$3,588,640.06
Future Riverine Risk with 25th percentile future rainfall with green infrastructure and the current building stock (Scenarios 57 through 86)	$1,533,624.13
Future Riverine Risk with 50th percentile future rainfall with green infrastructure and the current building stock (Scenarios 57 through 86)	$2,327,739.18
Future Riverine Risk with 75th percentile future rainfall with green infrastructure and the current building stock (Scenarios 57 through 86)	$2,823,036.16
Future Coastal flood risk due to changes in hurricane intensity and frequency with a future building stock and with green infrastructure (Scenarios 87 through 90)	$23,890,696.67
Future Coastal flood risk due to changes in hurricane intensity and frequency with a future building stock with not green infrastructure (Scenarios 91 through 94)	$30,061,498.20
Future Coastal flood risk due to changes in hurricane intensity and frequency with the current building stock and with green infrastructure (Scenarios 95 through 98)	$15,484,646.76
Future Coastal flood risk due to changes in hurricane intensity and frequency with the current building stock with not green infrastructure (Scenarios 99 through 102)	$22,486,843.87
Coastal wind hazards due to changes in hurricane intensity and frequency with future buildings and without a change in building construction requirements (e.g. hurricane shutters) that strengthen the building codes for hurricane wind protection for new and old construction. (Scenarios 103 through 106)	$45,265,071.00
Coastal wind hazards due to changes in hurricane intensity and frequency with future buildings and with a change in building construction requirements (e.g.	$42,349,521.00

Scenario	AAL Loss
hurricane shutters) that strengthen the building codes for hurricane wind protection for new and old construction. (Scenarios 107 through 110)	
Coastal wind hazards due to changes in hurricane intensity and frequency with current buildings and without a change in building construction requirements (e.g. hurricane shutters) that strengthen the building codes for hurricane wind protection for new and old construction. (Scenarios 111 through 114)	$33,603,040.00
Coastal wind hazards due to changes in hurricane intensity and frequency with current buildings and with a change in building construction requirements (e.g. hurricane shutters) that strengthen the building codes for hurricane wind protection for new and old construction. (Scenarios 115 through 118)	$31,532,450.00

Table 36: Average Annualized Losses for each set of Scenarios

Section 5 Discussion and Summary

The results of this study demonstrate the impacts for the citizens around Hinesville, Georgia and Tybee Island Georgia today as well as in 2080. 118 scenarios were performed over the two communities. Figure 47 (Appendix B) displays all of the building loss counts in the Hinesville are under each riverine flood scenario that was performed. When comparing the total buildings damaged in 2018 versus in 2080 there are significant increases throughout the watershed. In 2018, the Hinesville area can expect approximately 90 building damaged from the 1% annual chance flood (without any green infrastructure implementations). That number jumps to 768 damaged buildings in 2080 under the median expected rainfall projection for 2080 (without green infrastructure). In each simulation, green infrastructure makes an impact on the total buildings damaged. If green infrastructure is implemented in the watershed, 116 fewer building will be expected to be damaged in 2080 under the 1% annual chance flood. This type of reduction is apparent in all of the riverine scenarios.

Even more striking are the potential dollar losses into the future from riverine flooding (Appendix B, Figure 48). Today, the expected 1% annual chance losses are close to 3 million dollars. Under the 50% percentile rainfall projection for 2080, that number jumps to 33 million, a 1000% change in dollar losses. Green infrastructure is also shown to make a dramatic impact on future losses. When green infrastructure is implemented, there is a 20% reduction in losses in the watershed. In this work we consider the base case future rainfall scenario to be the 25% future rainfall projection and the worst case scenario rainfall projection to be the 75% rainfall for 2080. There is a 25 million dollar difference between the values calculated under each scenario. This difference further points a need for proper construction in the floodplain as well as the implementation of green infrastructure projects.

On Tybee Island, the coastal flood hazard will have widespread impacts into the future. In this work we considered an 8ft dune barrier for coastal flood protections for all 2018 scenarios. The 8ft barrier is high enough to protect against the Category 1 hurricane storm surge event, but would be overtopped or removed under other flood events. The 8 foot barrier does offer significant protection for the Category 1 hurricane storm surge by reducing the number of building damaged by nearly 650 (Appendix B, Figure 49). The reduction of losses is nearly 20 million dollars. For future scenarios the dune was elevated to protect against the 2018 Category 4 hurricane storm surge flood event. However, with stronger storms and sea level rise, future scenarios are not protected by the 12ft dune system. In the future Category 4 hurricane storm surge flood event, there are nearly 1,200 additional structures flooded (using a simulated future set of buildings) over the current (2018) flood risk (Appendix B, Figure 49). Figure 49 also shows very little impact of the higher dune for the Category 4 hurricane storm surge flood event (with green infrastructure).

The dollar losses for coastal flooding on Tybee are higher than what is expected for Hinesville due to the magnitude and extents associated with coastal flooding. The current CAT 1 hurricane storm surge event will produce nearly 24 million dollars' worth of damage, but with the 8ft dune system that number falls to only 4 million dollars. In the future however, stronger storms will produce catastrophic damages. Today the losses for a CAT 4 hurricane are estimated to total nearly 250 million dollars. Using the same building stock as in 2018 (no changes) those losses could increase to 438 million dollars (> 80%) increase in damages. The number goes over 550 million dollars with a simulated building stock representing building construction for 2018 – 2080 (Appendix B, Figure 50).

The hurricane wind scenarios show the impacts future hurricane winds will have on the buildings on Tybee Island. With only a 10% increase in hurricane winds between 2018 and 2080, the total damaged buildings (using the 2018 building stock) increased from 1,192 to 2,129 for a CAT 1 hurricane (Appendix B, Figure 51). Increasing the number of buildings with shutters from 5% to 10% did lower the numbers all damaged building for all scenarios. One interesting aspect of the hurricane analysis over the flood analysis are the more intense hurricane events. When comparing all scenarios for a CAT 4 hurricane, the number are nearly identical. This is because of the intense pressure hurricane winds at CAT4 strength place on structures. Mitigation measures are often not enough to withstand those events.

For the dollar losses associated with major hurricane events, there are large differences between the 2018 CAT 4 wind event losses and the 2080 wind event losses (Figure 52). A CAT 4 hurricane on Tybee Island would cause approximately 550 million dollars in 2018. In 2080 however that number increases to approximately 675 million dollars. Green infrastructure improvements (i.e., all new construction requires shuttering) lowers the overall impact of CAT 4 hurricanes by 10%.

Section 6 How to Use this Information

This study was designed to assess the potential impacts of hurricane related wind and flooding on Georgia coastal communities, both under current conditions and based upon the predictions of the scientific community related to climate change.

The report is not designed to predict with precision what will happen in the future. Its findings are based on a variety of assumptions related to the hazards modeled as well as the description of the built environment. Altering the modeled scenarios by simply shifting the track of a hurricane by a few miles would yield significant differences in both economic and social impacts. This, however, does not diminish the value of the report because its primary goal is to highlight the potential magnitude of increased impact that could be realized without the application of effective mitigation practices.

Readers of this report will note that the predicted increases impacts are in some cases significant. Yet, it is important to note that this study did not attempt to comprehensively evaluate the full range of impacts that would almost certainly be realized should the modeled events take place. For example, it did not consider the potentially significant economic impacts related to business interruption, impacts to the utility or transportation infrastructure, or the possibility of casualties, PTSD or other social impacts. This is important to consider given that, as significant as the losses reported for this study are, the totality of social and economic losses would likely be much more profound if these events were to occur.

We hope that this study serves as a call to action for the homeowners, businesses, governmental organizations and other stakeholders who have interests not only in Tybee Island and Hinesville but in other Georgia coastal communities as well. The information in this report should not be a reflection of what will happen, but rather what could occur if current conditions are not mitigated.

For next steps we recommend the following:

- Use the findings in this report to inform stakeholders of the magnitude of impact that could be realized from hurricanes of the present and future. Explore and implement the many regulatory as well as economic incentivizes that can encourage these individuals and organizations to take action to mitigate these impacts through more effective land use planning, hazard resistance construction practices, and educational outreach.
- Consider expanding this study to other Georgia coastal communities. By considering the unique characteristics of each community, it is possible to identify effective mitigation options, such as green infrastructure, that will mitigate the impacts of current and future hazards.

Appendix A Flood Scenario Maps

Maps of each flood hazard, with and without mitigation, evaluated in this study are provided in this appendix.

A.1 Current Condition Riverine Flood Scenarios

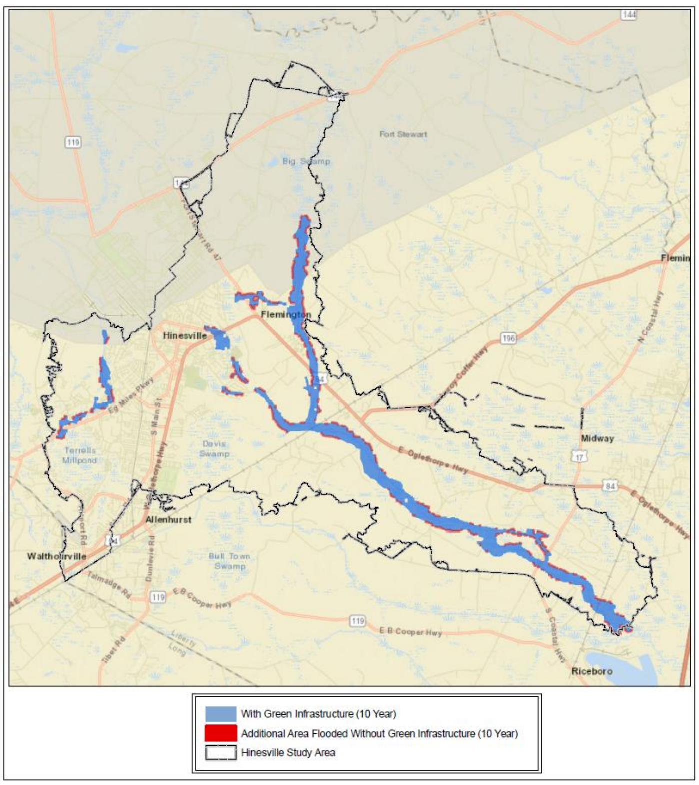

Figure 23: Current Riverine Flood Risk with Green Infrastructure for the 10-Year Return Period

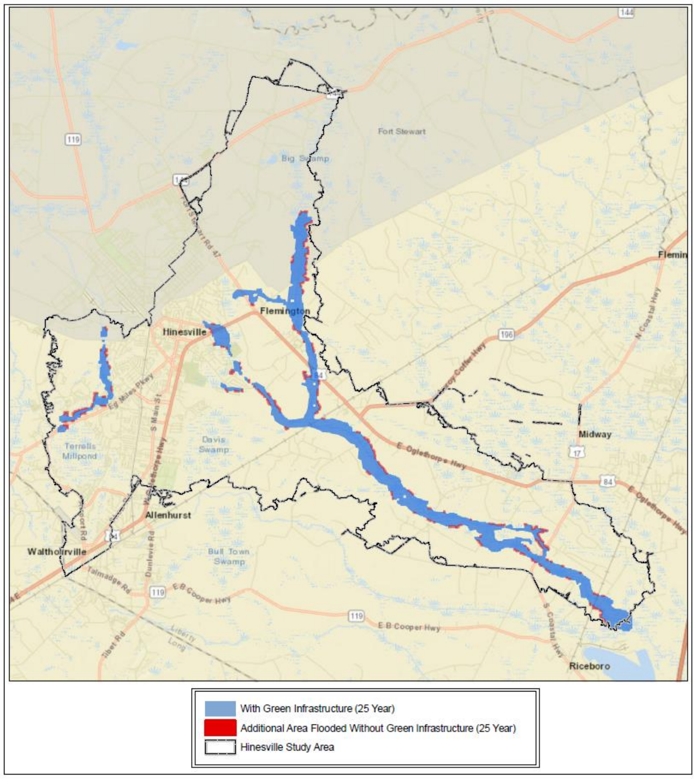

Figure 24: Current Riverine Flood Risk with Green Infrastructure for the 25-Year Return Period

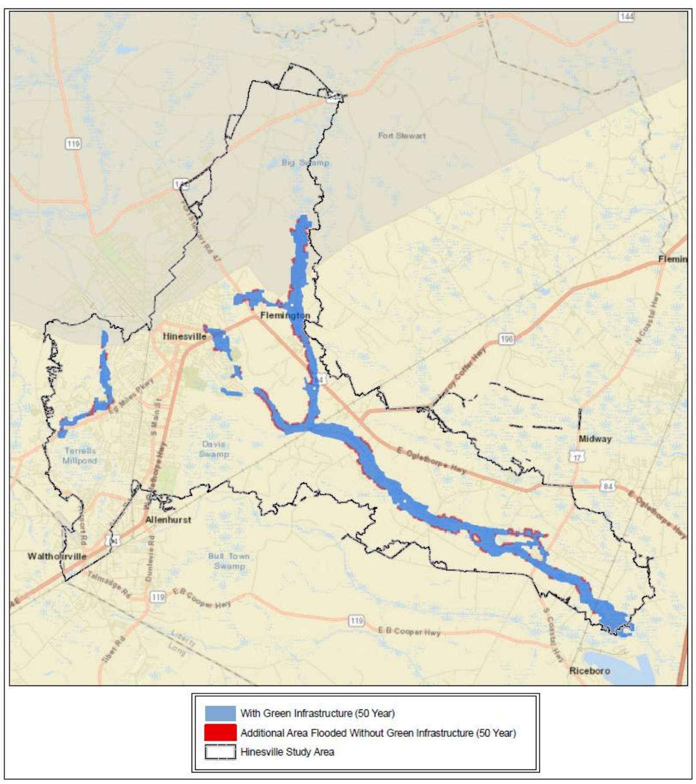

Figure 25: Current Riverine Flood Risk with Green Infrastructure for the 50-Year Return Period

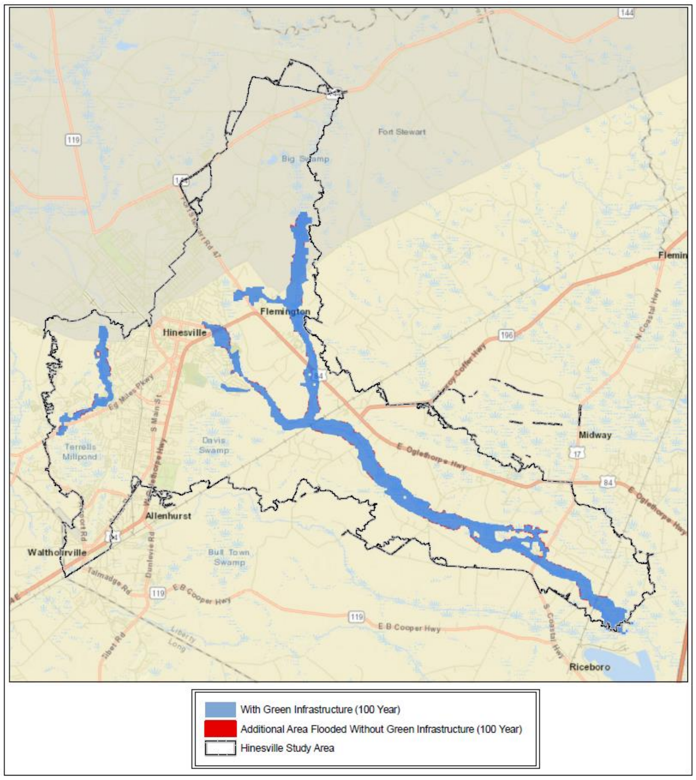

Figure 26: Current Riverine Flood Risk with Green Infrastructure for the 100-Year Return Period

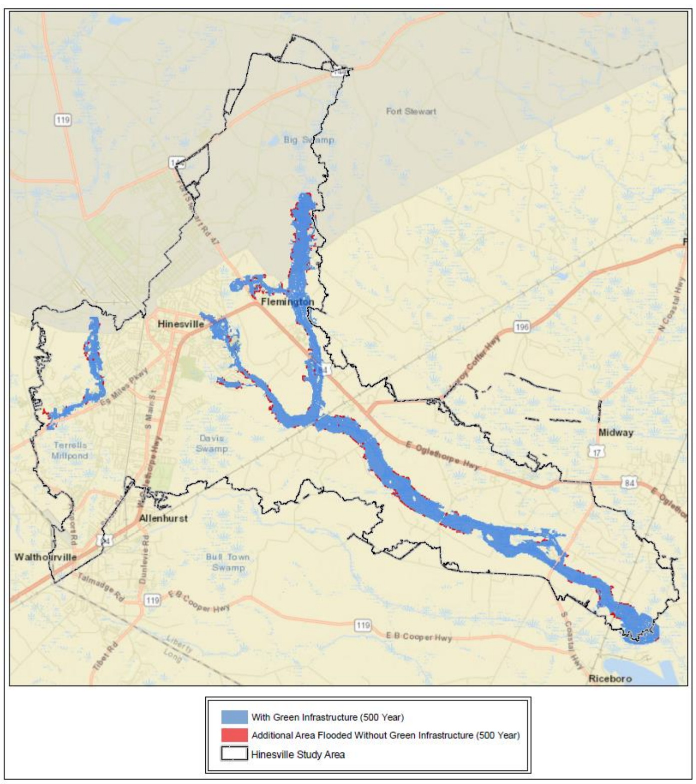

Figure 27: Current Riverine Flood Risk with Green Infrastructure for the 500-Year Return Period

A.2 Current Condition Coastal Flood Scenarios

No maps were developed for scenarios that modeled current coastal flood risk with green infrastructure for the 10, 25, 50, 100 or 500 return periods. While the depths of water were positively impacted as a result of the inclusion of green infrastructure (resulting in a reduction in potential losses), the extent of water remain unchanged.

A.3 Future Condition Riverine Flood Scenarios

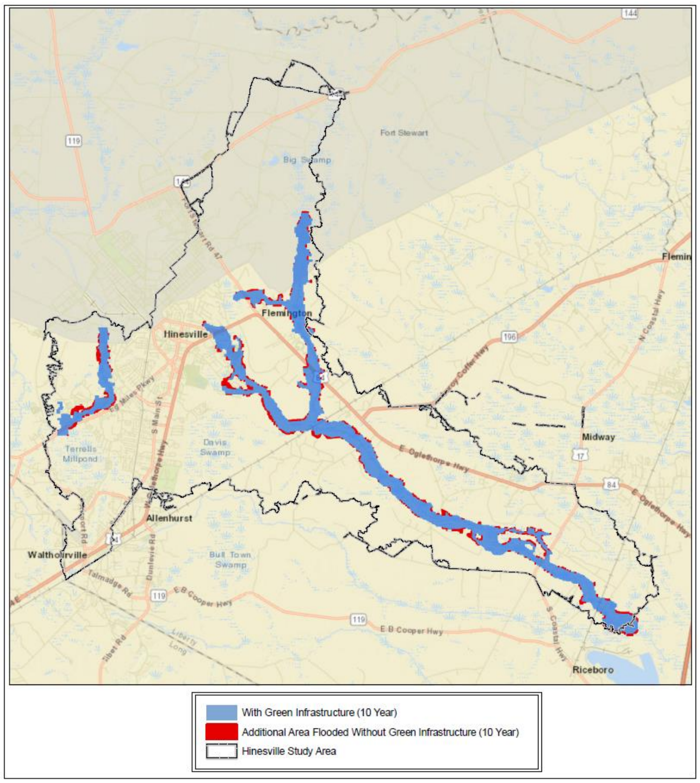

Figure 28: Future Condition Riverine Flood Risk with and without Green Infrastructure (10 year, 10th percentile) with "business as usual" projection of impervious surface area

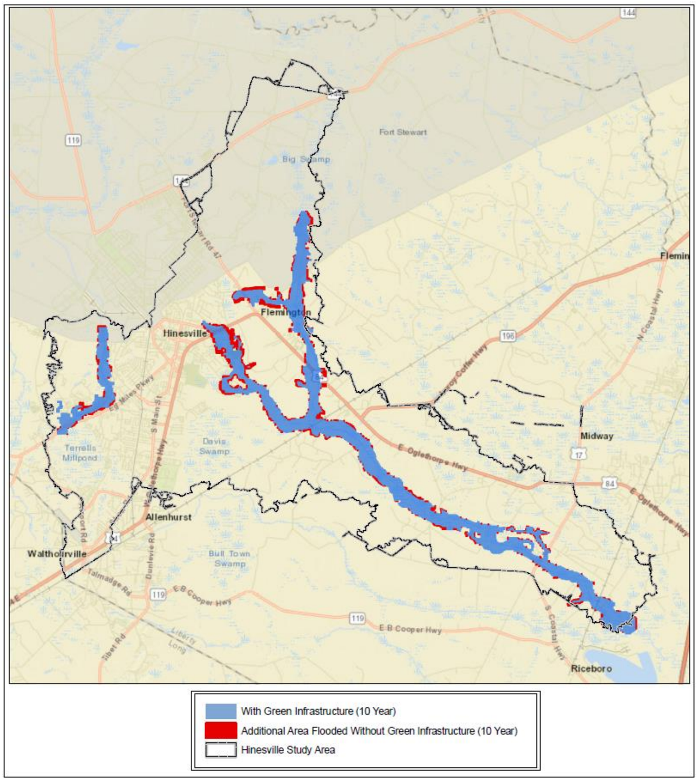

Figure 29: Future Condition Riverine Flood Risk with and without Green Infrastructure (10 year, 50th percentile) with “business as usual” projection of impervious surface area

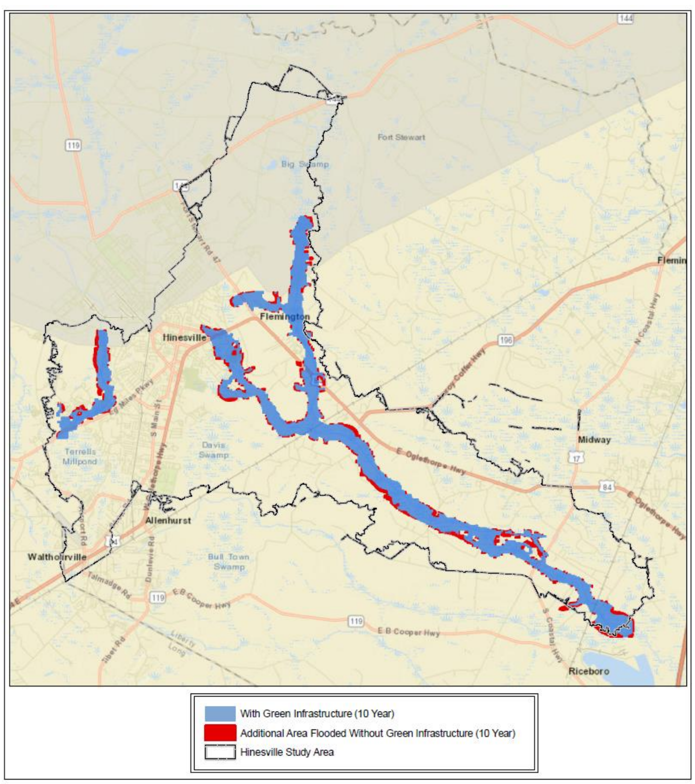

Figure 30: Future Condition Riverine Flood Risk with and without Green Infrastructure (10 year, 90th percentile) with “business as usual” projection of impervious surface area

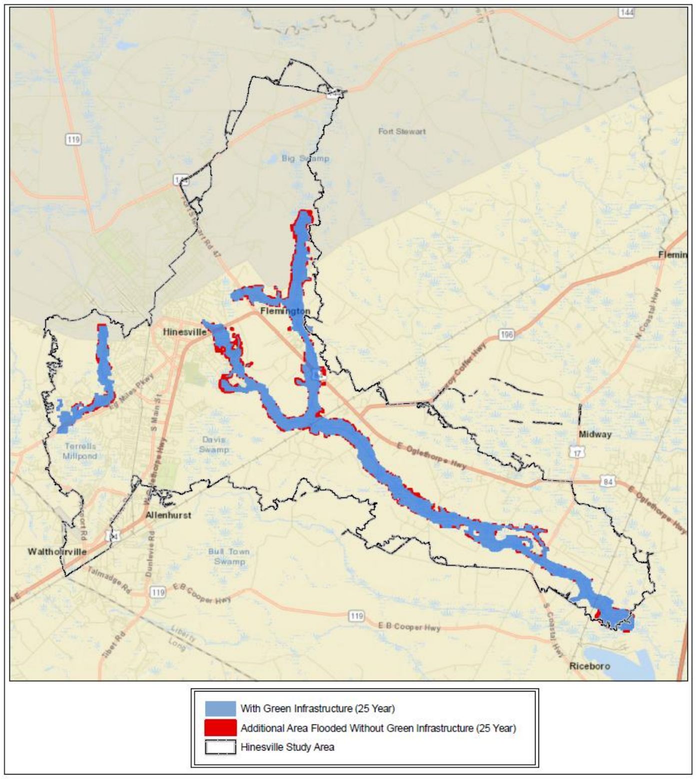

Figure 31: Future Condition Riverine Flood Risk with and without Green Infrastructure (25 year, 10th percentile) with “business as usual” projection of impervious surface area

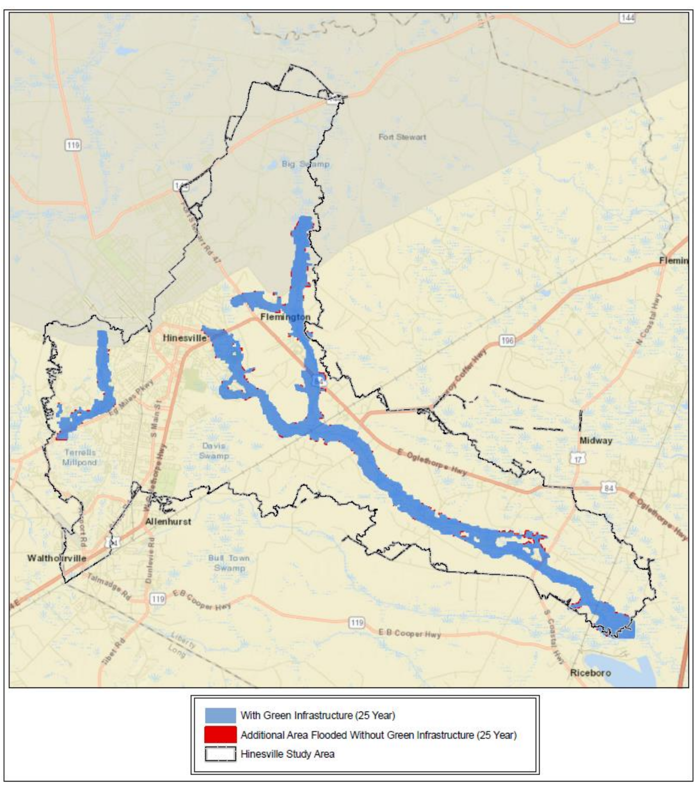

Figure 32: Future Condition Riverine Flood Risk with and without Green Infrastructure (25 year, 50th percentile) with “business as usual” projection of impervious surface area

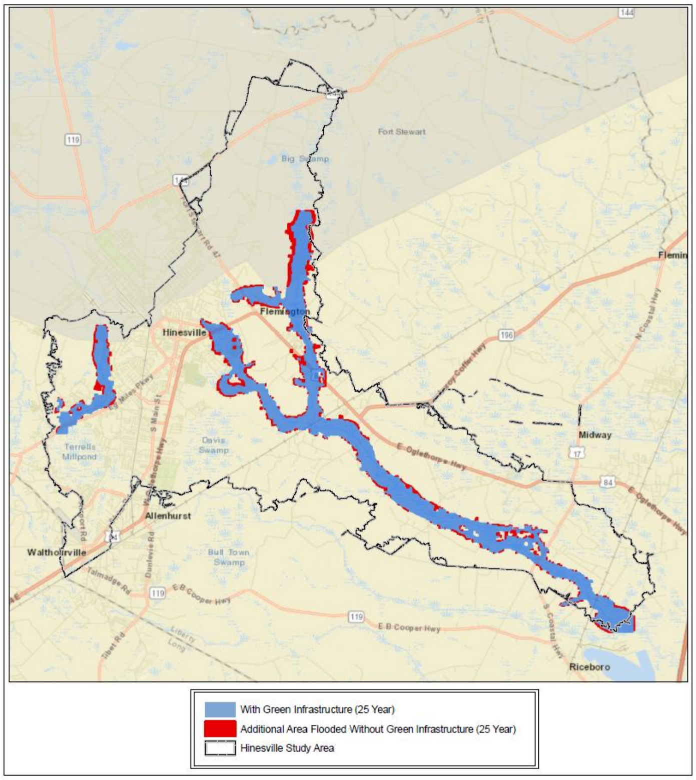

Figure 33: Future Condition Riverine Flood Risk with and without Green Infrastructure (25 year, 90th percentile) with "business as usual" projection of impervious surface area

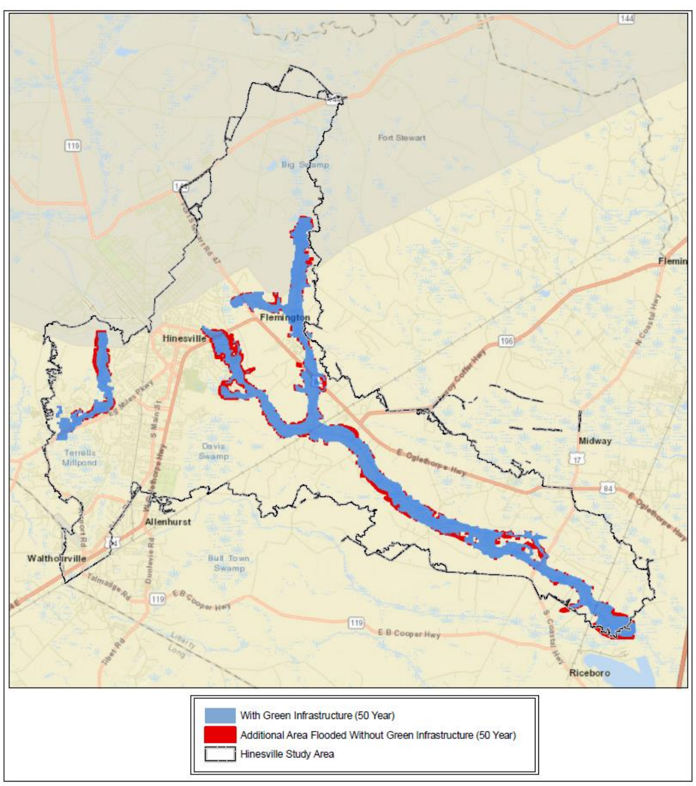

Figure 34: Future Condition Riverine Flood Risk with and without Green Infrastructure (50 year, 10th percentile) with "business as usual" projection of impervious surface area

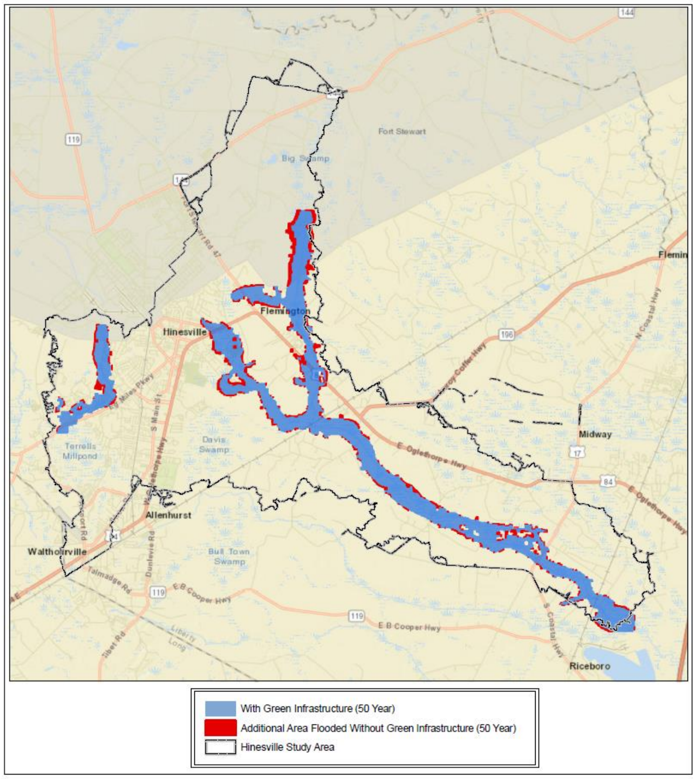

Figure 35: Future Condition Riverine Flood Risk with and without Green Infrastructure (50 year, 50th percentile) with "business as usual" projection of impervious surface area

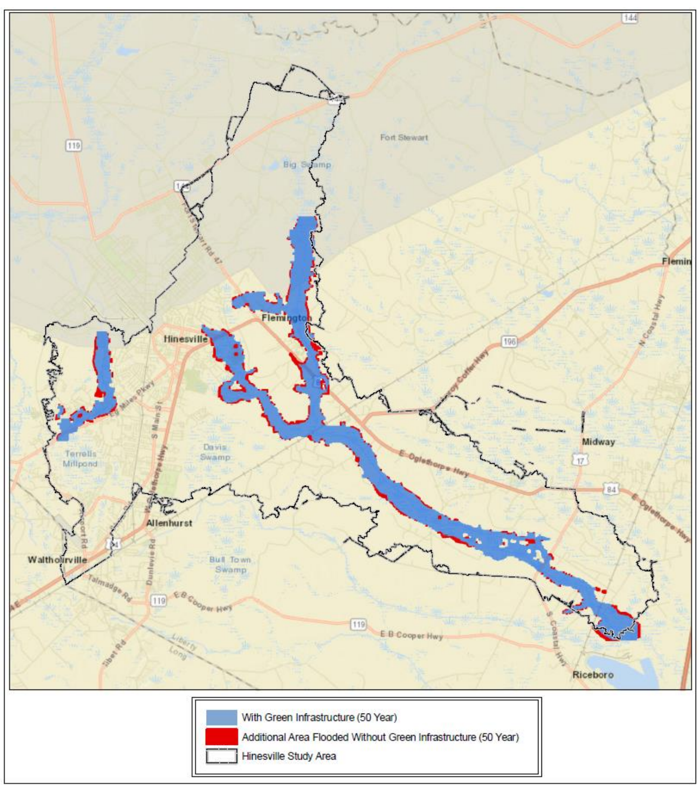

Figure 36: Future Condition Riverine Flood Risk with and without Green Infrastructure (50 year, 90th percentile) with "business as usual" projection of impervious surface area

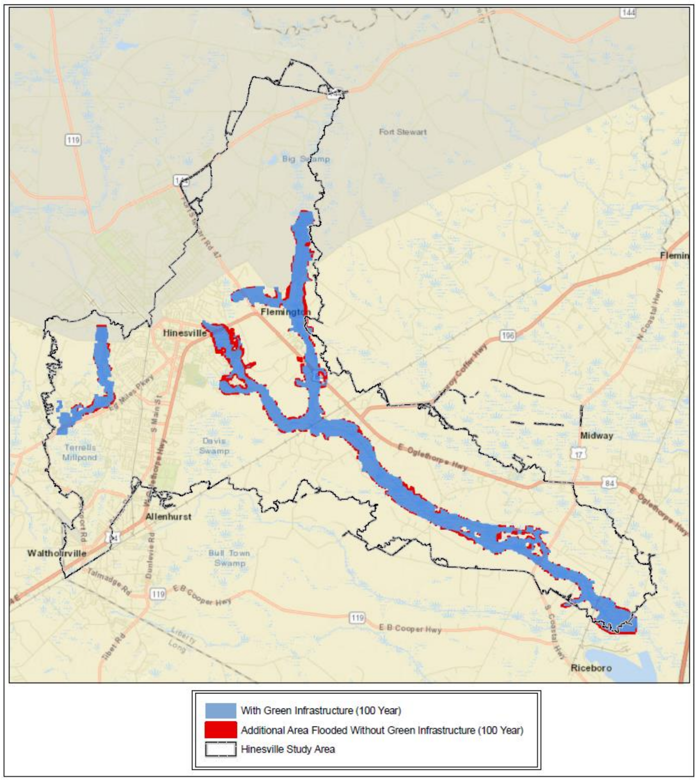

Figure 37: Future Condition Riverine Flood Risk with and without Green Infrastructure (100 year, 10th percentile) with "business as usual" projection of impervious surface area

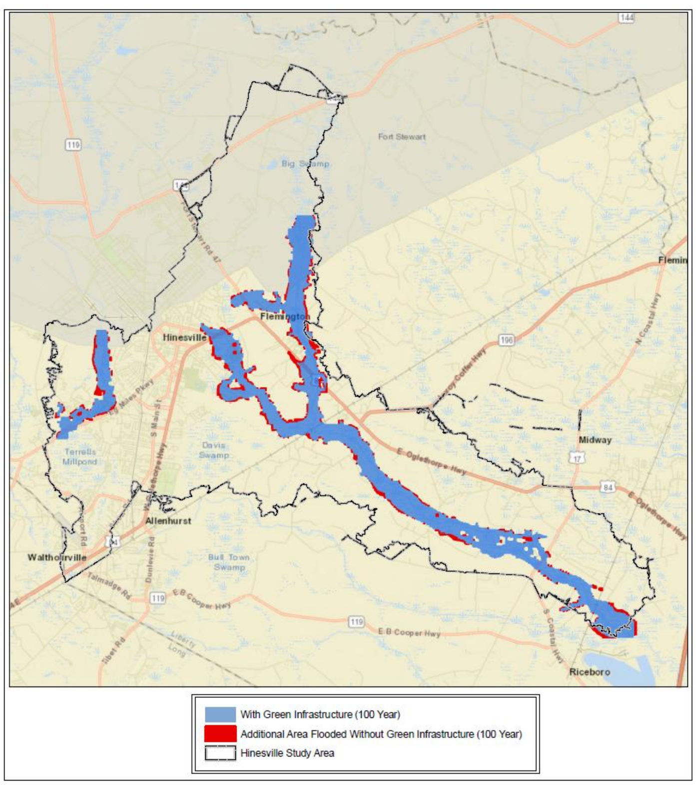

Figure 38: Future Condition Riverine Flood Risk with and without Green Infrastructure (100 year, 50th percentile) with "business as usual" projection of impervious surface area

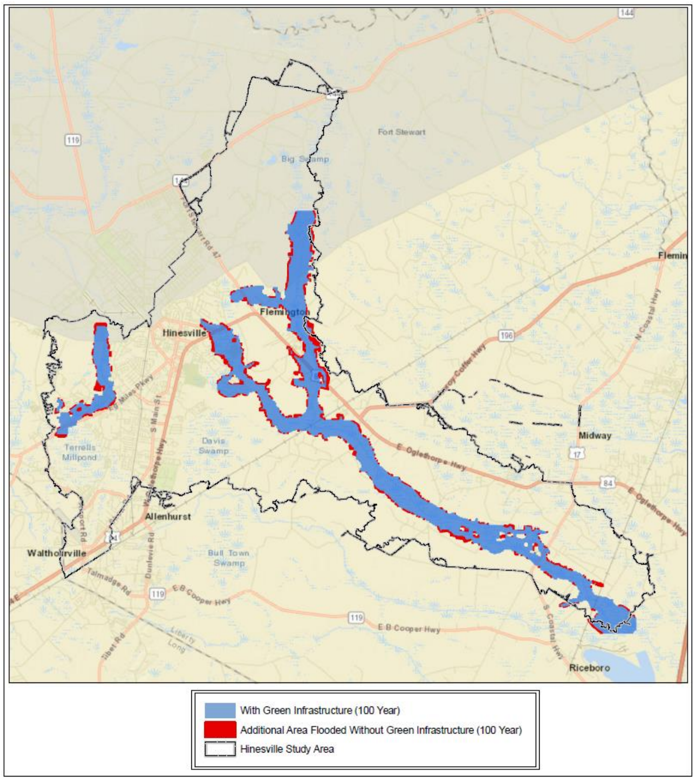

Figure 39: Future Condition Riverine Flood Risk with and without Green Infrastructure (100 year, 90th percentile) with “business as usual” projection of impervious surface area

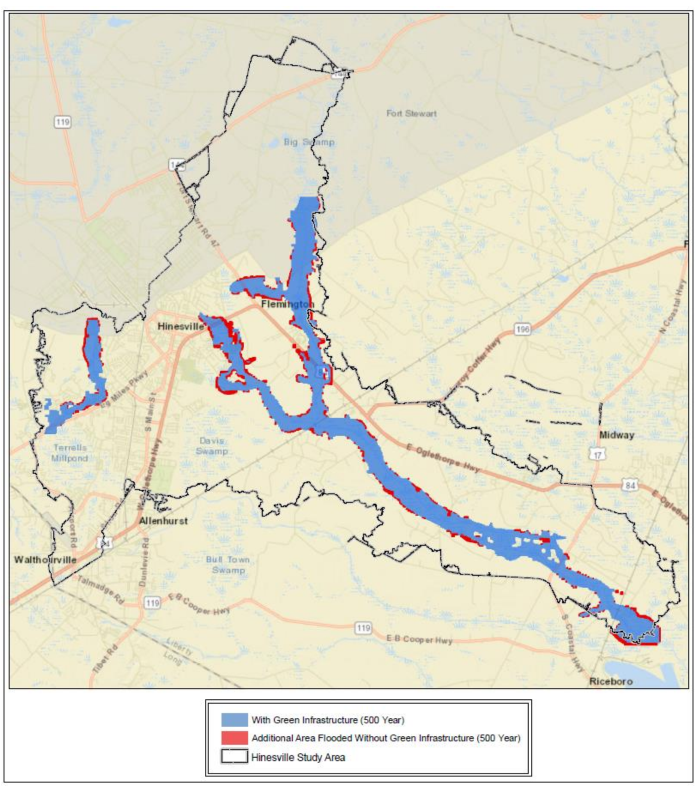

Figure 40: Future Condition Riverine Flood Risk with and without Green Infrastructure (500 year, 10th percentile) with “business as usual” projection of impervious surface area

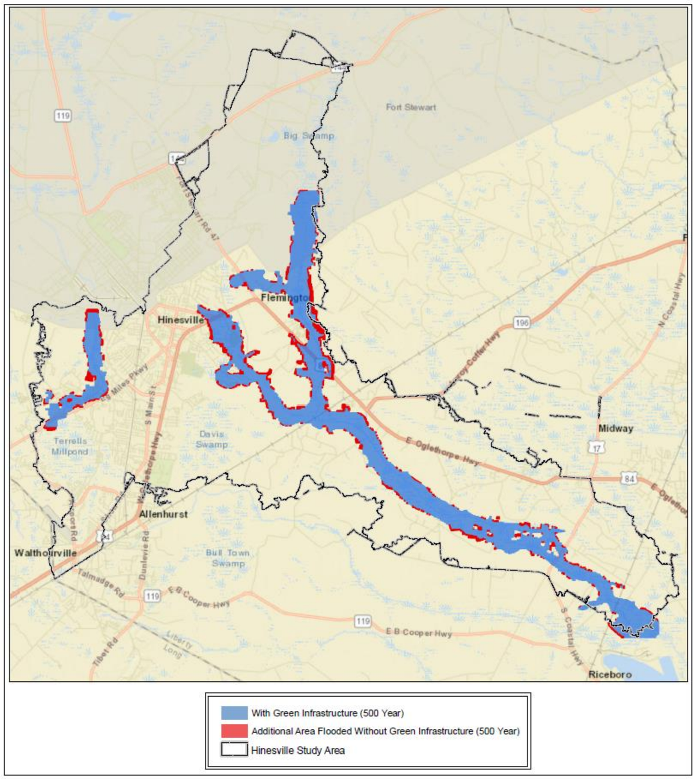

Figure 41: Future Condition Riverine Flood Risk with and without Green Infrastructure (500 year, 50th percentile) with "business as usual" projection of impervious surface area

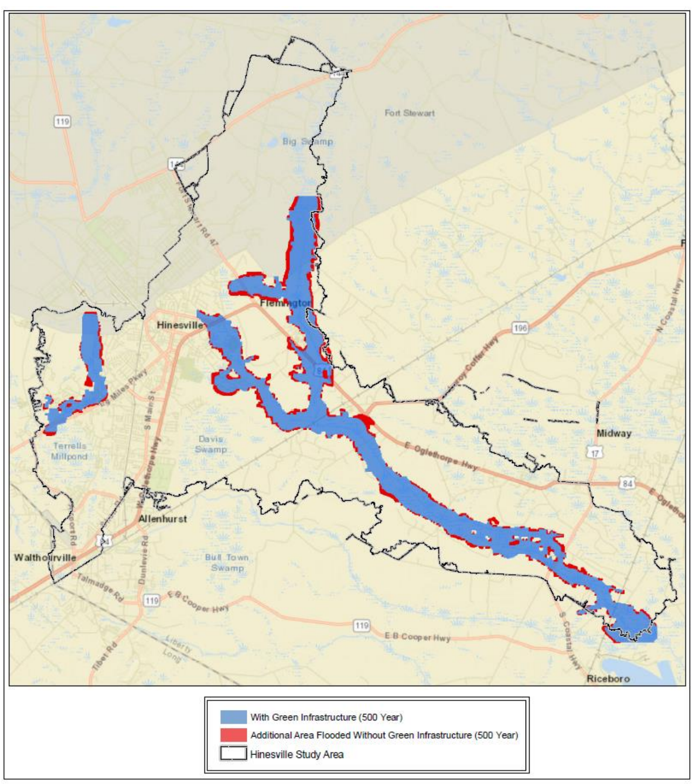

Figure 42: Future Condition Riverine Flood Risk with and without Green Infrastructure (500 year, 90th percentile) with "business as usual" projection of impervious surface area

A.4 Future Condition Coastal Flood Scenarios

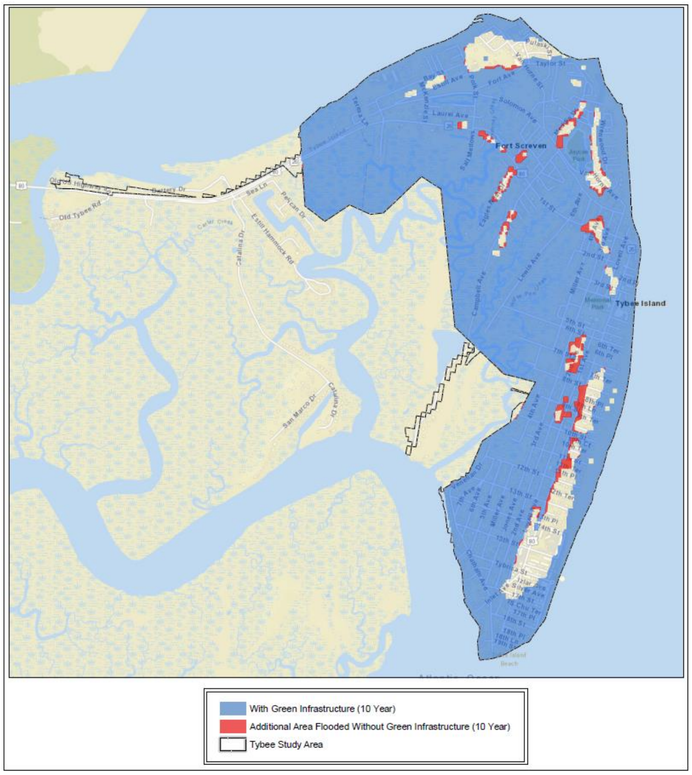

Figure 43: Future Condition Coastal Flood Risk with and without Green Infrastructure (Category 1 Hurricane)

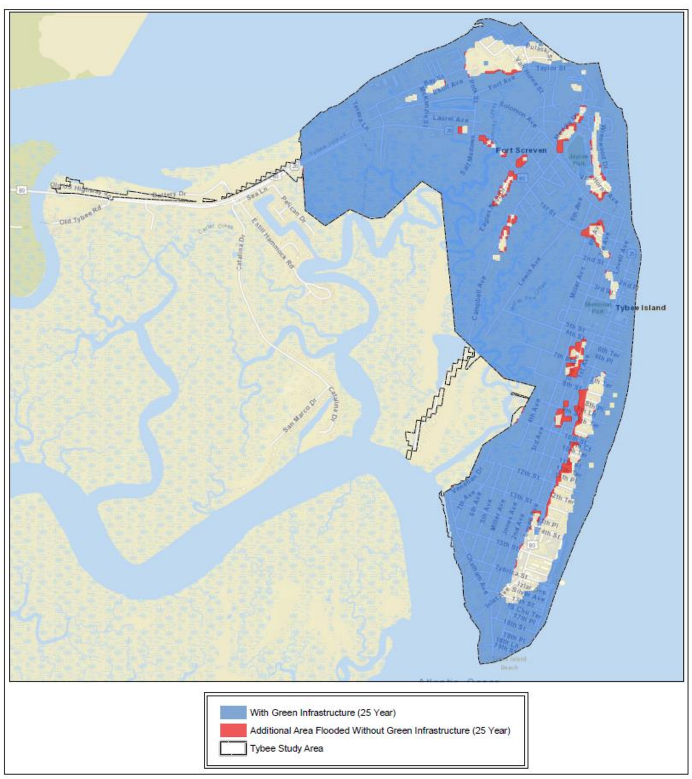

Figure 44: Future Condition Coastal Flood Risk with and without Green Infrastructure (Category 2 Hurricane)

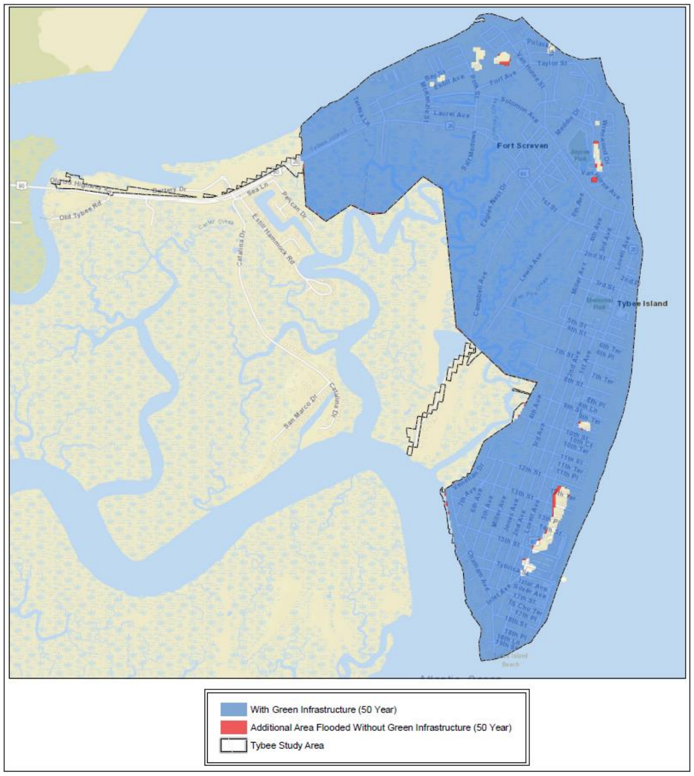

Figure 45: Future Condition Coastal Flood Risk with and without Green Infrastructure (Category 3 Hurricane)

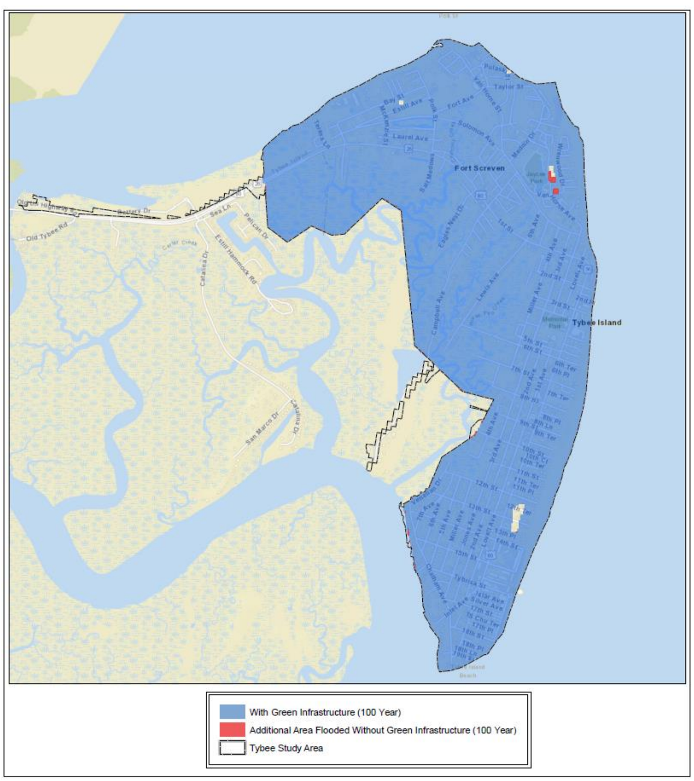

Figure 46: Future Condition Coastal Flood Risk with and without Green Infrastructure (Category 4 Hurricane)

Appendix B Results Graphs

In this appendix, graphs that summarize the results of all 118 scenarios are provided.

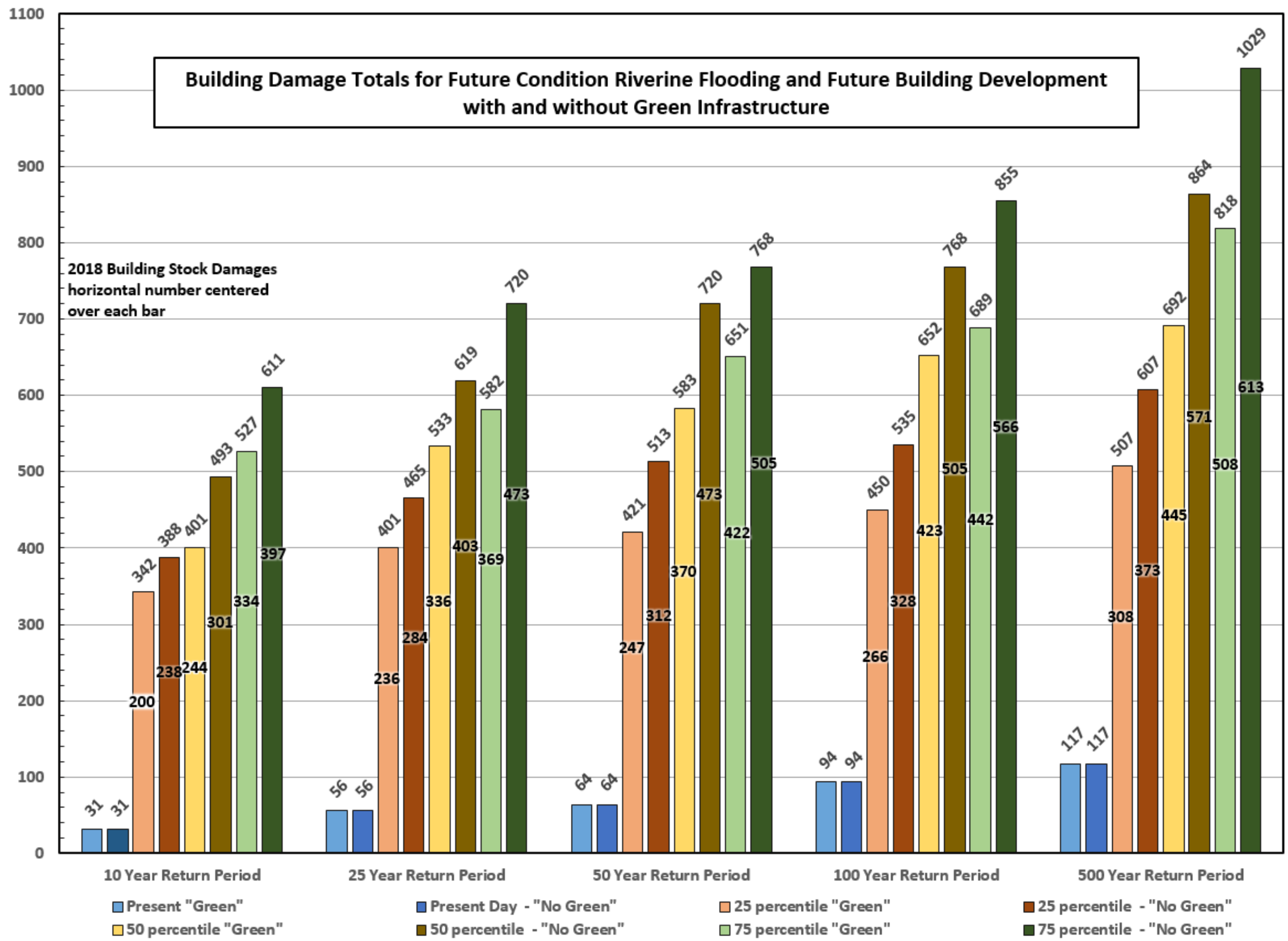

Figure 47: Building Damage Counts for all Riverine Flood Scenarios in this Study

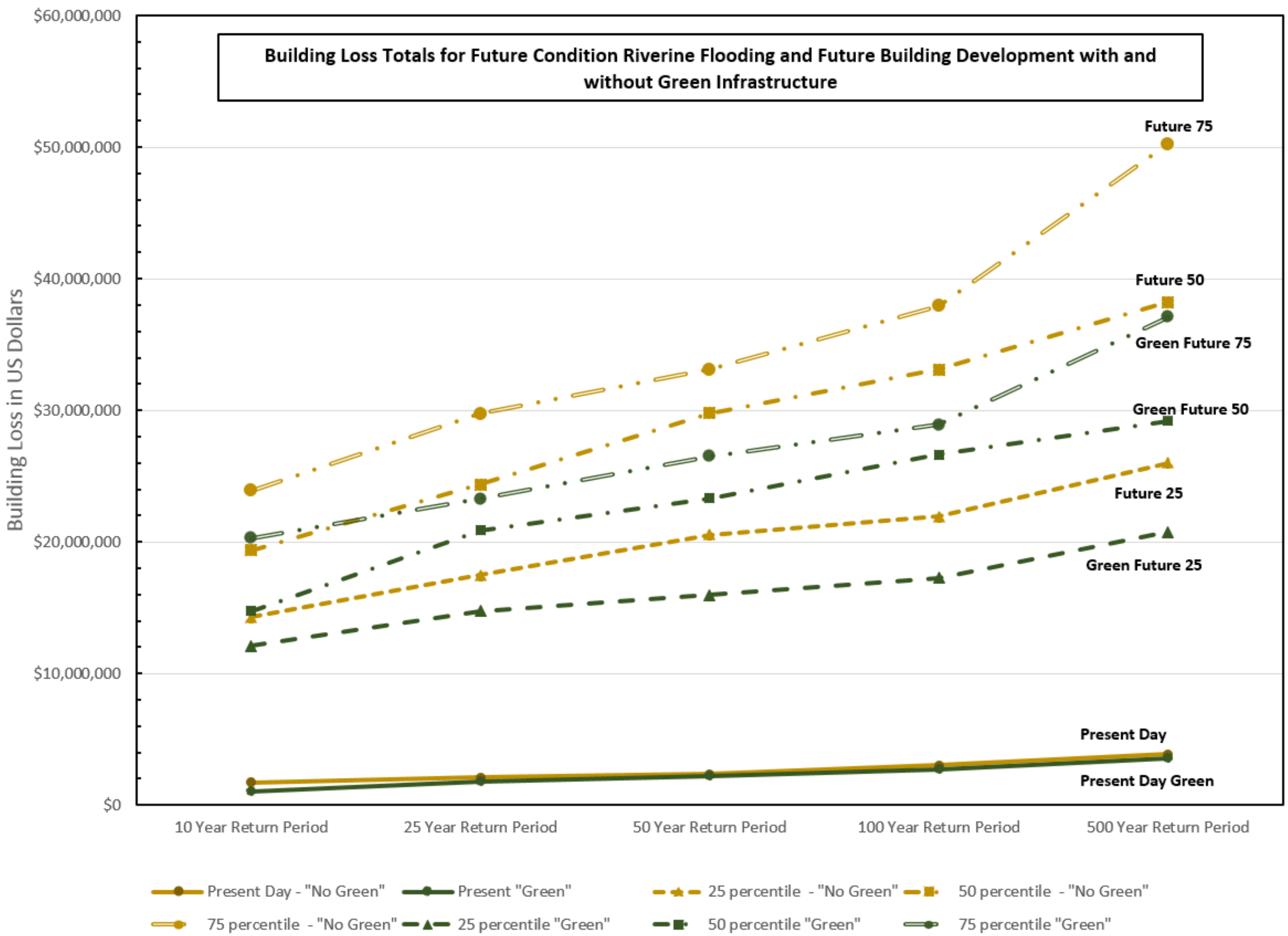

Figure 48: Building Damage Losses for all Riverine Flood Scenarios in this Study

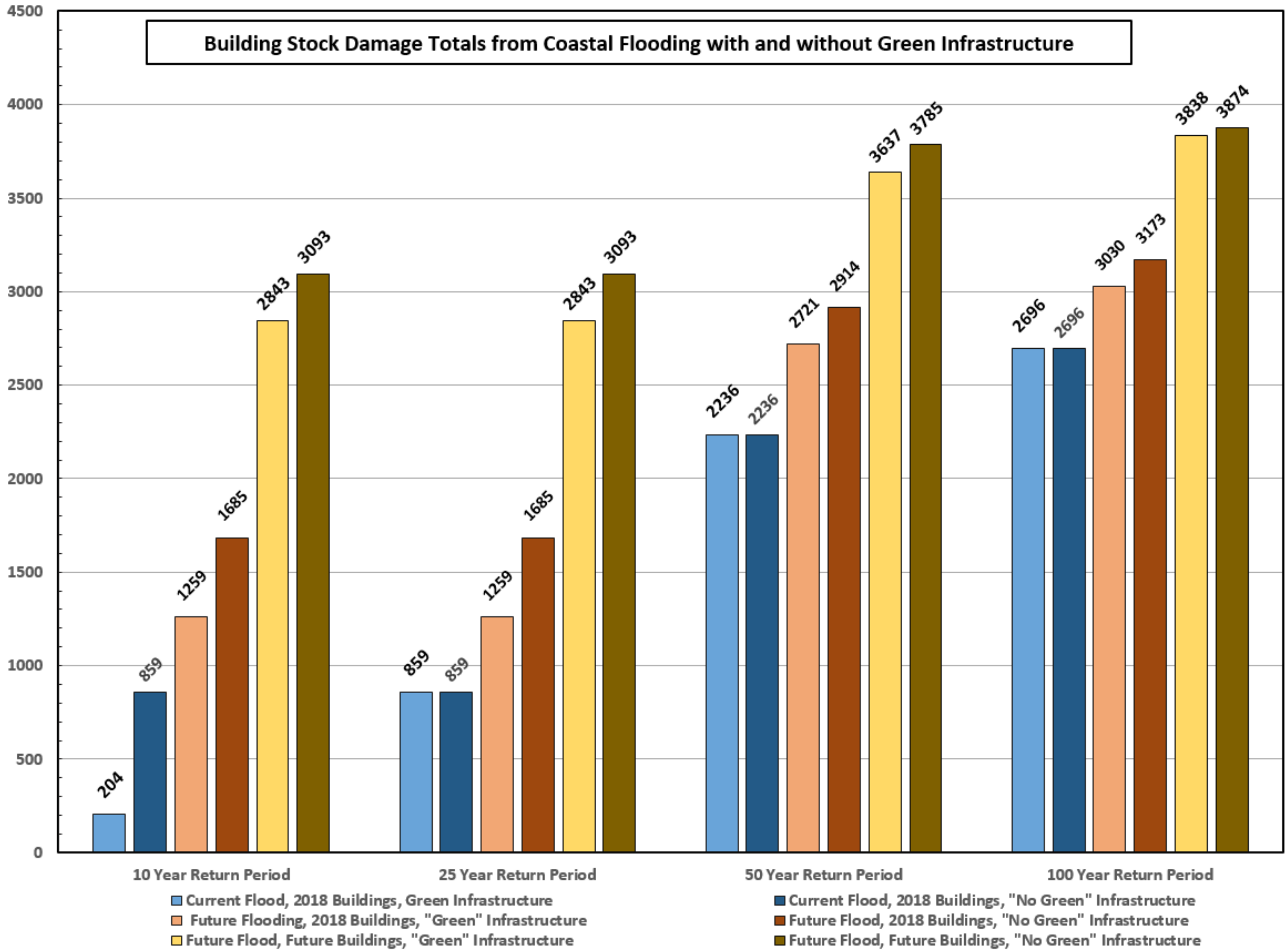

Figure 49: Building Damage Counts for all Coastal Flood Scenarios in this Study

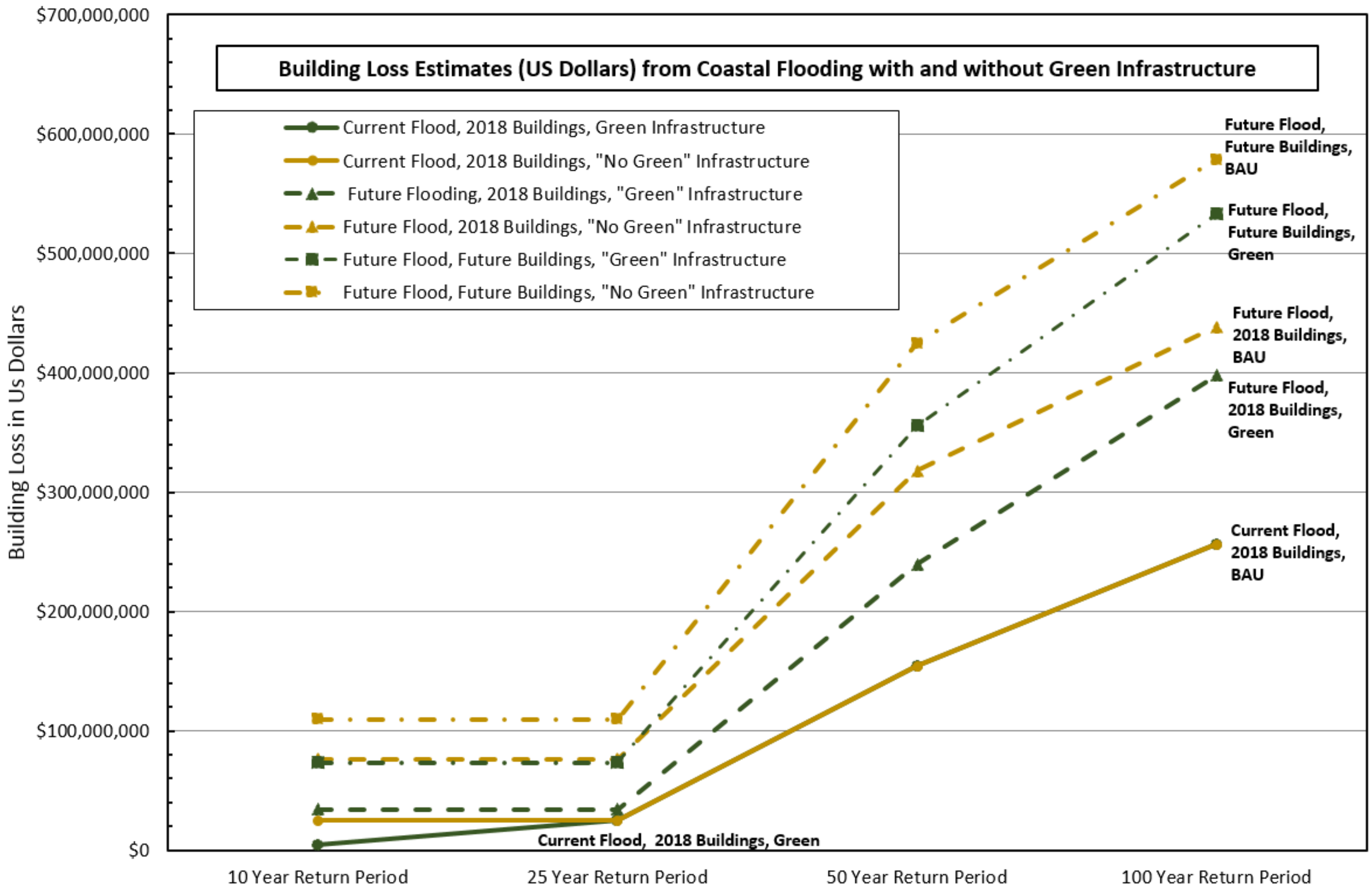

Figure 50: Building Damage Losses for all Riverine Flood Scenarios in this Study

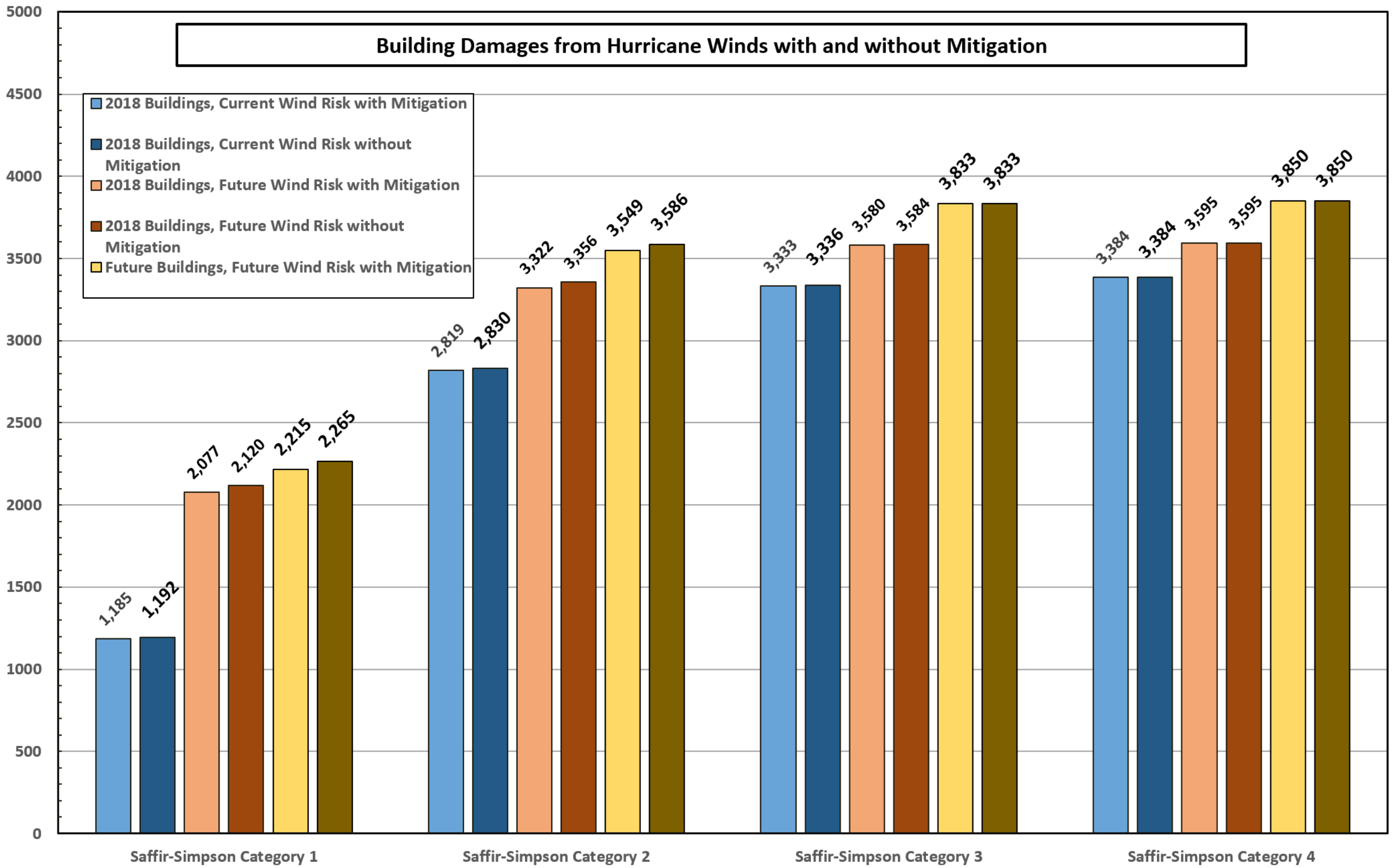

Figure 51: Building Damage Counts for all Hurricane Wind Scenarios in this Study

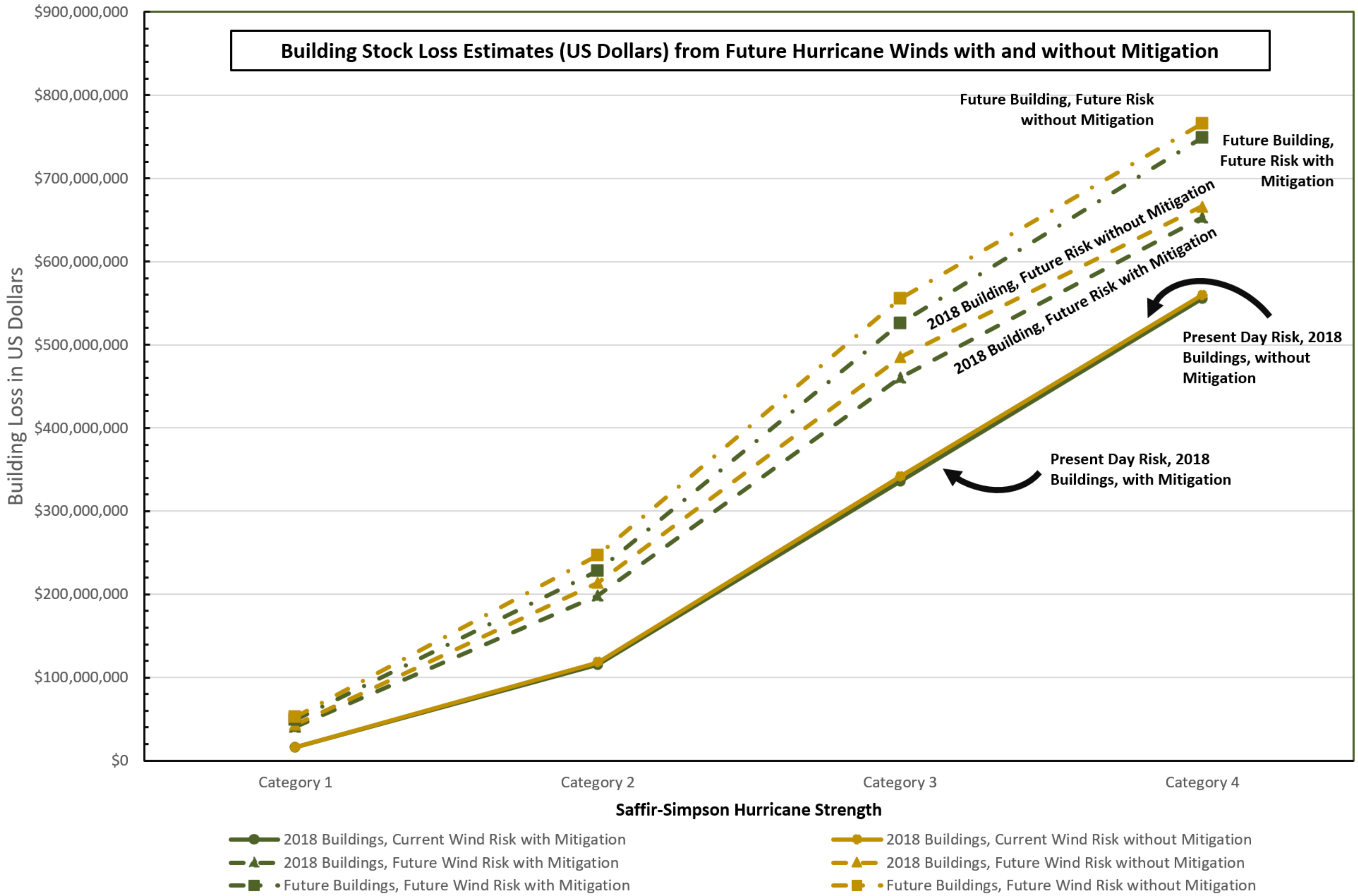

Figure 52: Building Damage Losses for all Hurricane Wind Scenarios in this Study