MIAMI-DADE COUNTY, FLORIDA

Miami-Dade Back Bay

COASTAL STORM RISK MANAGEMENT

Final Integrated Feasibility Report and

Environmental Assessment

Economic Environment and Social Considerations

Appendix A-5

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US Army Corps of Engineers ®
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MIAMI-DADE COUNTY

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1 ECONOMIC EVALUATION METHOD

1.1 Introduction

This appendix presents an economic evaluation of the Recommended Plan (RP) for the Miami-Dade Back Bay Coastal Storm Risk Management Feasibility Study. Due to the large geographic scale of the study and the inability to provide a comprehensive recommendation under this study effort, a process was completed to identify the most vulnerable areas based on high frequency flooding potential and social vulnerability. The process to identify those areas is fully described in Section 1 of the main report. This analysis was conducted in accordance with Engineer Regulation (ER) 1105-2-100, Planning Guidance Notebook, and ER 1105-2-101, Planning Guidance, Risk Analysis for Flood Damage Reduction Studies. The National Economic Development Procedures Manual for Flood Risk Management and Coastal Storm Risk Management, prepared by the Water Resources Support Center, Institute for Water Resources, was also used as a reference, along with the USACE Engineer Research and Development Center G2CRM Manual. G2CRM was used in this study since the model is designed to evaluate inundation of areas in a coastal environment wherein the effect of wave action contributes to the damage. The G2CRM analysis is covered in Section 2 of this appendix.

The economic appendix consists of a description of the methodology used to determine National Economic Development (NED) damage under existing and future conditions and projects costs. The damage and costs were calculated using October 2023 (FY24) price levels. Damage was converted to equivalent average annual values using the FY24 Federal discount rate of 2.75 percent and a period of analysis of fifty years. The year 2040 was identified as the base year for each of the alternatives as the basis for plan comparison.

1.1.1 National Economic Development Benefit Categories Considered

The NED procedure manuals for coastal and urban areas recognize four primary categories of benefits for flood risk management measures: inundation reduction, intensification, location, and employment benefits. The majority of the benefits attributable to a project alternative, generally, result from the reduction of actual or potential damage to buildings and/or its contents caused by inundation.

Physical Flood Damage Reduction

Physical flood damage reduction benefits include the decrease in potential damage to residential, commercial, industrial or public buildings and their contents. While future population growth was projected for the study area, a future development building inventory was not included in the damage calculations due to the limited remaining available land and the expectation that future growth will more likely be accomplished through redevelopment.

1.1.2 Regional Economic Development

When the economic activity lost in the flooded region can be transferred to another area or region in the national economy, these losses cannot be included in the NED account. However, the impacts on the employment, income, and output of the regional economy are considered part of the Regional Economic Development (RED) account. The input-output macroeconomic model RECONS was used to address the impacts of the construction spending only associated with the RP, since only this alternative provides detailed cost information necessary to prepare a complete and accurate analysis.

1.2 Study Area Description

1.2.1 Geographic Location

The County is located in the South Miami-Dade watershed approximately 230 miles southeast of Orlando, FL and approximately 120 miles east of Naples, FL. The County is bordered mostly by water with the Biscayne Bay in the center and the Atlantic Ocean to the east. The most populous county in Florida, Miami-Dade County is home to 34 incorporated municipalities, cities, towns and villages, as well as to unincorporated communities and neighborhoods. Additional major water bodies that traverse the County include Miami River, Little River, and a large number of various canals and waterways.

1.2.2 Land Use

The U.S. Census totals the number of developed and undeveloped land within Miami-Dade County as 1,899 square miles, with one third of this land area located in Everglades National Park. Miami-Dade County was established in 1836 and has since grown from an original population of 1,000 residents to over 2.7 million today. The County is split up into 34 different municipalities, with the City of Miami being the largest.

The County has established an Urban Development Boundary (UDB) that discourages development outside its bounds. Due to the density of the buildings in Miami-Dade County and the very limited vacant land, a future development building inventory was not included in the damage calculations. In 2008, the UDB contained 269,000 acres (420 square miles), of which approximately six percent was undeveloped. Very little land has been added to the UDB in the last twenty years. It is anticipated that the majority of future development will be the infill of buildings on the limited vacant land, or redevelopment.

1.2.3 Storm Damage History

According to the Miami-Dade Emergency Operations Center Comprehensive Emergency Management Plan Volume I (revised November 2017), Southeast Florida has experienced 35 hurricanes between 1994 and 2016 of which nine were major hurricanes (Category 3 or above). Over 1.9 million residents are required to evacuate in the event of a Category 5 hurricane which can become difficult due to surrounding counties evacuating simultaneously thus increasing clearance times. Residents also tend to delay evacuation until the last minute which results in further traffic jams and clearance times. More detailed storm information is available in Section 1 of the main report. **Table 1** shows the historic FEMA flood claims in MDC since 1978 as of October 29, 2019, with price levels adjusted to 2024.

Table 1. Historic Federal Emergency Management Agency Flood Claims in Miami-Dade County

Total Claims Since 1978	Total Paid Since 1978	Average Amount Paid Per Claim	Total Claims Since 1978
57,785	$955,743,735	$16,539	57,785

1.3 Socioeconomic Setting

The impacts of flooding affect local industries, including tourism, commercial shipping/logistics, technology, and education, as well as residents of the peninsula. Business operations are reduced when anticipating a coastal storm, especially if evacuation orders are issued, but if the storm significantly damages property and infrastructure, operations would be impacted for a longer duration of time. Residents may have flood insurance to cover some damage, but they are still financially impacted by storm events.

1.3.1 Population and Number of Households

Table 2 displays the population for the County for the years 1980, 1990, 2000, and 2010, as well as projections for the years 2020 and 2040. The County experienced relatively constant population growth between the years 1980 and 2010 and is expected to maintain this growth rate in the next 20 years according to the U.S Census Bureau.

Table 2. Historical and Projected Miami-Dade Population (1,000s)

County	1980	1990	2000	2010	2020	2040
Miami-Dade	1,625	1,937	2,259	2,507	2,861	3,367

Table 3 shows the total number of households in the County for the years 1990, 2000, and 2010, and projections for years 2020 and 2040. The projected number of households was based on U.S. Census Bureau data and extended from the year 2030 to the year 2040 based on the compound annual growth rate population growth rate forecasted by U.S Census Bureau.

Table 3. Number of Households in Miami-Dade County

County	1980	1990	2000	2010	2020	2040
Miami-Dade	1,625	1,937	2,259	2,507	2,861	3,367

The County experienced a decline in the rate of increasing total number of households between 1990 through 2010, followed by an increasing growth rate starting in year 2010. From year 2010 to 2040, the total number of households is expected to increase by approximately 33%, with Northern Miami and the Miami Beach area expected to experience the most household growth at a 54% increase and 45% increase respectively. The West Miami area is expected to see the least household growth at a 3% increase. In the year 2010, 58% of households were single-family, 41% were multifamily, and 2% were mobile homes; by 2040 it is projected that only 48% of households will be single-family and only 1% mobile homes, with the largest household category becoming multifamily at 51% (2040 Miami-Dade Transportation Plan).

1.3.2 Income

Table 4 displays the median household income levels for Miami-Dade County for the years 1990, 2000, 2005, 2010, 2014, 2018, and 2021, the year with the latest available data according to the U.S. Bureau of Economic Analysis. As shown in the table and based on Bureau of Economic Analysis data, Miami-Dade County experienced a steady increase in household income between 2000 and 2018. In 2010, 29% of households earned less than $25,000 annually, and 26% earned between $25,000 - $50,000. It is expected in the year 2040 for the annual household income of these two categories to be 31% and 26% respectively (2040 Miami Transportation Plan).

Table 4. Median Household Income ($)

County	2000	2005	2010	2014	2018	2021
Miami-Dade	33,228	37,142	40,145	42,754	52,043	57,815

1.3.3 Employment

Table 5 displays the total number of employed civilians by industry in Miami-Dade County age 16 and up based on 2023 Bureau of Labor and Statistics data. According to this data, approximately 58% of employed civilians in Miami-Dade are white collar workers, while 20% are considered blue collar and 22% are considered service and farm. The unemployment rate of Miami-Dade County in 2018 was 6.33%.

Table 5. 2023 Employed Civilians 16+ by Industry of Miami-Dade County

Category	Total Persons	Percentage of Total
Accommodation/Food Services	118,883	8.90%
Admin/Support/Waste Management	77,548	5.81%
Agriculture/Fishing/Hunting	8,942	0.67%
Entertainment/Recreation Services	27,241	2.04%
Construction	111,093	8.32%
Education Services	96,356	7.22%
Insurance/Real estate/Rent/Lease	100,506	7.53%
Health Care/Social Asst.	173,381	12.99%
Information	24,844	1.86%
Management of Companies	1,970	0.15%
Total Manufacturing	56,109	4.20%
Other Services	77,713	5.82%
Prof/Sci/Tech/Admin	99,429	7.45%
Public Administration	42,258	3.17%
Retail Trade	155,864	11.67%
Transport/Warehouse/Utils	115,348	8.64%
Wholesale Trade	47,636	3.57%
Total	1,335,121	100.00%

The County's economy is diverse and includes Federal government, higher education, manufacturing, port activity, residential construction, downtown business and residential development, and the medical and health professions. Economic growth within the county is expected to continue due to proximity to major transportation routes such as Interstate 95, the Port of Miami, Miami International Terminal, and Miami International Airport.

In all portions of the study area, growth is highly dependent upon the major employment sectors. A steady pace in employment in Miami-Dade County is likely the result of the influx of population and businesses that support the Port of Miami and Miami International Airport. From the years 2010 to 2040, growth is expected in all employment industries excluding Agriculture, with the most growth of 68% expected in the health care and restaurant industries and the least growth in the utilities industry at 28%. Due to limited development outside the UDB, the agriculture industry is expected to decline approximately 33% between 2010 and 2040. Miami-Dade County has a gross domestic product (GDP) of approximately $111 billion, with the largest contributing sector being Finance, Insurance and Real Estate at 26%, followed by Wholesale and Retail Trade at 16%.

1.3.4 Compliance

Given continued growth in population and employment, it is expected that development or, most likely, redevelopment will continue to occur in the study area with or without a coastal storm risk management system. In general, this will not conflict with Policy Guidance Letter (PGL) 25 and Executive Order 11988, which states that the primary objective of a flood risk reduction project is to protect existing development, rather than to make undeveloped land available for more valuable uses. The overall growth rate is anticipated to be the same with or without the project in place as no new lands will be created but rather measures will reduce the risk of population being displaced. All measures considered as part of this study are nonstructural and will not change depths, extents, or frequency of flooding in the study area. However, it is possible that the construction of structural measures outside the scope of this study could reduce the perceived necessity for higher flood risk management standards and therefore, redevelopment behind structural measures could occur at lower standards than if the structural measures were never constructed. It is, therefore, recommended that buildings with lowest adjacent grades at or below the effective FEMA Base Flood Elevation (BFE) be treated as if they will remain within a regulatory floodplain and be subject to the existing floodplain ordinance.

1.4 Scope Of Study

The study investigated nonstructural measures that comprise alternative plans. Project alternatives, including the RP, are described in the main report in Sections 8 and 9.

1.4.1 Determination of Study Area

It was determined that there are six socially vulnerable economic damage centers within the study area: Biscayne Canal, Cutler Bay, Little River, Miami River, North Beach, and South Beach. These were determined by identifying high frequency storm areas intersecting with environmental justice communities. Those areas were further refined and/or adjusted using Miami-Dade County's Adaptation Action Areas and FEMA's repetitive loss and severe repetitive loss areas. Further information regarding this analysis is in Section 1 of the main report.

1.4.2 Nonstructural Measures

After thorough screening, which is described in Section 4.3.6 Screening of Measures in the main report, the following nonstructural measures are being considered within these areas.

- Elevation of residential homes and multifamily buildings of four units or less
- Dry floodproofing of nonresidential buildings and critical infrastructure (CI).

1.5 Study Methodology

To develop plans to address water resource problems within a study area, three conditions must be fully analyzed: the "existing" condition, the "future without project" condition, and the "future with project" condition.

In this analysis, the existing condition represents current conditions that is without sea level change. The future without project condition is the condition that would likely exist in the future without the implementation of a Federal project and incorporates sea level change. This condition is evaluated for a 50 year period for coastal storm management projects, and the results are expressed in terms of average annual damage. For this study, the future without project condition is for the years 2040-2089. The future with project condition is the condition that would likely exist in the future with the implementation of a Federal project, using the same 50 year period as in the future without project condition.

The difference in expected annual flood damage to the Miami-Dade County study area assets between the future without and with project conditions represents the flood risk management benefits to the project. Economic and other significant outputs may accrue to the project as well, including recreation benefits, ecosystem restoration benefits, regional economic benefits, and other social effects. Other social effects, which often defy quantification in monetary terms, range from improvement in the quality of life within the study area to community impacts. This analysis attempts to recognize and, where possible, quantify the reduction of damage from coastal storm surge inundation due to the Federal project in the study area (i.e. NED benefits).

1.6 Assumptions Used in Computing Damage

This section of the analysis presents the assumptions used in computing average annual equivalent flood damage for the study area:

- Floodplain residents will react to a floodplain management plan in a rational manner.
- Buildings will continue to be repaired to pre-flood conditions after each flood event. The standard assumption is one rebuild per ten years over a fifty-year period of analysis. This results in a maximum rebuild of 5 times, and not removed from the asset inventory (i.e., cumulative damage threshold not used).
- Residential buildings are raised after receiving substantial damage within the period of analysis if the asset FFE is lower than the BFE. Substantial damage is defined by FEMA as total cost of repairs is fifty percent or more of the building's market value before the disaster occurred. Once that level is reached, the building would be raised to the effective FEMA BFE plus one additional foot to account for freeboard. Note that G2CRM does not use market value but instead uses depreciated replacement values; therefore, the 50% threshold may be higher or lower than market value for some buildings. The FEMA BFE used in the model is the effective FEMA BFE from 2009; therefore, the target elevation to which the model assumes buildings will be elevated may be represented lower once sea level change is considered. For that reason, an assumption was made that buildings would be elevated to eight feet above existing ground elevation due to any substantial damage in the Future without Project (FWOP) condition.
- Nonresidential depth-percent damage relationships for buildings are from expert elicitation found in the revised 2013 draft report completed by the USACE Institute of Water Resources. Nonresidential flood depth-damage functions derived from expert elicitation are assumed to be representative of nonresidential buildings in the floodplain (USACE and URS, 2009 Revised 2013).
- A facility-level depth-damage relationship was developed for the Central District Wastewater Treatment Plant (CDWWTP) that assumes a constant percentage of damage at a given stage for seven CDWWTP components.
- The present value damage, first costs, and benefits were annualized using the FY 2024 Federal discount rate of 2.75% assuming a period of analysis of 50 years.
- All values are equivalent to October 2023 FY 24 dollars.

- All project alternatives are evaluated for a 50 year period of analysis.
- The project construction is scheduled to begin in 2027.
- The project base year, the year in which benefits begin to accrue, is assumed to be 2040.
- The final year of the 50-year period of analysis ends December 31, 2089.
- Unless otherwise stated, elevations are in feet (ft.) North American Vertical Datum of 1988 (NAVD88).
- Sea level change follows the USACE high curve and used a sea level change (SLC) rate of 0.0138 feet per year based on the National Oceanic and Atmospheric Administration (NOAA) Vaca Key tide gage. The high USACE SLC curve was analyzed. Sensitivity analysis was performed on the Intermediate and Low SLC curves.
- Depreciation is calculated for buildings during the life cycle analysis by determining the depreciated replacement value.

1.7 Risk And Uncertainty

Risk and uncertainty are inherent in water resources planning and design. These factors arise due to errors in measurement and from the innate variability of complex physical, social, and economic situations. The measured or estimated values of key planning and design variables are rarely known with certainty and can take on a range of possible values. Risk analysis in flood risk management projects is a technical task of balancing risk of design exceedance with reducing the risk from flooding; trading off uncertainty of flood levels with design accommodations; and providing for reasonably predictable project performance. Risk-based analysis is therefore a methodology that enables issues of risk and uncertainty to be included in project formulation.

The U.S. Army Corps of Engineers (USACE or Corps) has a mission to manage flood risks:

"The USACE Flood Risk Management Program (FRMP) works across the agency to focus the policies, programs and expertise of USACE toward reducing overall flood risk. This includes the appropriate use and resiliency of structures such as levees and floodwalls, as well as promoting alternatives when other approaches (e.g., land acquisition, flood proofing, etc.) reduce the risk of loss of life, reduce long-term economic damage to the public and private sector, and improve the natural environment."

As a part of that mission, USACE developed the Generation II Coastal Risk Model (G2CRM) to support planning-level studies of hurricane protection systems (HPS).

1.8 G2CRM Model Overview

G2CRM is distinguished from other models currently used for that purpose by virtue of its focus on probabilistic life cycle approaches. This allows for examination of important long-term issues including the impact of climate change and avoidance of repetitive damage. G2CRM is a desktop computer model that implements an object-oriented probabilistic life cycle analysis (PLCA) model using event-driven Monte Carlo simulation (MCS). This allows for incorporation of time-dependent and stochastic event-dependent behaviors such as sea level change, tide, and building raising and removal. The model is based upon driving forces (storms) that affect a coastal region (study area). The study area is comprised of individual sub-areas (model areas) of different types that interact hydraulically and may be defended by coastal defense elements that serve to shield the areas and the assets they contain from storm surge flooding. Within the specific terminology of G2CRM, the important modeled components are:

- Driving forces - storm hydrographs (surge and waves) at locations, as generated externally from high fidelity storm surge and nearshore wave models such as ADCIRC and STWAVE;
- Modeled areas (MAs) - areas of various types (coastal upland, unprotected area) that comprise the overall study area. The water level in the modeled area is used to determine consequences to the assets contained within the area.
- Protective system elements (PSEs) - the infrastructure that defines the coastal boundary be it a coastal defense system that protects the modeled areas from flooding (levees, pumps, closure buildings, etc.), or a locally developed coastal boundary comprised of bulkheads and/or hardened shoreline.
- Assets – spatially located entities that can be affected by storms. Damage to building and contents is determined using damage functions. For buildings, population data at individual buildings allows for characterization of loss of life for storm events.

The model deals with the engineering and economic interactions of these elements as storms occur during the life cycle, areas are inundated, protective systems fail, assets are damaged, and lives are lost. A simplified representation of hydraulics and water flow is used. Modeled areas currently include unprotected areas and coastal uplands defended by a seawall or bulkhead. Protective system elements are limited to bulkheads/seawalls.

1.8.1 Modeling Variables

According the USACE Engineering Regulation (ER) 1105-2-101, 7. Variables in Risk Assessment. (b.):

A variety of variables and their associated uncertainties may be incorporated into the risk assessment of a flood risk management study. For example, economic variables in an urban situation may include, but are not necessarily limited to depth-damage curves, structure values, content values, structure first-floor elevations, structure types, flood warning times, and flood evacuation effectiveness. Uncertainties in economic variables include building valuations, inexact knowledge of structure type or of actual contents, method of determining first-floor elevations, or timing of initiation of flood warnings. Other key variables and associated uncertainties include the hydrologic and hydraulic conditions of the system. Uncertainties related to changing climate should be addressed using the current USACE policy and technical guidance.

Monte Carlo Simulation (MCS) is a method for representing uncertainty by making repeated runs (iterations) of a deterministic simulation, varying the values of the uncertain input variables according to probability distributions. Economic variables are input using a triangular distribution. The following sections attempt to characterize the uncertainties for both the economic and engineering inputs that went into the G2CRM for the study area.

1.8.2 Economic Inputs

Uncertainty was quantified for errors in the underlying components of building values for residential and nonresidential buildings, content to structure (building) value ratios for residential and nonresidential buildings, depth-percent damage relationship for both residential and nonresidential buildings, and first floor elevations for all buildings. G2CRM used the uncertainty surrounding these variables to estimate the uncertainty surrounding the storm-damage relationships developed for each in the study area.

The uncertainty surrounding each of the economic and engineering variables is also considered in the model. Either a normal probability distribution, with a mean value and a standard deviation, or a triangular probability distribution, with a most likely, maximum and minimum value, was entered into the models to quantify the uncertainty associated with the key economic variables.

Structure (Building) Inventory

Parcel and building polygons were downloaded from Miami-Dade County's GIS portal site to assist with characterizing residential and nonresidential buildings for the economic analysis. Data included addresses, property class description, occupancy type, total value, property use, dwelling year built, number of units, etc. First floor elevations (FFE) were calculated based on the following:

1. Foundation type data per asset was deemed unreliable. Therefore, assets were organized into single-family residential, multifamily residential, and nonresidential bins. Elevation certificate sample data was linked up with the assets within the modeled areas. The sample size consisted of approximately 238 assets for which there were elevation certificate data.
    - This data was then added to the building's lowest adjacent grade (LAG) using LiDAR data. This was accomplished by getting zonal statistics in GIS on the edges of the building's polygons to determine the LAG at the potential entrance of a building. The foundation heights added onto the LAG resulted in the calculated FFE.
2. The calculated FFEs were verified against elevation certificates (EC) when available to determine any adjustments that should be made due to any errors.
3. **Table 6** provides the illustration of the triangular distribution of distance between the LAG and the FFE. It was this value distance in feet between the LAG and FFE. The lowest adjacent grade was determined for all assets in the structure inventory and this distribution was applied to get to the FFE distribution for each asset.

Table 6. Triangular Distribution of FFE

Foundation Type	Asset Category	# Assets with Elevation Certificate Data	FFE Minimum	FFE Most Likely	FFE Maximum
Type 1	Single-family	56	0.30	2.00	4.38
Type 2	Multifamily	154	-	2.00	4.75
Type 3	Nonresidential	28	-	1.00	4.60

G2CRM also uses a minimum, most likely, and maximum FFE for triangulation described as P1, P2, and P3 respectively.

Table 7 shows the descriptive statistics for the average foundation height, average ground elevation, and average FFE for buildings within the refined focus areas. Note, 140 buildings were excluded from the model due to lack of information regarding building parameters.

Table 7. Descriptive Statistics on Foundation Height, Ground Elevation, and First Floor Elevations (ft NAVD88)

Descriptive Statistic	Foundation Height	Ground Elevation	First Floor Elevation
Count	4,875	4,875	4,875
Mean	1.89	3.88	5.77
Standard Deviation	0.41	1.64	1.66
Minimum	-1.22	-3.19	-2.19
25th Percentile / 1st Quartile	2.00	2.68	4.62
50th Percentile / 2nd Quartile / Median	2.00	3.40	5.37
75th Percentile / 3rd Quartile	2.00	4.87	6.81
Maximum	10.15	14.65	16.65

As shown in **Table 7**, there could be some errors in the data. Some buildings may show a negative ground elevation either due to on-going construction in the area or building parcels that may be near the water. **Table 8** displays the occupancy types used in this study and their descriptions.

Table 8. Occupancy Types and Descriptions

Occupancy Type	Description
COM1-MR	Average Retail-Mid-rise (5-9 story)
COM1-MS	Average Retail-Multistory (2-4 story)
COM1-SS	Average Retail-Single-story
COM2-MS	Average wholesale-Multistory (2-4 story)
COM2-SS	Average wholesale-Single-story
COM3-MR	Average Personal & Repair Services-Mid-rise (5-9 story)
COM3-MS	Average Personal & Repair Services-Multistory (2-4 story)
COM3-SS	Average Personal & Repair Services-Single-story
COM4-HR	Average Prof/Tech Services-High-rise (10 stories or more)
COM4-MR	Average Prof/Tech Services-Mid-rise (5-9 story)
COM4-MS	Average Prof/Tech Services-Multistory (2-4 story)
COM4-SS	Average Prof/Tech Services-Single-story
COM5-MS	Bank-Multistory (2-4 story)
COM5-SS	Bank-Single-story
COM6-SS	Nonresidential Single-story
COM7-MS	Average Medical Office-Multistory (2-4 story)
COM7-SS	Average Medical Office-Single-story
COM8-MS	Average Entertainment/Recreation-Multistory (2-4 story)
COM8-SS	Average Entertainment/Recreation-Single-story
COM9-MR	Average Theatre-Multistory (2-4 story)
COM9-MS	Average Theatre-Multistory (2-4 story)

Occupancy Type	Description
EDU1-SS	Average school-Single-story
EDU2-MS	Average college/university-Multistory (2-4 story)
EDU2-SS	Average college/university-Single-story
GOV1-MR	Average government services-Mid-rise (5-9 story)
GOV1-MS	Average government services-Multistory (2-4 story)
GOV1-SS	Average government services-Single-story
IND1-SS	Average heave industrial-Single-story
IND3-MS	Average Food/Drug/Chem-Multistory (2-4 story)
IND3-SS	Nonresidential Buildings
MFR-HR	Multifamily Residence-High-rise (10 stories or more)
MFR-MR	Multifamily Residence-Mid-rise (5-9 story)
MFR-MS	Multifamily Residence-Multistory (2-4 story)
MFR-MS-4	Multifamily Residence-Multistory|Apartment 1-3 Story
MFR-SS	Multistory Multifamily Residence -Single-story
MFR-SS-4	Multistory Multifamily Residence |Apartment 1-3 Story
REL1-MR	Church-Mid-rise (5-9 story)
REL1-MS	Church-(2-4 story)
REL1-SS	Church-Single-story
RES4-MR	Average Hotel, & Motel-Mid-rise (5-9 story)
RES4-MS	Average Hotel, & Motel-Multistory (2-4 story)
RES4-SS	Average Hotel, & Motel-Single-story
RES6-MS	Nursing Home-Multistory (2-4 story)
RES6-SS	Nursing Home-Single-story
SFR-MS	Multistory Single-Family Residence
SFR-SS	Multistory Single-Family Residence

Building Values and Uncertainty

The structure value uncertainty is related to the development of the triangular distribution parameters. The assessment of the contents was derived from the value of the structure. The minimum, maximum and most-likely (ML) square footage per occupancy type was identified for the entire study area of ~500k buildings in which occupancies are listed in **Table 8**. This data was obtained from Miami-Dade County's building polygon data off their GIS portal. Subsequently, the structure value was calculated at 2024 price levels. The most-likely value was based on occupancies with similar square footage values and the highest frequency among the groups. See table below. The minimum is the smallest square footage and the maximum the highest square footage per occupancy type. For example, the square footage for Multifamily residencies ranges from 1,000 to 14,000 but the ML is 2,000 sqft.

Table 9. Building Distribution

Occupancies	% Population ~500k	ML sqft
Single-family residency	73%	2,000
Multifamily residency	22%	2,000
Others	5%	

Note: Single and multifamily represent ~ 90 % of the buildings modeled by G2CRM ~4,800. Most likely sqft was utilized for the structure value calculation (in USD). Subsequently the valuation was named "Structure value P2" for the modeling.

Depreciated replacement value (DRV) per square foot was calculated for residential, non-residential and some critical infrastructures buildings. Values from The Gordian's 45th Edition of Square Foot Costs with RSMeans" data was utilized to obtain this information. The DRV captured the county data occupancies which included the number of stories that were mapped to the RSMeans 2024 data definitions. Subsequently, the cost per square footage was identified for the parameters. The total structure value at the occupancy level was calculated by multiplying the living space by the cost per square foot. Lastly, the depreciation factors including the regional adjustment were applied to calculate the final DRV for each occupancy group.

The structure age distribution from the 2024 county database ranged from 2-122 years and is clustered with the largest percentage between 34 to 80 years. The RSMeans "adjustment" depreciation for residential and non-residential structures ranged from 2 to 60 "observed age". This adjustment takes into account the condition of the building and materials. The RSMeans assumed an adjusted average effective age of thirty years. The "effective age" takes remodeling and/or modernization into consideration.

The average replacement cost per square foot was calculated for four exterior wall types including wood frame, brick veneer, stucco, or masonry because the living square footage is not available for all structures within each residential occupancy. The RSMeans depreciation schedule for non-residential structures provides three percentages for 30-year old structures based on their exterior wall type: 40% for wood frame exterior walls; 35% for masonry on wood frame; and 30% for masonry on steel frame. The masonry on wood exterior wall depreciation percentage (35 percent) was used as the most-likely value and applied to all of the nonresidential structures in the inventory. Lastly, the DRV calculation above was integrated into the entire ~500k Miami inventory data.

Future Development Inventory

Due to the density of buildings in the County and limited vacant land, a future development building inventory was not included in the damage calculations. It is anticipated that the majority of future development will be the infill of buildings on the limited vacant land, or, most likely, redevelopment. Moreover, existing floodplain ordinance requires new or substantially improved buildings in FEMA's Special Flood Hazard Area, or the 1% annual chance floodplain, to be constructed at BFE plus one foot of additional elevation. This can vary depending on the building type as well. For instance, some critical infrastructure may require two or three feet above BFE. Therefore, the percentage of infill or new development is anticipated to have a negligible impact on the growth of the building inventory and future damages.

Content-to-Structure Value Ratios

Content-to-Structure Value Ratios (CSVR) represent the value of the contents of a building as a percentage of building depreciated replacement value. Site-specific CSVR information was not available for the study area. Residential and nonresidential CSVRs used in this feasibility study were obtained from North Atlantic Coast Comprehensive Study: Resilient Adaptation to Increasing Risk, Physical Depth Damage Function Summary Report and the Non-residential Flood Depth-Damage Functions Derived from Expert Elicitation Draft Report, revised 2013. **Table 10** displays that a CSVR was computed for each residential and nonresidential building in the study as a percentage of the total depreciated replacement value. A triangular distribution was used to estimate the error.

Table 10. Content-to-Structure Value Ratios and Triangular Distribution

Occupancy Type	Description	CSVR Percent		
		Min	Most Likely	Max
COM1-MR	Average Retail-Mid-rise (5-9 story)	43	43	43
COM1-MS	Average Retail-Multistory (2-4 story)	43	43	43
COM1-SS	Average Retail-Single-story	43	43	43
COM2-MS	Average wholesale-Multistory (2-4 story)	36	36	36
COM2-SS	Average wholesale-Single-story	36	36	36
COM3-MR	Average Personal & Repair Services-Mid-rise (5-9 story)	66	66	66
COM3-MS	Average Personal & Repair Services-Multistory (2-4 story)	66	66	66
COM3-SS	Average Personal & Repair Services-Single-story	66	66	66
COM4-HR	Average Prof/Tech Services-High-rise (10 stories or more)	18	18	18
COM4-MR	Average Prof/Tech Services-Mid-rise (5-9 story)	18	18	18
COM4-MS	Average Prof/Tech Services-Multistory (2-4 story)	18	18	18
COM4-SS	Average Prof/Tech Services-Single-story	18	18	18
COM5-MS	Bank-Multistory (2-4 story)	18	18	18
COM5-SS	Bank-Single-story	18	18	18
COM6-SS	Nonresidential Single-story	44	44	44
COM7-MS	Average Medical Office-Multistory (2-4 story)	60	60	60
COM7-SS	Average Medical Office-Single-story	60	60	60
COM8-MS	Average Entertainment/Recreation-Multistory (2-4 story)	25	25	25
COM8-SS	Average Entertainment/Recreation-Single-story	25	25	25
COM9-MS	Average Theatre-Multistory (2-4 story)	25	25	25
EDU1-SS	Average school-Single-story	6	6	6
EDU2-MS	Average college/university-Multistory (2-4 story)	6	6	6
EDU2-SS	Average college/university-Single-story	7	7	6
GOV1-MR	Average government services-Mid-rise (5-9 story)	18	18	18
GOV1-MS	Average government services-Multistory (2-4 story)	18	18	18
GOV1-SS	Average government services-Single-story	18	18	18
IND1-SS	Average heave industrial-Single-story	38	38	38

Occupancy Type	Description	CSVR Percent		
		Min	Most Likely	Max
IND3-MS	Average Food/Drug/Chem-Multistory (2-4 story)	38	38	38
IND3-SS	Nonresidential Buildings	38	38	38
MFR-HR	Multifamily Residence-High-rise (10 stories or more)	10	10	10
MFR-MR	Multifamily Residence-Mid-rise (5-9 story)	10	10	10
MFR-MS	Multifamily Residence-Multistory (2-4 story)	10	10	10
MFR-MS-4	Multifamily Residence-Multistory|Apartment 1-3 Story	10	10	10
MFR-SS	Multistory Multifamily Residence -Single-story	10	10	10
MFR-SS-4	Multistory Multifamily Residence |Apartment 1-3 Story	10	10	10
REL1-MR	Church-Mid-rise (5-9 story)	7	7	7
REL1-MS	Church-(2-4 story)	7	7	7
REL1-SS	Church-Single-story	7	7	7
RES4-MR	Average Hotel, & Motel-Mid-rise (5-9 story)	26	26	26
RES4-MS	Average Hotel, & Motel-Multistory (2-4 story)	26	26	26
RES4-SS	Average Hotel, & Motel-Single-story	26	26	26
RES6-MS	Nursing Home-Multistory (2-4 story)	10	10	10
RES6-SS	Nursing Home-Single-story	10	10	10
SFR-MS	Multistory Single-Family Residence	50	50	50
SFR-SS	Multistory Single-Family Residence	50	50	50

Content-to-Structure Value Uncertainty

A triangular probability distribution was used to represent the uncertainty surrounding the contents-to-structure value ratios (CSVRs) for residential buildings. The minimum CSVR value, 25 percent, was obtained from the Willoughby General Reevaluation Report, an evaluation completed in Norfolk, Virginia, while the maximum CSVR value, seventy percent, was based on a survey of homes in coastal Louisiana. This survey was produced for the USACE New Orleans District and is the product of a very thorough and extremely detailed expert panel elicitation. A triangular probability distribution was also used to represent the uncertainty surrounding the CSVRs for the nonresidential occupancies.

First Floor Elevations

Ground elevations were obtained from Light Detection and Ranging (LiDAR) digital elevation model (DEM), developed in support of new FEMA coastal Flood Insurance Rate Map update, using NAVD88. Parcel data from the 2024 real estate assessment tables provided by the County included some of the data needed. The team determined the average height above ground for each foundation type and validated with FEMA Elevation Certificates provided by the County.

First Floor Elevation Uncertainty

There are two sources of uncertainty surrounding the first floor elevations: the use of the 2015 Light Detection and Ranging (LiDAR) data to estimate the ground elevation, and the use of parcel data to determine the foundation heights above ground elevation.

LiDAR

The metadata for the DEM describes the accuracy below:

The Fundamental Vertical Accuracy for LiDAR data over well-defined surfaces was tested to meet or exceed a 0.60 foot fundamental vertical accuracy in open well defined terrain at 95 percent confidence level using RMSE(z) x 1.9600 as set forth in the FGDC Geospatial Positioning Accuracy Standards, Part 3: NSSDA. For the purpose of this document, open terrain is defined as unobscured, consolidated surfaces, with minimal slope (< 5%) and may contain low-lying grasses through which LiDAR pulses can penetrate; LiDAR errors in these areas will have a statistically normal distribution with a mean = 0 and variance = 1. Vertical accuracies will meet the 95 percent confidence level for open terrain, assuming all systematic errors have been eliminated to the greatest extent possible and the errors are normally distributed.

The South Atlantic Coastal Study (SACS) DEM was used for this study. This data was used to update ground elevations throughout the County. **Figure 1** and **Figure 2** show the DEM by focus area.

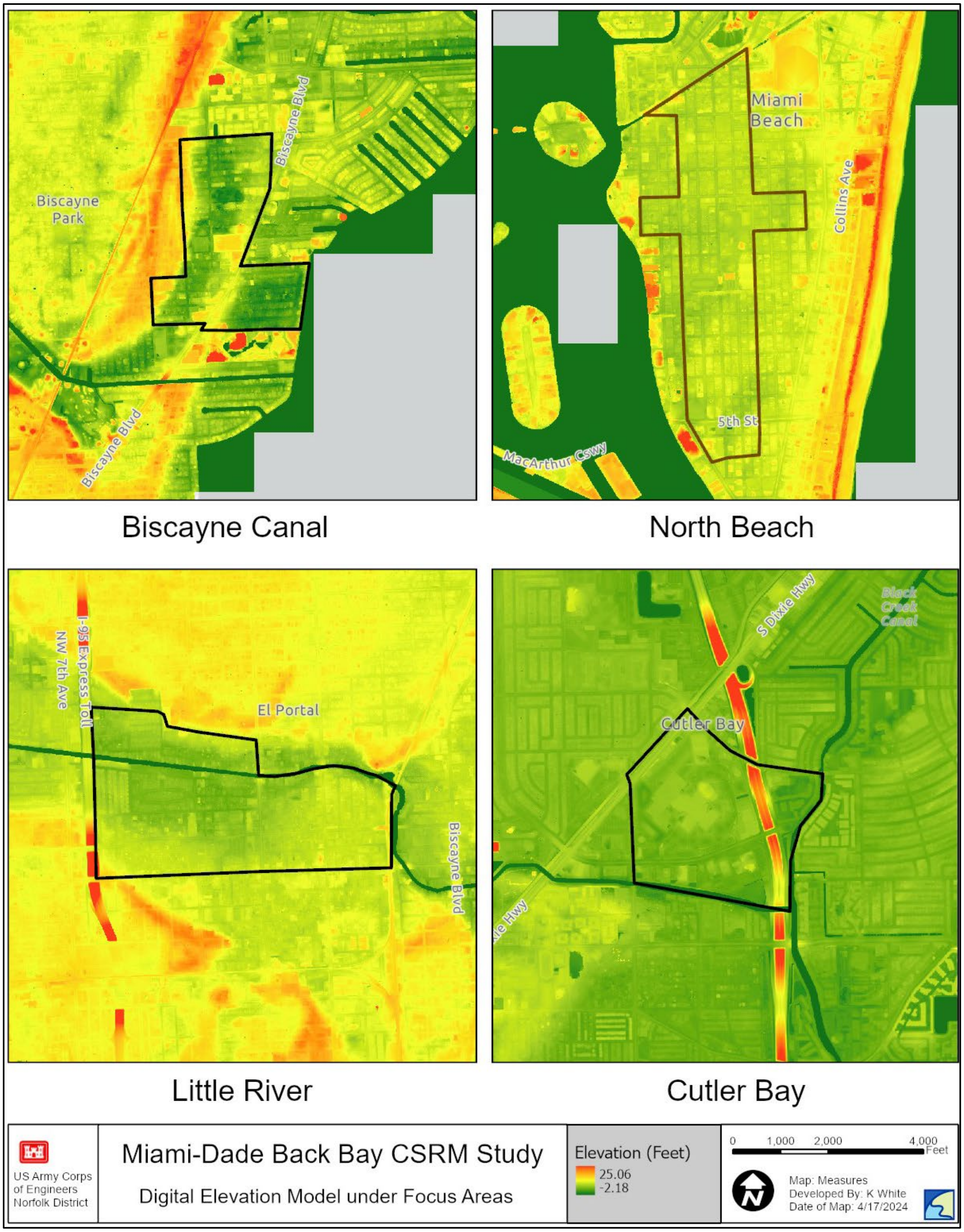

Figure 1. Digital Elevation Model Under Biscayne Canal, North Beach, Little River, and Cutler Bay Focus Areas

Figure 2. Digital Elevation Model Under Miami River and South Beach Focus Areas

Parcel Data

Parcel data for Miami-Dade County did not include foundation type. Based on conversations with local building officials, slab foundation was associated with majority of the buildings.

Depth-Damage Relationships

The U.S. Army Corps of Engineers recently completed a report detailing the results of a two-year study to address coastal storm and flood risk to vulnerable populations, property, ecosystems, and infrastructure affected by Hurricane Sandy in the United States' North Atlantic region. North Atlantic Coast Comprehensive Study (NACCS) is designed to help local communities better understand changing flood risks associated with climate change and to provide tools to help those communities better prepare for future flood risks. It builds on lessons learned from Hurricane Sandy and attempts to bring to bear the latest scientific information available for state, local, and tribal planners.

A depth-damage function is a mathematical relationship between the depth of flood water above or below the first floor of a building and the amount of damage that can be attributed to that water. Various depth damage functions (DDFs) were considered for use in the study; however, given that no geographically specific curves were available for the Florida coastal region, a broader geographic collection of curves were considered. Given the high amount of multifamily and high rise condominiums in the study area, combined with the salt-water environment associated with the location, the DDFs established within the NACCS Physical Depth Damage Function Summary Report were determined to be the most appropriate for use on the study. The NACCS curves were used to model damage for all residential buildings and the majority of nonresidential buildings, unless curves for more specific nonresidential building types were developed as part of the Nonresidential Flood Depth-Damage Functions Derived from Expert Elicitation Report in 2013. These curves were used in lieu of the NACCS curves for nonresidential inundation to match specific nonresidential occupancy types more closely within the building inventory.

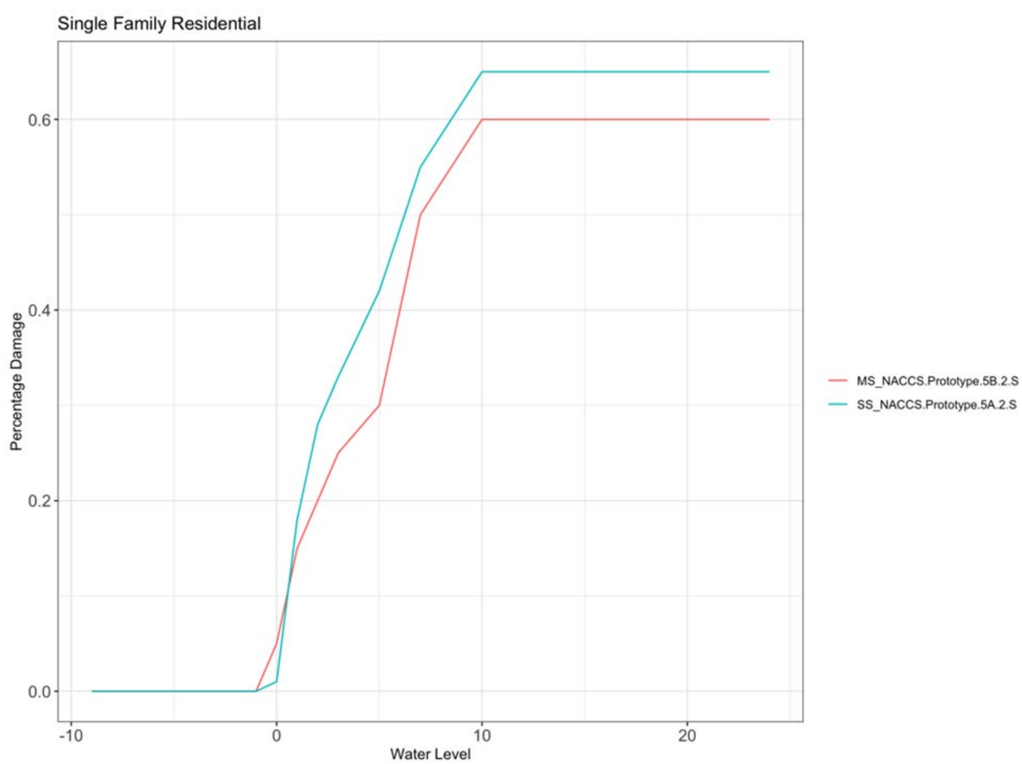

Figure 3. Single-Family Residential DDFs

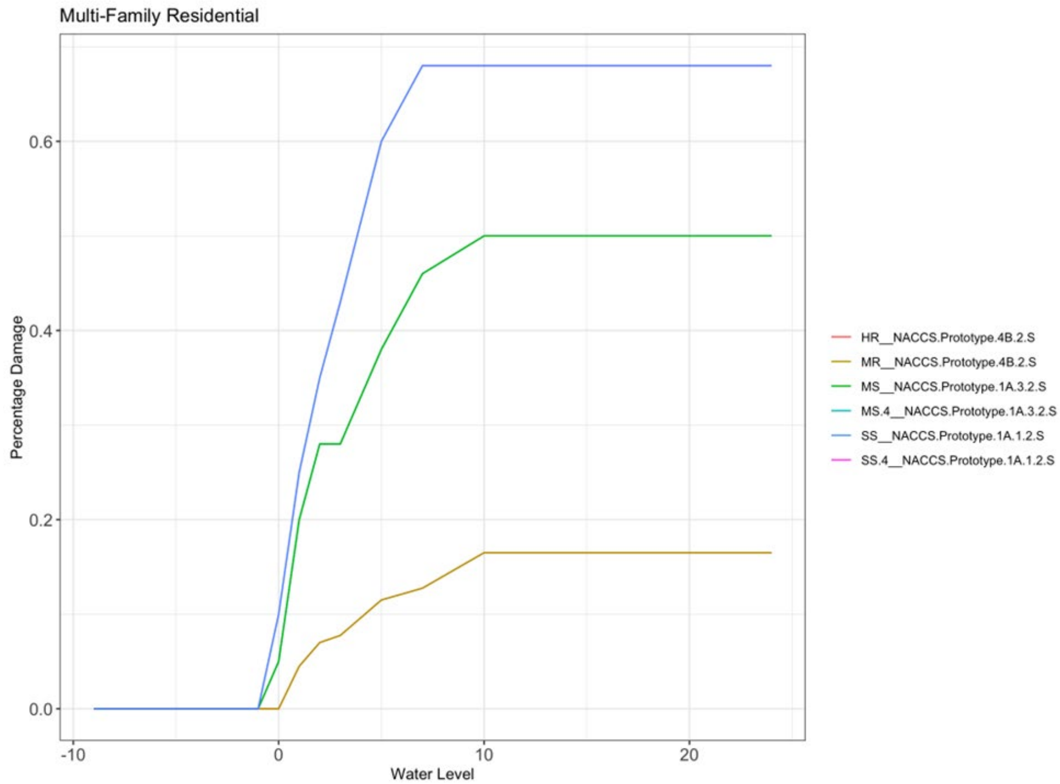

Figure 4. Multifamily Residential DDFs

Note: [MFR.HR and MFR.MR], [MFR.MS.4 and MFR.MS], [MFR.SS.4 and MFR.SS] uses the same damage function.

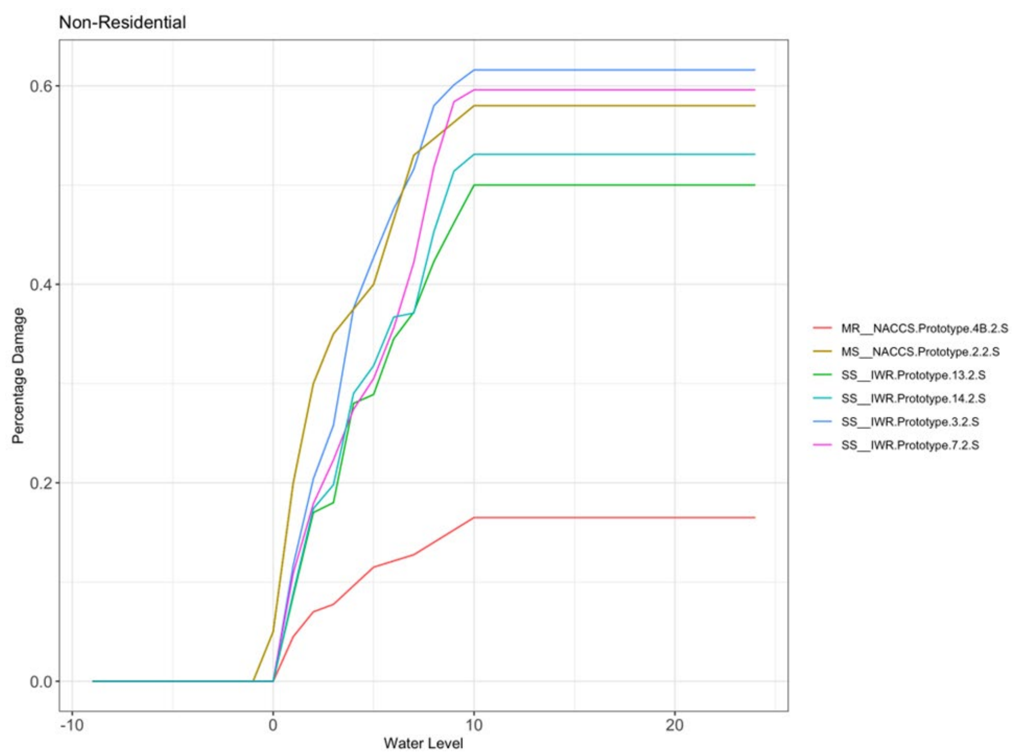

Figure 5. Nonresidential DDFs

Depth Damage Relationship Uncertainty

A triangular probability density function was used to determine the uncertainty surrounding the damage percentages associated with each depth of flooding for the various residential and nonresidential occupancy categories. A minimum, maximum, and most-likely damage estimate for each depth of flooding was obtained from the Physical Depth Damage Function Summary Report published as a part of NACCS study and the 2013 Draft Nonresidential Flood Depth-Damage Functions Derived from Expert Elicitation. A national panel of building, construction, insurance, and restoration experts was used to develop the data contained in these reports. Moreover, both contained a normal distribution function with an associated standard deviation of damage to account for uncertainty surrounding the damage percentage associated with each depth of flooding. This distribution was then converted into a triangular distribution for input into the model. Depth-damage relationships are computed separately for building and contents.

Central District Wastewater Treatment Plan Depth Damage Function Development

The Central District Wastewater Treatment Plan (CDWWTP) is the primary wastewater treatment facility for the City of Miami and serves over one million residents. The facility's location on Virginia Key is vulnerable to impacts of hurricanes and large storms. A Facility-level DDF that encompasses seven CDWWTP components was developed for use in the G2CRM model. Building and content DDFs were developed for each of the seven CDWWTP components as well as Master Pump Station No. 1 using existing DDFs and professional judgment. Total damageable property values for building and contents at each of the seven CDWWTP components were developed using insurance information provided by the Miami-Dade Water and Sewer Department (WASD) and professional judgment. Expected damage at each depth increment was computed as the product of the mode damage percentage from the DDF multiplied by the mode total damageable property value of building or contents. Expected damages were summed across the seven CDWWTP components to generate a facility-level estimate of expected damages at each depth increment. The percent damage for the aggregated facility-level DDF at each depth increment is computed as the total value of damage at a given depth increment divided by the total value of damageable property. The procedure was repeated for minimum and maximum damage percentages and damageable property values. Depth damage relationships for the CDWWTP represent planning level estimates and could be refined in future feasibility study efforts. **Table 11** presents the aggregated facility-level DDF for the seven CDWWTP components.

Table 11. Central District Wastewater Treatment Plant Structure Facility-Level Depth-Damage Function

Flood Depth (feet)	Minimum Damage (%)	Mode Damage (Most Likely, %)	Maximum (%)
0	-	0.00079	0.00199
1	0.00079	0.01851	0.04529
2	0.02046	0.05021	0.0987
3	2.496	4.877	7.41
4	4.862	7.377	9.89
5	10.99	14.83	18.98
6	15.19	18.98	24.82
7	18.98	24.82	36.52
8	33.09	48.69	64.46
9	48.69	64.46	74.49
10	64.46	74.49	88.39
11	74.04	88.09	98.66

DDF development for Pump Station No. 1 assumes that water would inundate the pump station and cause failure of different components at different water surface elevations. Inundation of various components would result in differing levels of loss of service at Pump Station No. 1 and associated sewage backup. The specific water surface elevations associated with failure of specific components is not identified. The proportion of loss of service of Pump Station No. 1, and associated sewage backup, is based on professional judgment for the overall pump station. **Table 12** presents the DDF developed for Master Pump Station No. 1.

Table 12. Master Pump Station No. 1 Structure Depth-Damage Function

Flood Depth (feet)	Minimum Damage (%)	Mode Damage (Most Likely, %)	Maximum (%)
0	-	3.13	8.02
1	3.13	8.02	15.67
2	8.02	15.67	21.80
3	15.67	21.80	31.33
4	28.22	40.77	49.55
5	40.77	49.55	56.41
6	49.55	56.41	68.88
7	54.53	66.99	78.84
8	65.11	76.95	84.44
9	75.06	82.55	93.78
10	80.67	91.89	100

Table 13 and **Table 14** present DDFs developed for contents at the CDWWTP and Master Pump Station No. 1, respectively.

Table 13. Central District Wastewater Treatment Plant Content Depth-Damage Function

Flood Depth (feet)	Minimum Damage (%)	Mode Damage (Most Likely, %)	Maximum (%)
0	0.00196	0.00613	0.01364
1	0.03511	0.05816	0.1208
2	0.06397	0.1031	0.2099
3	5.114	8.034	11.89
4	7.991	10.63	13.86
5	14.12	18.92	26.61
6	17.12	24.79	32.91
7	22.95	31.06	41.23
8	38.96	52.51	59.30
9	50.02	56.85	61.85
10	89.96	95	100
11	89.96	95	100

Table 14. Master Pump Station No.1 Content Depth-Damage Function

Flood Depth (feet)	Minimum Damage (%)	Mode Damage (Most Likely, %)	Maximum (%)
0	0	0.35	13
1	0.12	0.92	25
2	0.32	1.77	33
3	0.62	2.33	50
4	1.24	5.30	90
5	1.86	6.36	95
6	2.23	6.72	100
7	2.23	6.72	100
8	2.23	6.72	100
9	2.23	6.72	100
10	2.23	6.72	100

1.8.3 Engineering Inputs to the G2CRM Model

This section covers all the Engineering inputs required for G2CRM.

Storms

For the study area, a reduced storm set was selected. The number of storms selected was driven by schedule and budget constraints, and by knowledge gathered from other previous and ongoing USACE feasibility studies about the minimum number of storms required to adequately capture the storm surge hazard. The goal of storm selection was to find the optimal combination of storms given a predetermined number of storms to be sampled, referred to as reduced storm set. In the process of selecting the number for the study area, it was determined that a reduced storm set of this size adequately captured the storm surge hazard for the range of probabilities covered by the full storm set.

The storm selection process involved using the storm suite from the 2017 South Florida Storm Surge Study (SFLSSS). The SFLSSS process included using five historical storms for validation and the document is referenced in the Engineering Appendix. Once the SFLSSS validation process of the storms was completed, the production runs included 392 hypothetical storms from the SFLSSS and 390 storms were used for this study. After Norfolk District selected save points for the study area, ERDC developed the hazard curves for the selected 779 save points from the SFLSSS study. The Storm data from the SFLSSS included water level time series, wave periods, and wave data.

Save Points

The numerical modeling aspect of the study area is to provide estimates of waves and water levels for existing condition, future without project condition, and future with project condition. A save point is a point of interest in the study area. These save points contained the water elevations and wave heights for each of the storms in the reduced storm set to be used in G2CRM. These water elevations will be applied to the model areas along with economic inputs to derive flood damage in the existing condition, future without project condition, and future with project condition for the Miami-Dade County Study Area.

Stage-Probability Relationships – H5 Files

Stage-probability relationships were provided for the existing conditions. Water surface hydrographs were provided for 9 annual exceedance probability (AEP) events: 50% (2-year), 20% (5-year), 10% (10-year), 5% (20-year), 2% (50-year), 1% (100-year), 0.5% (200-year), 0.2% (500-year), and 0.1% (1000-year). The without-project water surface profiles were based on 8 Save Points.

For each of these AEP events, the water surface profiles for the year 2089 were calculated by adding relative sea level change, as determined by the USACE Sea Level Rise Calculator using the USACE High Curve to the Save Point elevations. The mean sea level trend of 0.0138 ft./yr. (Vaca Key, FL) was used as the sea level change rate. Additional information regarding water surface elevation calculations can be found in the Engineering Appendix.

2 EXISTING CONDITION

There are thousands of buildings in the FEMA one percent annual exceedance probability (AEP), or 100-year floodplain, in the Miami-Dade County Study Area. These property owners are technically required to purchase flood insurance, although flood insurance has eligibility requirements and numerous exclusions. The FEMA National Flood Insurance Program (NFIP) does not cover additional living expenses, such as temporary housing, while the building is being repaired or is unable to be occupied; loss of use or access to the insured property; financial losses caused by business interruption; property and belongings outside of an insured building, such as trees, plants, wells, septic systems, walks, decks, patios, fences, seawalls, hot tubs and swimming pools; most self-propelled vehicles, such as cars, including their parts; and personal property kept in basements. Federal flood insurance coverage is also capped at $250,000 per building and $100,000 for contents.

The inventoried buildings were categorized as residential or nonresidential which were further categorized into occupancy types (reference Building Inventory section of this appendix). **Table 15** displays the count and the most likely depreciated replacement values (DRV - estimated replacement cost less depreciation) of the buildings within the refined focus areas by the main occupancy types.

Table 15. Structure (Building) Inventory by Occupancy Types within Refined Focus Areas

Occupancy Type	Description	Count	Most Likely DRV of Buildings
CI-COM4-HR-RT	Critical Infrastructure-Communication	1	17 million
CI-COM6-HR	Critical Infrastructure-Hospital	1	75 million
CI-COM6-MS	Critical Infrastructure-Hospital	1	17 million
CI-COM6-SS	Critical Infrastructure-Medical	1	8 million
CI-EDU1-MS-EOC	Critical Infrastructure-Emergency Operations Center	1	141 million
CI-GOV1-HR-RT	Critical Infrastructure Government	1	15 million
CI-GOV1-HR-SH	Critical Infrastructure -Shelter	1	50 million
CI-GOV1-MS-CH	Critical Infrastructure -Government	1	28 million
CI-GOV2-MR-EOC	Critical Infrastructure -Government	1	13 million
CI-GOV2-MR-FS	Critical Infrastructure -Fire Station	1	15 million
CI-GOV2-MR-PS-EOC	Government Critical Infrastructure	1	37 million
CI-GOV2-MS-EOC	Government Critical Infrastructure	3	806 million
CI-GOV2-MS-FS	Government Critical Infrastructure	4	14 million
CI-GOV2-MS-PS	Critical Infrastructure- Police Station	8	139 million
CI-GOV2-SS-FS	Critical Infrastructure - Fire Station	3	11 million
CI-GOV2-SS-FS-EOC	Critical Infrastructure - Fire Station |Emergency Operations Center	2	16 million
CI-IND3-MS-CDWWTP	Critical Infrastructure - Waste Water Treatment Plan	1	263 million
CI-IND3-MS-PUMP-1	Critical Infrastructure-Pump Station	1	24 million
CI-MFR-HR-RT	Critical Infrastructure	1	46 million
COM1-MR	Average Retail-Mid-rise (5-9 story)	3	6 million
COM1-MS	Average Retail-Multistory (2-4 story)	52	675 million
COM1-SS	Average Retail-Single-story	57	52 million
COM2-MS	Average wholesale-Multistory (2-4 story)	10	8 million
COM2-SS	Average wholesale-Single-story	4	2 million
COM3-MR	Average Personal & Repair Services-Mid-rise (5-9 story)	1	77 million
COM3-MS	Average Personal & Repair Services-Multistory (2-4 story)	24	19 million
COM3-SS	Average Personal & Repair Services-Single-story	30	12 million
COM4-HR	Average Prof/Tech Services-High-rise (10 stories or more)	6	123 million
COM4-MR	Average Prof/Tech Services-Mid-rise (5-9 story)	9	83 million
COM4-MS	Average Prof/Tech Services-Multistory (2-4 story)	24	34 million
COM4-SS	Average Prof/Tech Services-Single-story	27	12 million
COM5-MS	Bank-Multistory (2-4 story)	6	8 million

Occupancy Type	Description	Count	Most Likely DRV of Buildings
COM5-SS	Bank-Single-story	2	1 million
COM6-SS	Nonresidential Single-story	1	0.4 million
COM7-MS	Average Medical Office-Multistory (2-4 story)	2	3 million
COM7-SS	Average Medical Office-Single-story	1	0.2 million
COM8-MS	Average Entertainment/Recreation-Multistory (2-4 story)	3	3 million
COM8-SS	Average Entertainment/Recreation-Single-story	3	2 million
COM9-MR	Average Theatre-Multistory (2-4 story)	1	35 million
COM9-MS	Average Theatre-Multistory (2-4 story)	1	2 million
EDU1-SS	Average school-Single-story	3	2 million
EDU2-MS	Average college/university-Multistory (2-4 story)	9	24 million
EDU2-SS	Average college/university-Single-story	1	0.1 million
GOV1-MR	Average government services-Mid-rise (5-9 story)	7	230 million
GOV1-MS	Average government services-Multistory (2-4 story)	68	188 million
GOV1-SS	Average government services-Single-story	44	108 million
IND1-SS	Average heave industrial-Single-story	1	0.20 million
IND3-MS	Average Food/Drug/Chem-Multistory (2-4 story)	3	2 million
IND3-SS	Nonresidential Buildings	7	6 million
MFR-HR	Multifamily Residence-High-rise (10 stories or more)	17	414 million
MFR-MR	Multifamily Residence-Mid-rise (5-9 story)	70	735 million
MFR-MS	Multifamily Residence-Multistory (2-4 story)	1,289	1.72 billion
MFR-MS-4	Multifamily Residence-Multistory|Apartment 1-3 Story	193	113 million
MFR-SS	Multistory Multifamily Residence - Single-story	785	286 million
MFR-SS-4	Multistory Multifamily Residence |Apartment 1-3 Story	133	57 million
REL1-MR	Church-Mid-rise (5-9 story)	4	41 million
REL1-MS	Church-(2-4 story)	14	36 million
REL1-SS	Church-Single-story	11	7 million
RES4-MR	Average Hotel, & Motel-Mid-rise (5-9 story)	1	3 million
RES4-MS	Average Hotel, & Motel-Multistory (2-4 story)	24	35 million
RES4-SS	Average Hotel, & Motel-Single-story	9	18 million

Occupancy Type	Description	Count	Most Likely DRV of Buildings
RES6-MS	Nursing Home-Multistory (2-4 story)	6	10 million
RES6-SS	Nursing Home-Single-story	4	3 million
SFR-MS	Multistory Single-Family Residence	374	83 million
SFR-SS	Multistory Single-Family Residence	1,357	176 million
Grand Total		4,735	7.1 billion

Note: October 2023 FY(24) price level

2.1 Modeled Areas

The term "modeled areas" describes various geographic units that may exist within the study area. Flood elevations are uniform within a modeled area (MA). A storm event is processed to determine the peak stage in each defined MA and it is this peak stage that is used to estimate consequences to assets within the MA. Therefore, MA boundaries tend to correspond to the drainage divides separating local-scale watersheds. The MAs for Aventura, Biscayne Canal, Cutler Bay, Little River, Miami River, North Beach, South Beach, and Virginia Key were included as one study. **Figure 6** shows the MAs the associated save points used.

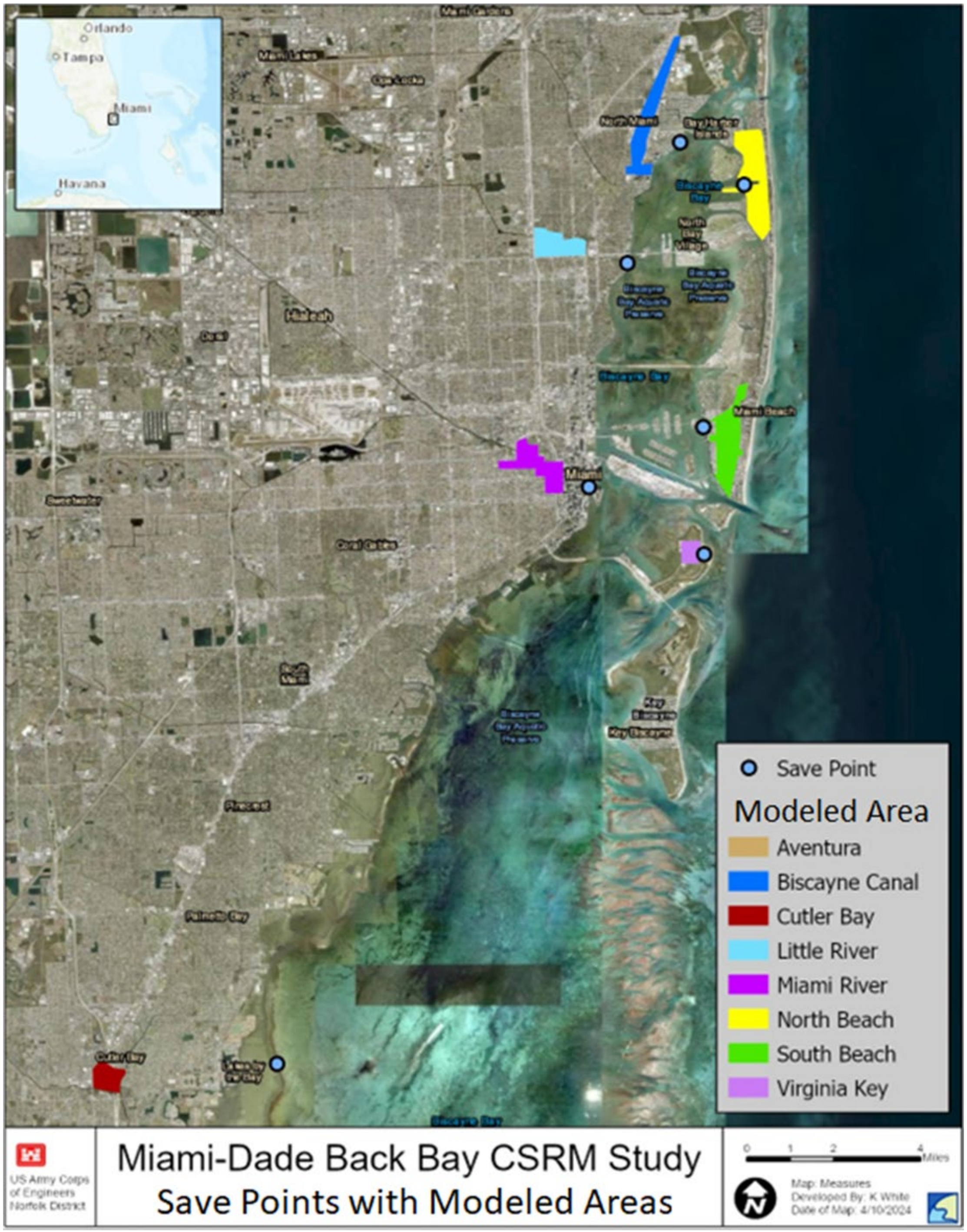

Figure 6. Modeled Areas with Save Points within Refined Focus Areas

Considerable professional judgment was used in defining MA boundaries including considering natural or built topological features such as high ground, ridges, highways, etc.

The focus areas were used as the MAs where nonstructural measures were being recommended. Data from save points was used to identify changes in water levels and wave heights to determine where MAs could be broken down even further. It is important to have the best representation of MAs as possible; otherwise, the model may falsely produce damage at buildings when the water would never reach the site.

2.2 Model Area Type

Each of the MAs were modeled as an Upland MA. Each MA requires waterside ground elevation data to be put into the database. Typically, this is the average ground elevation within the MA. That data is used in calculating the wave height by determining the depth limited wave height as shown in the equation below:

Depth Limited Wave Height = 0.78 * (surge + tide + SLC Contribution - Waterside Ground Elevation)

Due to the equation, any areas where the waterside ground elevation is higher than any surge + tide + SLC contribution (dependent on the storm year) would not contribute any additional wave height to the total water level.

Table 16 displays the stillwater levels associated with the save points which are linked to each MA. The water levels were based on the 50% confidence levels on the 0.5% AEP which includes storm surge, astronomical tides, and wave setup, and USACE high curve SLC up to the year 2089.

Table 16. Save Point Data Associated with Modeled Areas

Modeled Areas	Save Point	0.5% AEP Water Levels (ft, NAVD88)
Aventura	248	9.98
Biscayne Canal	507	10.36
Cutler Bay	439	13.77
Little River	614	10.07
Miami River	443	11.6
North Beach	271	9.62
South Beach	196	8.34
Virginia Key	105	9.94

Figure 7 shows an example of how the waterside ground elevation was determined for the Edgewater MA. ESRI's software ArcMap was used to draw interpolation lines across Miami-Dade County's DEM along the coast using the 3D spatial analyst tool. The graph within **Figure 7** shows the profile graph of the interpolation line which shows the ground elevation being on average close to the 3 foot NAVD88 mark.

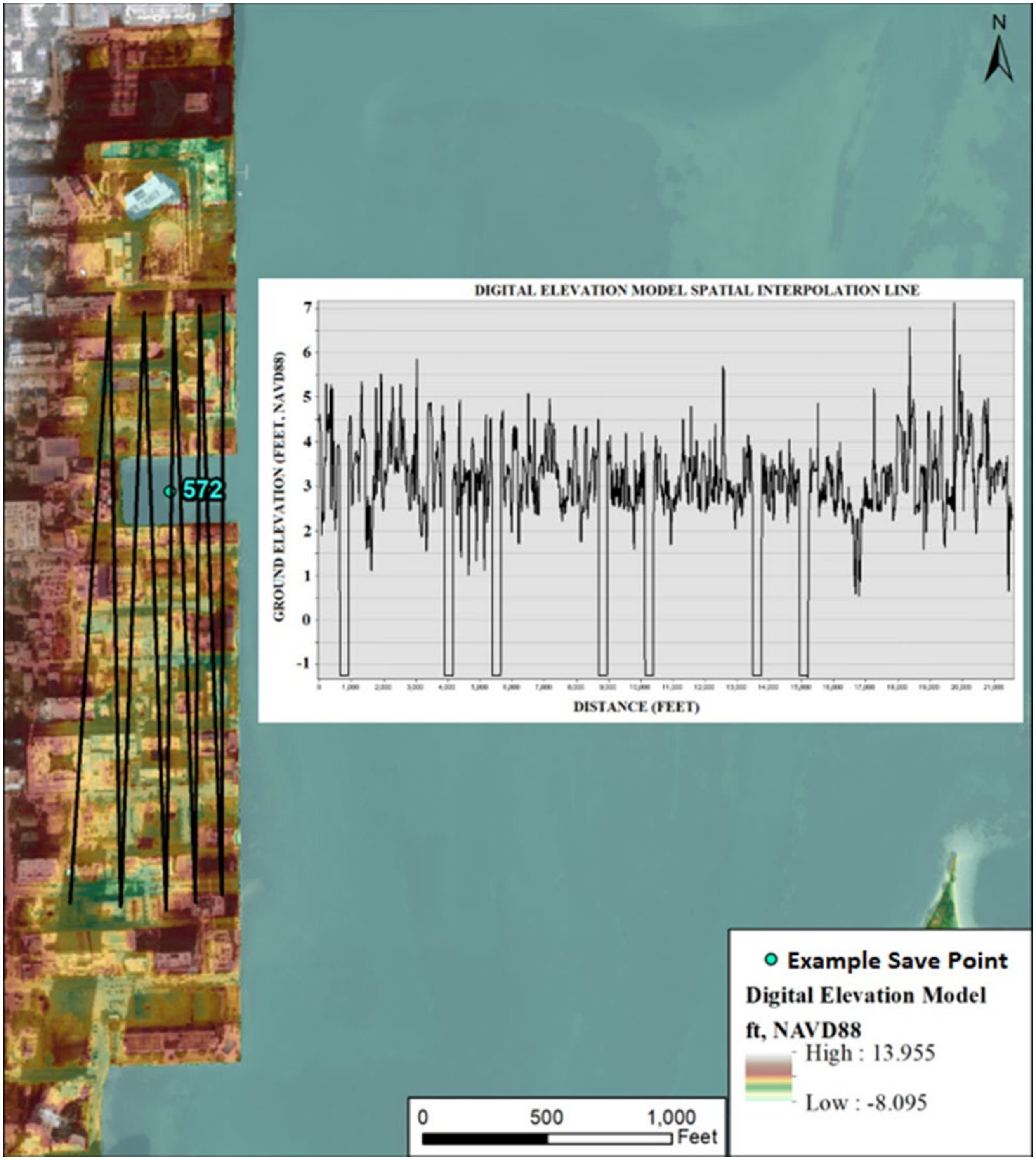

Figure 7. Example of Determining Waterside Ground Elevations

2.3 Plan Alternative Files

Plan Alternative (PA) files in G2CRM are needed to run future with project scenarios. Future without project can be run without PA files. PAs can be used to change particular fields within the asset shapefile such as by removing a building from the inventory (acquisition of a building), changing the first floor elevation of a building (elevating a building), changing the top of wall elevation of a bulkhead, changing the occupancy type of a building to another occupancy type, etc. **Table 17** shows the template for a PA where adjustments can be made.

Table 17. Plan Alternative Template for Adjustments

Plan Detail	
Column	**Description**
Plan Text ID	Unique identifier for the plan alternative from the Plan sheet
Adjustment Text ID	Unique identifier for the adjustment item
Adjustment Time	Time the adjustment item is to be performed in format M/D/YYYY H24:MM
Adjustment Group	Not used
Adjustment Cost	Cost of the adjustment item
Adjustment Type	Object type to be adjusted (from the Allowable Adjustment Type Target sheet)
Adjustment Element	Element that should be adjusted (for assets and buildings this is the Asset ID; for all others, this is the name of the object)
Adjustment Target	Property of the adjustable object to be adjusted (from the Allowable Adjustment Type Target sheet)
Value Fixed or Relative	Fixed = 1, Relative = 0
Adjusted Value	Value that the property should be adjusted to or by (depending on if the adjustment is fixed or relative)

2.4 Volume Stage Functions

Volume-stage functions (alternatively called stage-volume functions) are associated with an upland MA. For the study area, the volume-stage functions were derived from the digital terrain model (the same used to determine ground elevation of buildings) provided by Engineering and GIS sections and describe the relationship between the volume contained in the model area and the associated stage (water depths) for each MA.

2.5 Assets

Assets are spatially located entities that can be affected by storms. Typically, they start off as building polygons taken from building inventory. Centroids, usually a point in the center of the building polygon, are created and used for input in G2CRM in the correct format required. For this analysis, assets were taken for all buildings in Miami-Dade County and then eventually narrowed to cover the refined focus areas. Miami-Dade County is a highly urbanized, relatively flat community with a mean elevation of five feet NAVD88. The low elevations and tidal connections place a significant percentage of the county at risk of flooding from coastal storms. The number of buildings will change depending on the design water elevation, which can vary throughout the study due to optimization of using sea level change rates. **Table 18** shows the most likely depreciated replacement value for buildings and contents for all the buildings within the MAs. This includes all possible buildings in the refined focus areas and not the Recommended Plan (RP).

Table 18. Most Likely Building and Content Values in Modeled Areas (Oct 2023 Price Levels)

Modeled Areas	Buildings	Most Likely Building Values	Most Likely Content Values
Aventura	3	93 Million	44 Million
Biscayne Canal	611	281 Million	52 Million
Cutler Bay	110	811 Million	336 Million
Little River	1,348	587 Million	127 Million
Miami River	721	1.11 Billion	171 Million
North Beach	1,100	1.35 Billion	181 Million
South Beach	841	2.68 Billion	583 Million
Virginia Key	1	263 Million	214 Million
Total	**4,735**	**7.18 Billion**	**1.70 Billion**

2.6 Evacuation Planning Zones

According to the Fourth National Climate Assessment, communities in the Southeast are particularly vulnerable to flooding. Extreme weather and climate-related events can have lasting mental health consequences in affected communities, particularly if they result in degradation of livelihoods or community relocation. Populations including older adults, children, low-income communities, and some communities of color are often disproportionately affected by, and less resilient to, the health impacts of climate change. Lessons from numerous coastal storm events have made it clear that even if the elderly, functionally impaired persons, and/or low income residents wish to evacuate from areas at risk from a pending coastal storm, they are unable to evacuate due to their physical or socioeconomic condition. Flooding in urban areas can cause serious health and safety problems for the affected population. The most obvious threat to health and safety is the danger of drowning in flood waters. Swiftly flowing waters can easily overcome even good swimmers. When people attempt to drive through flood waters, their vehicles can be swept away in as little as two feet of water.

An evacuation planning zone (EPZ) is a spatial area, defined by a polygon boundary that is used within loss of life calculations in G2CRM to determine the population remaining in buildings during a storm (i.e. population that did not evacuate). Since the study area was divided into multiple MAs, the extent of each MA shapefile is the same as that of the EPZ shapefile extent; however, within the EPZ shapefile, there may be multiple evacuation zones providing various population data. G2CRM then assigns each asset within that MA to the EPZ for potential life loss given a storm event. The remaining population is also needed as a percent minimum, most likely, and maximum.

The 2012 Statewide Regional Evacuation Study Program – Volume 1-11 Technical Data Report South Florida Region Appendix IIIB was used to fill in information needed in the EPZ. The EPZ requires data such as the evacuation rate per storm threat scenario as shown in **Table 19**.

Table 19. Evacuation Rate for Residents Living in Site-Built Homes in Miami-Dade County

Evacuation Rate (%)	Storm Threat Scenario				
Site-Built Homes	Cat 1	Cat 2	Cat 3	Cat 4	Cat 5
Cat 1 Surge Evacuation Zone	40	50	65	80	90
Cat 2 Surge Evacuation Zone	30	45	60	80	90
Cat 3 Surge Evacuation Zone	20	25	60	80	85
Cat 4 Surge Evacuation Zone	10	15	30	70	85
Cat 5 Surge Evacuation Zone	8	8	15	55	80
Inland of Surge Evacuation Zones	5	5	5	10	20

The MAs were overlaid on top of the Hurricane Evacuation Zones as shown in **Figure 8.** The appropriate remaining population data was filled in depending on where the MAs landed on the zones. Cat 5, 4, and 3 data from **Table 20** was used to fill in the minimum, most likely, and maximum remaining population data respectively which is required for the EPZ. The percentages used in the EPZ file were subtracted from 100 since the EPZ requires the population estimate to be the population remaining instead of evacuating. **Table 20** below shows the percentage of population evacuating and remaining by modeled area.

Table 20. Population Evacuated and Remaining

		% Population Evacuated			% Population Remaining		
Modeled Areas	Evacuation Zone	Min	Most Likely	Max	Min	Most Likely	Max
Virginia Key	1	65	80	90	10	20	35
Cutler Bay	2	60	80	90	10	20	40
North Beach	2	60	80	90	10	20	40
South Beach	2	60	80	90	10	20	40
Miami River	2	60	80	90	10	20	40
Biscayne Canal	3	60	80	85	15	20	40
Aventura	4	30	70	85	15	30	70
Little River	4	30	70	85	15	30	70

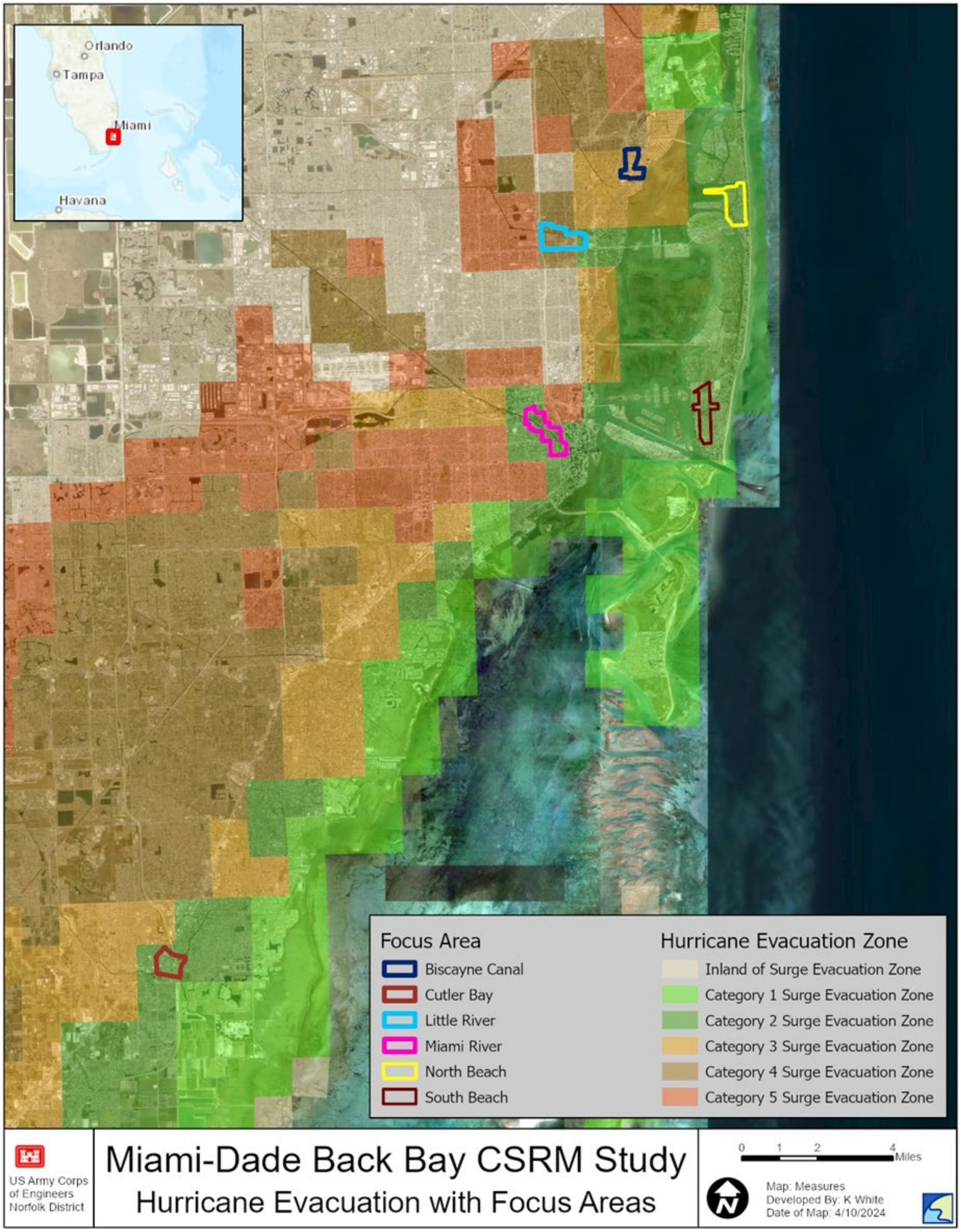

Figure 8. Modeled Areas over Hurricane Evacuation Zones

3 FUTURE WITHOUT PROJECT CONDITION

3.1 Modeling Assumptions

The G2CRM model was utilized to evaluate flood damage using risk-based analysis. Damage was reported at the index location for each of the study areas for which a building inventory had been conducted. The model also used the number of years that stages were recorded at a given gage to determine the hydrologic uncertainty surrounding the stage-probability relationships.

The possible occurrences of each variable were derived through the use of Monte Carlo simulation, which used randomly selected numbers to simulate the values of the selected variables from within the established ranges and distributions. For each variable, a sampling technique was used to select from within the range of possible values. With each sample, or iteration, a different value was selected. The number of iterations performed affects the simulation execution time and the quality and accuracy of the results. This process was conducted simultaneously for each economic and hydrologic variable. The resulting mean value and probability distributions formed a comprehensive picture of all possible outcomes. A mean and standard deviation was automatically calculated for the damage at each stage. Below are the run conditions used for each MA and description of the condition or further explanation of the run condition value:

Number of Iterations: 300

Number of iterations that the simulation should perform. 300 iterations were selected for the analysis.

Second, model stabilization was performed on the Cutler Bay MA to determine how much the average present value (PV) damage changed over each iteration. **Figure 9** shows the results that after approximately the first 25 runs, the percent change between average PV damage was less than 5%. The remainder of the 75 iterations had an average change of 0.09%.

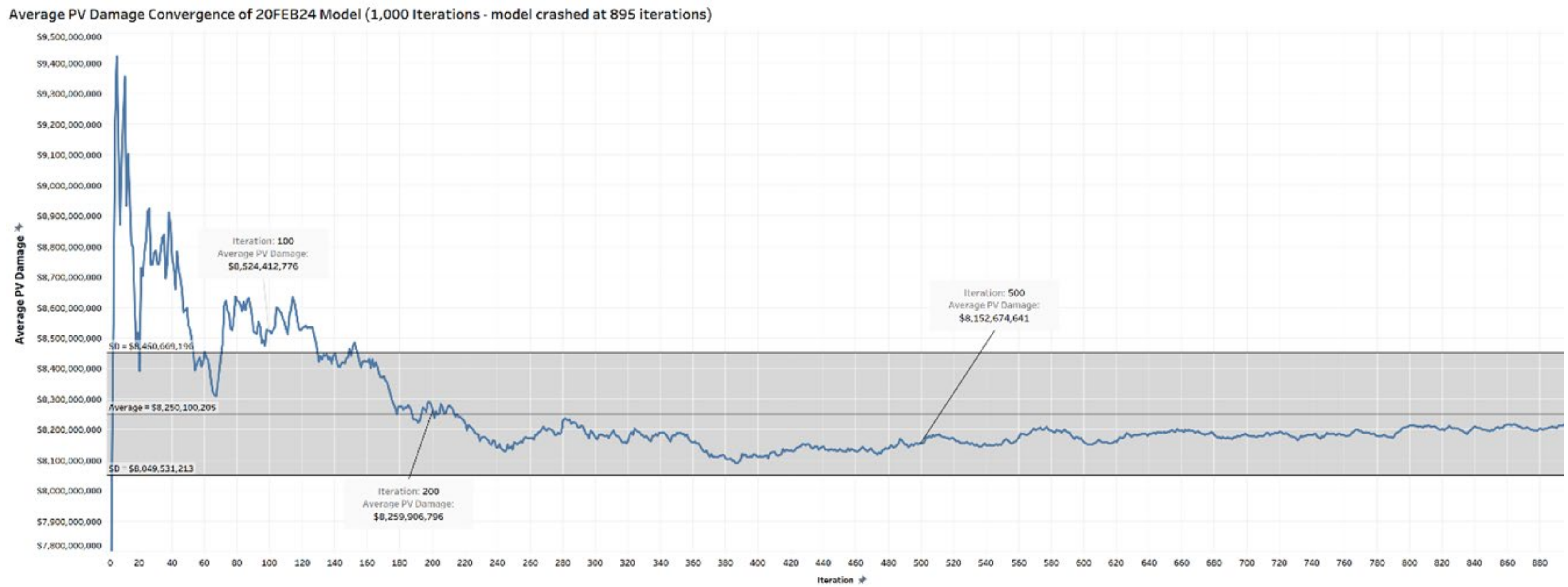

Figure 9. Model Stabilization

Both of these results indicated that 300 iterations was more than sufficient.

Start Year: 2025

The year that the simulation is to begin in. By starting in the year 2020, the building inventory can evolve and any residential buildings that are substantially damaged will have first floor elevations elevated to a target first elevation set in the model by the user. This is typically the FEMA BFE plus one foot of freeboard described earlier in Section 1.6.

Base Year: 2040

The year that the simulation is to measure present value from. This assumes all construction is completed by the year 2035 and benefits start accruing.

Sea Level Change Basis Year: 1992

This is the year of the stillwater levels in the save points.

Interest Rate: 0.0275

The interest rate used to calculate the net present value factor for the simulation. 0.0275 is the latest interest rate for Fiscal Year 2024.

Sea Level Change Rate: 0.0138 ft./yr.

Sea level change rate in average feet per year over the time period start month/year to simulation end date. NOAA Vaca Key, Florida Bay, FL - Station ID: 8723970 was used as the tide gage of reference for this study. Further information discussing the reasoning is in Appendix B. **Figure 10** shows the relative sea level trend for this tide gage which shows the trend at 3.85 millimeters per year based on monthly mean sea level data from 1971 to 2019. 4.21 millimeters per year is equivalent to 0.0138 feet per year.

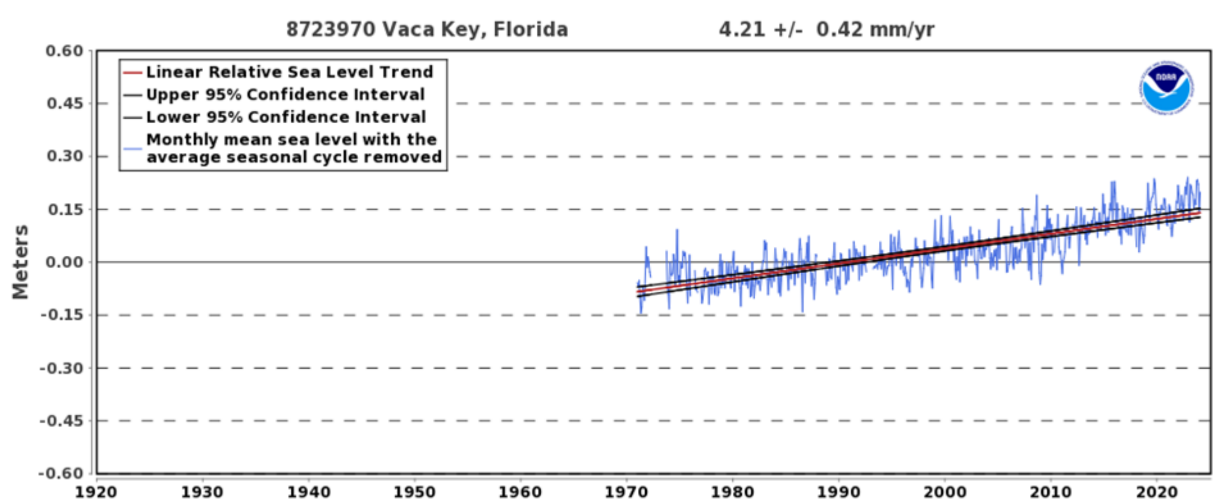

Figure 10. Vaca Key Relative Sea Level Trend

It should be noted that unlike other models, G2CRM gradually adds sea level rise depending on when the storms get activated instead of adding the full amount over the period of analysis from the beginning. For instance, if a storm was stimulated in the year 2040, only the sea level rise until 2040 will be added to the total water level calculations.

USACE Sea Level Change Curve: High Curve

For the initial runs of this study, the USACE high curve was used for all analysis. This is the curve that is recognized by the Southeast Florida Regional Climate Change Compact as the most likely scenario for their region. All three SLC curves were evaluated for project performance.

Calculate Depreciation: No

Turning this on will make the simulation depreciate assets linearly over the lifecycle of the simulation. The decision was made not to turn this on since the buildings are already valued at the depreciated replacement value. It is also assumed that over time, buildings typically appreciate instead of depreciating. It could also be possible that homeowners or business owners will remodel or upgrade parts of their building throughout its life. Due to these reasons, the team did not want to add additional depreciation to the buildings which would lower its valuation.

Raise Structures: Yes

By turning this on, it lets the model know that assets should be raised once it is substantially damaged. As mentioned previously in this appendix, this is defined by FEMA as total cost of repairs is 50 percent or more of the building’s market value before the disaster occurred. Once that level is reached, the building would be raised to the effective FEMA BFE plus one additional foot to account for freeboard. It should be noted that the building inventory utilizes depreciated replacement values and not market values so there will be some discrepancies on what is determined to be substantial damage.

Calculate Assets: Yes

This means the model will use assets (buildings) during its simulation.

Use Benefit Base: No

This feature indicates whether the statistics for the simulation should recognize the in-benefits base status of the building (“Yes”) or assume all buildings are in the benefits base (“No”). This depends on the homeowner or locality’s compliance with Section 308 of the Water Resources Development Act (WRDA) 1990 which disallows counting any benefits from a home towards a Federal project’s benefit-cost analysis if it was not built to compliance. That is, if a building was built or substantially improved after July 1 of 1991 (when the Act became effective), it needs to have its first floor elevation above the FEMA BFE as well as any freeboard the locality requires.

Cumulative Damage Removal: No

This is an indicator telling the model to remove buildings from the inventory once it reaches a certain damage threshold multiplier of the building’s value. There is no policy or evidence from studies that a building would be acquired after it receives a certain amount of damage; therefore, the team decided not to use this feature.

Calculate Life Loss: Yes

This feature allows the model to calculate life loss during the simulation. This is based on the population data that is filled in the asset file. Population data is needed for Day Time Under 65 years of age (D_U65), Night Time Under 65 (N_U65), Day Time Over 65 (D_65), and Night Time Over 65 (N_65). Population data was obtained from the US Census for Miami-Dade County. This analysis assumes that single-family residences and multifamily residences of four stories or less have population at risk (PAR). PAR was not included for any other building type because it is assumed that in the event of a hurricane, nonresidential buildings would be closed or evacuated. Residents of mid and high rise residential buildings are assumed to vertically evacuate. **Table 21** shows the population at Risk for various occupancy types.

Table 21. Population at Risk (PAR) in G2CRM Model

Occupancy Type*	Frequency	Mean Population N_U65	Mean Population D_U65	Mean Population N_65	Mean Population D_65
MFR-MS	1308	32	18	7	7
MFR-MS-4	193	8	4	1	1
MFR-SS	792	51	29	10	10
MFR-SS-4	133	12	4	4	4
SFR-MS	392	2	1	0	0
SFR-SS	1384	3	1	1	1

*Refer to **Table 8** for occupancy type descriptions

Auto-Generated Waves: Yes

Auto-generated waves were used which converted the full wave file from the save point data to a depth limited wave file. This was due to wave heights showing up extremely high in some areas compared to the storm database. The team was advised by ERDC to use auto-generated waves which resulted in wave heights in output files corresponding more closely to the save point data.

3.1.1 Sea Level Change Scenarios

The without-project conditions and benefits for the Recommended Plan (RP) were developed employing the USACE high sea level change scenario. The benefits and costs were further evaluated on the USACE low and intermediate sea level change scenarios.

3.2 Measure Refinements

This section covers the different measures that were applicable to the refined focus areas, and how they were further refined from optimization.

3.2.1 Refining Nonstructural Measures

The location of where nonstructural mitigation would occur was now fixated on the six focus areas. Biscayne Canal, Cutler Bay, Little River, Miami River, North Beach, South Beach, and Virginia Key are the focus areas where only nonstructural measures would be applied. **Table 22** shows the nonstructural measures that were carried forward applicable in the refined focus areas.

Table 22. Nonstructural Measure Screening

Nonstructural Measure	Discussion
Elevation	Elevating the first floor elevation above the design water elevation allows for the building and contents to receive less damage and remain intact. Evacuation is still highly recommended during a storm event when warranted.
Dry Floodproofing	Allows for flood risk reduction for the first few feet of elevation, typically up to four feet above grade.

3.2.2 Refining Critical Infrastructure

Reducing coastal storm risk to critical infrastructure was critical to this effort. The priority asset categories for critical infrastructure were determined during charrette workshops in Miami with the NFS and stakeholders through a screening process. The following CI were determined for this study:

- Communication Buildings
- Emergency Operation Centers
- Evacuation Shelters
- Fire Stations
- Police Stations
- Pump Station #1

3.3 G2CRM Model Results

The forecast of the future without project condition reflects the conditions expected during the period of analysis and provides the basis from which alternative plans are evaluated, compared, and selected since a portion of the flood damage would be prevented (i.e. flood damage reduced) with a Federal project in place. The same buildings in the Miami-Dade County Study Area will continue to be affected by the risk of flooding from coastal storms and suffer increasing losses each year. This section covers model results for the without project condition.

The total FWOP present value damage is estimated to be $4.72 billion within the focus areas. This is based on FY24 price levels and is associated with structure and content damage over the economic period of analysis of 50 years. This is the damage the economic model G2CRM is showing would potentially occur in the absence of a flood risk management measure.

Table 23 breaks down that FWOP damage by measure type and refined focus area. As shown in the table, there are approximately $4.72 billion in expected PV damage due to coastal storm for the period of analysis under the future without project condition.

Table 23. Future Without Project Condition

Focus Area	Present Value Future Without Project Estimated Damage	Present Value Future With Project Estimated Damage Annualized
Biscayne Canal	$263,000	$10,000
Cutler Bay	$569,000	$21,000
Little River	$527,000	$20,000
Miami River	$702,000	$26,000
North Beach	$1,308,000	$48,000
South Beach	$1,348,000	$50,000
Total	**$4,717,000**	**$175,000**

Note: October 2023 FY(24) price level, Period of Analysis: 50 years, Values displayed in $1,000's, Rounded, Interest Rate 2.75%

Damage is expected to increase under the future without project condition. Exacerbating the flooding is the phenomenon of relative sea level change, which is the combination of water level rise and vertical land movement. Figure 11 shows a map of the future without project damage within the refined focus areas per census block. It should be noted that the higher damage shown inland of Miami River is due to the census blocks being larger.

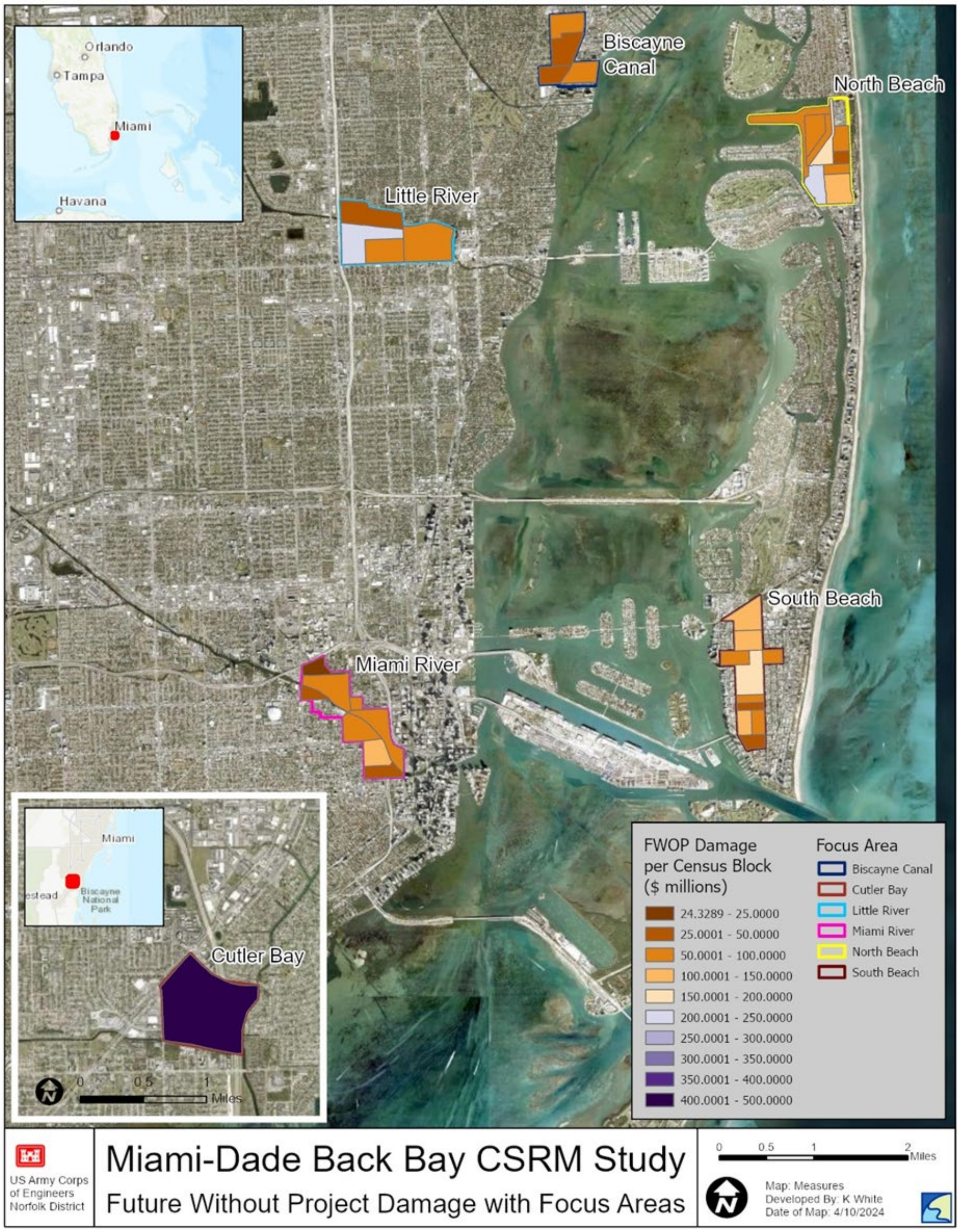

Figure 11. Spatial View of FWOP Damage

4 FUTURE WITH PROJECT CONDITION

The future with project condition is the most likely condition expected to exist in the future if a specific project is undertaken. A total of five alternatives were considered for this study. The analysis did not formulate a project alternative for recreation because it is considered incidental to the project. The analysis includes a discussion of residual flood damage and flood damage reduction for each alternative.

4.1 Formulation of Alternatives

A formulation strategy is a systematic way of combining measures into alternative plans based on the planning objectives. No single formulation strategy will result in a diverse array of alternatives, so a variety of strategies is needed.

4.2 Array of Alternatives

The array of alternatives was limited for this study due to the plan formulation and screening process discussed in Section 4 of the main report. Nonstructural coastal flood risk management measures were the primary measures used in this study. The array of alternatives is described in the table below.

Table 24. Final Array of Alternatives

Alternative Number	Alternative Name	Brief Description
1	No Action / Future Without Project	No action.
2	Critical Infrastructure Alternative	Analyzing measures for critical infrastructure within the focus areas. This includes dry floodproofing critical infrastructure.
3	Nonstructural Alternative	Elevating single-family residential buildings, elevating multifamily residential buildings of 4 units, and floodproofing nonresidential buildings within the focus areas.
4	Critical Infrastructure + Nonstructural Alternative	Combination of Alternative 2 and 3.
5	Critical Infrastructure + Subset of Nonstructural Alternative	Similar to Alternative 4 but focuses on residential buildings that are at the highest risk to coastal storm surge.

4.3 Evaluation and Comparison of Alternatives

Relevant data for each of the alternatives described above were entered into G2CRM as alternative plans and potential for flood damage reduced were calculated. **Table 25** shows the design water surface elevation (DWSE) and average ground elevation for the nonstructural MAs.

Table 25. Design water surface elevation for Nonstructural Measures

Area	WSE (ft. NAVD88)	Average Adjusted Significant Wave Height (ft)	Design Water Surface Elevation (ft. NAVD88)	Average First Floor Elevation (ft. NAVD88)
Biscayne Canal	9.9	1.0	10.6	5.6
Aventura	9.5	0	9.5	7.5
Cutler bay	13.3	1.1	14.0	8.0
Little River	9.6	1.0	10.3	6.7
Miami River	11.1	1.0	11.8	6.4
North Beach	9.1	1.0	9.9	4.9
South Beach	8.3	1.0	9.0	4.7
Virginia Key	9.5	0	9.5	13.7

The DWSE used the 0.5% AEP on the 50% confidence level stillwater elevation as a starting point which includes wave setup, astronomical tides, storm surge, and USACE high curve SLC to the year 2089. 0.5% AEP, or the 200-year floodplain, was chosen as a starting point in agreement with Miami-Dade County. The reason the DWSE in the table shows ranges is due to all save points having additional significant wave heights (SWH) associated with them; however, whether or not SWH was added to determine the DWSE was dependent on each structure's location with respect to the FEMA special flood hazard area (SFHA) – areas at high risk of flooding. The following method was used to determine how much additional wave height was added if additional SWH was needed for a structure's DWSE:

1. Buildings that fell within FEMA's effective SFHA were considered for additional SWH.
    a. If the building fell within the VE zone or coastal high hazard area (1% AEP, but with additional hazard associated with storm waves 3 feet or greater) then the full value of the SWH from the save point was added.
    b. If the building fell within the AE zone (1% AEP, but where wave heights are less than 1.5 feet) then 25% of the SWH was added to the stillwater elevation to get the DWSE. The goal was to estimate a percentage associated with the midpoint of the AE zone. 25% was chosen since 1.5 feet is the maximum wave height in an AE zone when there are no coastal A zones, and the midpoint of 1.5 is 0.75'. 0.75' is 25% of 3' which is the minimum wave height needed to be in a VE zone which is where 100% of the SWH was included; therefore, 25% of the SWH was added for these buildings.
2. Buildings that did not fall within SFHA did not have additional wave height added to determine the DWSE.

Once the adjusted SWH was determined, if any, that value was then added to the DWSE to determine the final DWSE. This method was coordinated with the vertical team at the Climate Community of Practice and the Planning Center of Expertise for Coastal Storm Risk Management. FEMA's effective SFHA was used which means there's a potential for the SFHA to expand over the next 50 years that is not being captured. This could mean there are some buildings within the existing SFHA's vicinity that may need additional SWH added to its DWSE based on when FEMA updates the SFHA in the future.

The DWSE described above was used as the starting point, or minimal DWSE for each building. To complete this study within an expedited schedule to accomplish a Chief's Report in 2024, the costs were developed assuming each house recommended for elevation would be elevated 12 feet above ground elevation. The DWSE using the 0.5% AEP including SLC and SWH was ranging from 8.7' to 15.4' NAVD88 with an average of approximately 11' NAVD88. Buildings are typically recommended to not be elevated beyond 12' above the ground due to structural limitations. Since the costs were developed using 12' above ground, the final DWSE for elevating homes was updated to ground elevation plus 12'.

Once the DWSE was determined for each building, it was checked against the estimated FFE of the building. Any building whose FFE was greater than the DWSE was considered not at risk for the purposes of this study and was not analyzed any further. The data was aggregated in compliance with PB 2019-03 by looking at buildings that shared similar floodplains and flood characteristics. Buildings whose FFE was lower than the DWSE was further analyzed as shown below:

1. Residential buildings (1-story, 2-story, and 3-story homes)
    a. These buildings were included in the FWP analysis for elevation
    b. The Plan Alternative (PA) file included all of these buildings, and the target elevation became the DWSE for the building
2. Nonresidential buildings
    a. These buildings were included in the FWP analysis for floodproofing
    b. The PA file included all of these buildings, and the occupancy type changed to add on the "-FP" tag which is associated with a different depth damage function (DDF). This DDF was modified so that the building would not be getting any damage under 4 feet which is the engineering limitation this study used for floodproofing. This is based on the National Nonstructural Committee best management practices.

The FWP condition runs were completed once the PA file was created for each alternative. The economics model (G2CRM) provides building and content damage for each building. Preventing this damage then becomes the benefit portion of any Benefit-to-Cost ratio (BCR) calculations. The FWOP and FWP results were then compared for analysis and BCRs were calculated for each building. Only buildings with an individual BCR greater than 0.35 were carried forward for Alternative 5. This approach was intended to identify the greatest number of assets to include in the plan, while still optimizing net benefits. Analysis for the floodproofing of nonresidential buildings was conducted in a similar manner to that of residential buildings. The number of buildings recommended for elevation is 2,057.

Table 26. Number of assets elevated and dry floodproofed per alternative

Asset Category	Measure	Alt1 (FWOP)	Alt 2	Alt 3	Alt 4	Alt 5
Single-family Residential	Elevate SFR	0	0	1,731	1,731	460
Multifamily Residential	Elevate 4 unit MFRs	0	0	326	326	324
Nonresidential	Dry Floodproof	0	0	403	403	403
CI	Dry Floodproof	0	27	0	27	27
Total		**0**	**27**	**2,460**	**2,487**	**1,214**

4.3.1 Life Loss Analysis

G2CRM is capable of modeling life loss using a simplified life loss methodology. The future without project condition was modeled to serve as a baseline due to the uncertainty in modeling life loss. Therefore, when compared to the future with project condition, any addition or reduction of life loss from the baseline would serve as a proxy in identifying impacts to life safety the alternatives might have.

Using the proper lethality function, a random number is generated and interpolated using the Lethality Function Values to get the expected fraction of life loss. The way the default lethality functions are formed is that the smaller the random number, the higher the life loss. This interpolation from the lethality function is multiplied by the nighttime population for the corresponding age range and the remaining population fraction in order to calculate the life loss under 65 and life loss for 65 and older. This is recorded in fractions of lives, so depending on the level of output, there exists small rounding differences.

There exists much uncertainty regarding the modeling of life loss; therefore, the results of the modeling should be viewed as more qualitative as opposed to a quantitative assessment of life loss even though the results are stated in numerical values. Also, the results should be viewed in terms of order of magnitude compared to the baseline. Viewing the results in this manner is a better use of the model to understand whether or not any recommended alternatives might or could have an impact to life safety as opposed to no action (e.g. introducing more risk of flooding). **Table 27** presents the mean life loss estimates for each measure in the study area over the fifty year period of analysis.

Table 27. FWOP and FWP Loss of Life

Alternatives	Direct Loss of Life Prevented	Residual Life Loss Risk (%)
1. No Action / FWOP	0 / 504	100%
2. CI Alternative	0 / 504	100%
3. Nonstructural Alternative	437/ 504	13%
4. CI + Nonstructural Alternative	437 / 504	13%
5. CI + Subset of Nonstructural Alternative	79 / 504	84%

4.3.2 Future Damage

The nonstructural future with project for alternatives 2, 3, 4, and 5 condition was modeled within G2CRM. The **Table 27** indicates the direct loss of life prevented. There is no loss of life reduction for alternative 2 since it was assumed that CI has no population that remains during a storm. Alternatives 3 and 4 loss of life reduction is 87% and for alternative 5 is 16% when compared to the FWOP. We can infer based on **Table 27** that the total loss of life is 504. The number of people saved with the model according to alternatives 3 and 4 is 437, 79 using alternative 5, and none utilizing alternative 2.

Analysis for the floodproofing of nonresidential buildings was conducted in a similar manner to that of residential buildings. The future with project modeling results, shown as present value damage and average annual damage, for each measure type and focus area is shown in **Table 28**.

Table 28. Future With Project Conditions by Focus Areas

Measure	Focus Area	Present Value Future Without Project Estimated Damage	Present Value Future With Project Estimated Damage	Benefits over 50 Years
CI	Biscayne Canal	$11,000	$8,000	$3,000
	Cutler Bay	$5,000	$2,000	$3,000
	Miami River	$73,000	$37,000	$36,000
	North Beach	$40,000	$13,000	$27,000
	South Beach	$195,000	$12,000	$183,000
Nonstructural	Biscayne Canal	$252,000	$168,000	$84,000
	Cutler Bay	$564,000	$219,000	$345,000
	Little River	$527,000	$368,000	$159,000
	Miami River	$629,000	$440,000	$189,000
	North Beach	$1,268,000	$943,000	$325,000
	South Beach	$1,153,000	$836,000	$317,000
Total		$4,717,000	$3,046,000	$1,671,000

Note: October 2023 FY(24) price level, Period of Analysis: 50 years, Values displayed in $1,000’s, Rounded, Interest Rate 2.75%

4.3.3 Benefits During Construction

Table 33 under Section 4.4.2, Costs and Schedule, shows the length of construction schedule for CI floodproofing, nonresidential floodproofing, and residential elevations. Benefits during construction are benefits accrued during the construction schedule period since buildings will be either be elevated or floodproofed during that time. G2CRM has a function to allow buildings to come online, meaning constructed, prior to others. As assets get elevated or floodproofed within the simulation prior to the base year, those assets receive benefits during construction, once the FWP condition is deducted from the FWOP condition. This means benefits will start accruing for those buildings prior to the base year of 2040 which is when all construction is expected to be completed. Since sequencing of buildings can vary and since participation rates are unknown, buildings were randomized in G2CRM to be constructed throughout the construction period to capture those benefits during construction. Alternative 2 and 5 will have less benefits during construction due to having less buildings included in them compared to Alternative 3 or 4.

4.3.4 Benefits to Costs

The equivalent annual benefits were then compared to the average annual cost to develop net benefits and a benefit-to-cost ratio (BCR) for each alternative. The net benefits for each alternative were calculated by subtracting the average annual costs from the equivalent average annual benefits, and a BCR was derived by dividing average benefits by average annual costs. Net benefits were used for identification of the NED plan in accordance with the Federal objective. For comparative purposes, the following **Table 29** summarizes the equivalent annual damage (benefits), average annual costs, first cost, net benefits, and BCR for each alternative.

Table 29. Benefit-to-Cost Ratio and Net Benefits of All Alternatives

Alternative	Total Average Annual Benefits	Total Average Annualized Cost	Project First Cost	Benefit-to-Cost Ratio (BCR)	Net Annual Benefits
Alternative 1. No Action / FWOP	$0	$0	$0	N/A	$0
Alternative 2. CI	$9,000	$5,000	$110,000	1.8	$4,000
Alternative 3. Nonstructural	$53,000	$116,000	$2,550,000	0.46	-$63,000
Alternative 4. CI + Nonstructural	$62,000	$121,000	$2,660,000	0.51	-$59,000
Alternative 5. CI + Subset of Nonstructural	$56,000	$74,000	$1,560,000	0.76	-$18,000

Note: October 2023 FY(24) price level, Period of Analysis: 50 years, Interest Rate 2.75%

Comparison of benefits with regards to costs was performed for each alternative. These comparisons provide the framework for completing the evaluation and comparison of alternative plans.

4.3.5 Plan Selection and Array of Alternatives Comparison across Four Evaluation Accounts

There are four accounts to facilitate and display the effects of alternative plans in the formulation of water resource projects while recognizing the importance of maximizing potential benefits relative to project costs. These accounts are National Economic Development (NED), Environmental Quality (EQ), Regional Economic Development (RED), and Other Social Effects (OSE). Plan formulation involves comparing each of the alternatives against the four evaluation accounts shown in **Table 30**. Further information on the evaluation of the array of alternatives with respect to the four accounts, including OSE, EQ, and RED, is provided in Sections 4 and 8 of the main report.

Table 30. Array of Alternatives Evaluation to Four Accounts

Alternative	NED ($1000s)	EQ	RED	OSE Score
Alternative 1. No Action / FWOP	N/A	No significant impacts to the environment	Value added: $0 FTE[4] jobs: 0	0
Alternative 2. CI Alternative	**AAB:**[1] $9,000 **AAC:**[2] $5,000 **NAB:**[3] $4,000 **BCR:** 2.1	No significant impacts to the environment	Value added: $114.5 million FTE jobs: 1,150	10
Alternative 3. Nonstructural Alternative	**AAB:** $53,000 **AAC:** $116,000 **NAB:** -$63,000 **BCR:** 0.46	No significant impacts to the environment	Value added: $2.5 billion FTE jobs: 24,200	17
Alternative 4. CI + Nonstructural Alternative	**AAB:** $62,000 **AAC:** $121,000 **NAB:** -$59,000 **BCR:** 0.51	No significant impacts to the environment	Value added: $2.7 billion FTE jobs: 25,300	33
Alternative 5. CI + Subset of Nonstructural Alternative	**AAB:** $56,000 **AAC:** $74,000 **NAB:** -$18,000 **BCR:** 0.76	No significant impacts to the environment	Value added: $1.6 billion FTE jobs: 15,200	22

[1]**AAB** – Average Annualized Benefits
[2]**AAC** – Average Annualized Costs
[3]**NAB** – Net Annual Benefits
[4]**FTE** – Full-time equivalent

Based on the evaluation of the array of alternatives, Alternative 4 was identified as the plan that maximizes comprehensive net public benefits and was therefore selected as the Recommended Plan (RP). Alternative 4, also known as the Maximum Risk Management Plan within the context of this refined study scope, is the alternative that maximizes both the OSE and RED accounts, maximizes human life loss prevented, and promotes the highest inclusion of vulnerable environmental justice communities. Alternative 2, CI Only, is defined as the NED Plan because it reasonably maximizes net NED benefits; however, because Alternative 4 maximizes comprehensive net public benefits, and more effectively satisfies the study objectives to manage coastal storm risk and improve coastal resiliency for vulnerable environmental justice communities, the USACE in collaboration with Miami-Dade County are pursuing a NED Policy Exception to support Alternative 4 as the RP rather than the NED Plan. The NED Policy Exception request to support Alternative 4 as the RP was approved by the Assistant Secretary of the Army for Civil Works on June 24, 2024. More details on the selection and description of the RP are provided in Section 8 and 9 of the main report respectively.

4.4 Recommended Plan

According the USACE Planning and Guidance Notebook (i.e. ER 1105-2-100), Chapter 2-3, (4):

Section 904 of the Water Resources Development Act of 1986 (WRDA of 1986) requires the Corps to address the following matters in the formulation and evaluation of alternative plans:

- Protecting and restoring the quality of the total environment.
- The well-being of the people of the United States
- The prevention of loss of life.
- The preservation of cultural and historical values

The ER goes on to state in Chapter 3-3 (11), Flood Damage Reduction:

"...An essential element of the analysis of the recommended plan is the identification of residual risk for the sponsor and the flood plain occupants, including residual damage and potential for loss of life, due to exceedance of design capacity."

Moreover, ER 1105-2-101, Planning, Risk Assessment For Flood Risk Management Studies, 5.Context:

"…All flood risk managers must balance the insights of USACE's professional staff with stakeholder concerns for such matters as residual risks, life safety, reliability, resiliency and cost while acknowledging no single solution will meet all objectives, and trade-offs must always be made"

The number of buildings recommended for elevating single-family buildings and multifamily buildings, dry floodproofing nonresidential buildings, and dry floodproofing CI in the RP is 2,057, 403, and 27 respectively. **Table 31** shows the breakdown of nonstructural measures per Focus Area as part of the RP.

Table 31. Nonstructural Measures per Focus Area in the RP

Focus Area	# of Single-Family Residential Elevations	# of Multifamily Residential Elevations	# of Nonresidential Floodproofings	# of CI Floodproofings	Total
Biscayne Canal	260	28	23	4	315
Cutler Bay	69	0	38	3	110
Little River	805	27	87	0	919
Miami River	185	68	105	4	362
North Beach	257	185	47	8	497
South Beach	155	18	103	8	284
Total	1,731	326	403	27	2,487

4.4.1 Sea Level Change Economic Uncertainty

Sensitive analysis was performed on the RP by also looking at the USACE Low and Intermediate SLC curves. **Table 32** displays the results of all three USACE SLC curves.

Table 32. Sea Level Change Economic Uncertainty

USACE SLC Curve	Average Annual Benefits	Average Annual Costs	Project First Cost	BCR	Net Benefits
High	$62,000	$121,100	$2,660,000	0.51	-$59,000
Intermediate	$30,000	$121,100	$2,660,000	0.25	-$91,000
Low	$23,000	$121,100	$2,660,000	0.19	-$98,000

Note: October 2023 FY(24) price level, Period of Analysis: 50 years, Interest Rate 2.75%

The USACE high curve resulted in the most net benefits. The USACE high curve also aligns with the Miami-Dade County's climate compact that they signed which recommends the USACE or NOAA high curve depending on the project life and scale.

4.4.2 Costs and Schedule

Continuing the comparison process, first cost estimates were developed for each of the alternatives that were evaluated. The structural construction cost estimate was developed using Micro-Computer Aided Cost Estimating System (MCACES), Second Generation (MII) using the appropriate Work Breakdown Structure (WBS). These cost estimates were developed utilizing cost resources such as RSMeans, MII Cost Libraries, and vendor quotations and are supported by the preferred labor, equipment, materials, and crew/production breakdown to align with current construction methods. Quantities were provided by the PDT and checked by the cost engineer.

Cost estimates were provided by Cost Engineering Section in FY24 price levels (reference Cost Engineering Appendix for more details). MII costs do not include interest during construction (IDC) and was calculated separately for each month using the formula below:

Interest Factor = $(((1+i)^{(1/12)^{(n-x)}})-1$

Where 1 + i = 1.025 for 2.75% interest rate

n = # of months for construction

x = the month for which IDC is being calculated

The total IDC ends up being the IDC calculated per month throughout the length of construction. IDC is included among the economic costs that comprise NED project costs. IDC represents the opportunity cost of capital incurred during the construction period. The cost of a project to be amortized is the investment incurred up to the beginning of the period of analysis. The investment cost at that time is the sum of construction and other initial cost plus interest during construction. Cost incurred during the construction period should be increased by adding compound interest at the applicable project discount rate from the date the expenditures are incurred to the beginning of the period of analysis. The construction period varied according to the Total Project Cost Summary (TPCS) schedule available in the Cost Engineering Appendix. **Table 33** shows a summarized version of the schedule.

Table 33. Cost Schedule Implementation

Measure	Duration (Years)	Fiscal Year Start	Fiscal Year End	Priority
CI Floodproofing	2	2027	2029	1
Residential Elevations	13	2027	2040	2
Nonresidential Floodproofing	6	2027	2033	3

It should be noted that IDC for nonstructural measures were not calculated for the full 13 years of construction based on the schedule. Per PB 2019-03, IDC was calculated assuming elevating and floodproofing of buildings will take four months to complete individually. It is anticipated that due to nonstructural measures being voluntary that there will not be full 100 percent participation. This could result in the construction period being less.

For comparison to the benefits, which are average annual flood damage reduced, the first costs were stated in average annual equivalent also based on the FY24 discount rate and period of analysis. In addition, annual operation and maintenance (O&M) costs were also added to the alternatives where applicable. Section 9.5, Operations, Maintenance, Repair, Replacement, and Rehabilitation, of the main report. The following tables display the results of the costs calculation. All costs include a capital recovery factor of 0.037, priced at an interest rate of 2.75%, and include a 52% contingency when applicable. Contingencies were determined following a thorough Cost and Schedule Risk Analysis (CSRA).

Table 34. Project Costs – Nonstructural and Critical Infrastructure ($1000s)

Project First Costs	
Construction	$1,592,000,000
Preconstruction, Engineering, and Design (PED)	$500,000,000
Construction Management (CM)	$245,000,000
Real Estate	$165,000,000
Cultural Resource Mitigation	$160,000,000
Project First Cost	**$2,660,000,000**
Average Annual Costs	$117,000,000
Annualized Interest During Construction (IDC)	$300,000
Annualized Operation, Maintenance, Repair, Replacement and Rehabilitation (OMRR&R)	$3,800,000
Total Average Annual Costs (AAC)	**$121,100,000**
Average Annual Benefits (AAB)	$62,000,000
Annualized Net Benefits	-$59,100,000
BCR	**0.51**

Note: October 2023 FY(24) price level, Period of Analysis: 50 years, Interest Rate 2.75%, Capital Recovery Factor 0.03702

The table above depicts life cycle costs for the RP including total construction costs, the annual operation and maintenance costs, and the total average annual costs.

4.5 Summary Of Recommended Plan

The RP maximizes comprehensive net public benefits and has a BCR of 0.51. The average annual damage and benefits, total annual costs, benefit-to-cost ratio, and net remaining benefits for the RP are displayed in **Table 35**.

Table 35. Economic Summary of the Recommended Plan at 2.75% ($1000s)

Economic Summary of RP	Alternative 4
Price Level	FY24
FY24 Water Resources Discount Rate	2.75%
Average Annual Benefits	$62,000
Average Annualized Cost	$121,100
Net-Benefits	-$59,100
Benefit Cost Ratio	0.51

The following **Table 36** summarizes the average annual benefits, average annual costs, BCR, and net benefits for the Recommended Plan at the 7% discount rate.

Table 36. Economic Summary of the Recommended Plan at 7%

Average Annual Benefits	Average Annual Costs	BCR	Net Benefits
$56,000	$306,400	0.18	-250,400

Note: October 2023 FY (24) price level, Period of Analysis: 50 years, 1000s

5 REGIONAL ECONOMIC DEVELOPMENT

5.1 Recons Methodology

When the economic activity lost in the study area can be transferred to another area or region in the national economy, these losses cannot be included in the NED account. However, the impacts of the employment, income, and output of the regional economy are considered part of the Regional Economic Development (RED) account. The input-output macroeconomic model, RECONS, was used to address the impacts of the construction spending associated with the Recommended Plan (RP).

For this Regional analysis, the regional economic development (RED) effects of implementing the RP or Alternative 4 will be estimated. The RECONS Standard Geographic Area for the Miami-Dade County was selected using an expenditure year of 2026.

This RED analysis, using RECONS, employs input-output economic analysis, which measures the interdependence among industries and workers in an economy. This analysis uses a matrix representation of a region's economy to predict the effect of changes, the implementation of a project of a specific USACE Business Line, to the various industries that would be impacted. The greater the interdependence among industry sectors, the larger the multiplier effect on the economy. Changes to government spending drive the input-output model to project new levels of sales (output), value added (Gross Regional Product or GRP), employment, and income for each industry.

The specific input-output model used in this analysis is RECONS (Regional Economic System). This model was developed by the Institute for Water Resources (IWR), Michigan State University, and the Louis Burger Group. RECONS uses industry multipliers derived from the commercial input-output model IMPLAN to estimate the effects that spending on USACE projects have on a regional economy. The model is linear and static, showing relationships and impacts at a certain fixed point in time. Spending impacts are composed of three different effects: direct, indirect, and induced.

Direct effects represent the impacts the new federal expenditures have on industries which directly support the new project. Labor and construction materials can be considered direct components to the project. Indirect effects represent changes to secondary industries that support the direct industries. Induced effects are changes in consumer spending patterns caused by the change in employment and income within the industries affected by the direct and induced effects. The additional income workers receive via a project and spent on clothing, groceries, dining out, and other items in the regional area are secondary or induced effects.

The inputs for the RECONS model are expenditures that are entered by Work Activity or industry sector, each with its own unique production function. RECONS Work Activities are used to capture the types of spending associated with a particular measure or alternative. Default Work Activities focus on structural measures and do not adequately reflect spending associated with nonstructural measures. RECONS includes functionality to develop study specific Work Activities using the North American Industry Classification System (NAICS). RECONS Work Activities were generated to reflect spending patterns associated with the measures envisioned as part of the proposed project. A RECONS Work Activity based on NAICS Code 236118 (“Addition, alteration and renovation (i.e., construction), residential building”) was used for elevation of residential buildings. A RECONS Work Activity based on NAICS Code 236210 (“Addition, alteration and renovation, industrial building (except warehouses)”) was used for activities related to dry floodproofing of critical infrastructure and nonresidential buildings. The baseline data used by RECONS to represent the regional economy of Miami-Dade, Broward, and Palm Beach Counties are annual averages from the Bureau of the Census, the Bureau of Labor Statistics, and the Bureau of Economic Analysis for the year 2019. The model results are expressed in 2026 dollars.

5.2 Recons Assumptions

Input-output analysis rests on the following assumptions. The production functions of industries have constant returns to scale, so if inputs are to increase, output will increase in the same proportion. Industries face no supply constraints; they have access to all the materials they can use. Industries have a fixed commodity input structure; they will not substitute any commodities or services used in the production of output in response to price changes. Industries produce their commodities in fixed proportions, so an industry will not increase production of a commodity without increasing production in every other commodity it produces. Furthermore, it is assumed that industries use the same technology to produce all of its commodities. Finally, since the model is static, it is assumed that the economic conditions of 2019, the year of the socio-economic data in the RECONS model database, will prevail during the years of the construction process.

5.3 Recons Metrics

"Output" is the total sum of transactions that take place as a result of the construction project, including both value added and intermediate goods purchased in the economy. "Labor Income" includes all forms of employment income, including employee compensation (wages and benefits) and proprietor income. "Gross Regional Product (GRP)" is the value-added output of the study region. This metric captures all final goods and services produced in the study areas because of the project's existence. It is different from output in the sense that one dollar of a final good or service may have multiple transactions associated with it. "Jobs" is the estimated worker-years of labor required in full time equivalent units to build the project.

5.4 Recons Results

The expenditures associated with All Work Activities, with Ability to Customize Impact Area and Work Activity at MIAMI BACK BAY, FL (NAO) are estimated to be $2,659,500,000. Of this total expenditure, $2,659,368,584 will be captured within the local impact area. The remainder of the expenditures will be captured within the state impact area and the nation. These direct expenditures generate additional economic activity, often called secondary or multiplier effects. The direct and secondary impacts are measured in output, jobs, labor income, and gross regional product (value added) as summarized in the following tables. The regional economic effects are shown for the local, state, and national impact areas. In summary, the expenditures $2,659,500,000 support a total of 23,349.5 full-time equivalent jobs, $1,562,277,433 in labor income, $2,548,681,558 in the gross regional product, and $4,985,605,608 in economic output in the local impact area. More broadly, these expenditures support 31,955.7 full-time equivalent jobs, $2,285,380,802 in labor income, $3,714,215,667 in the gross regional product, and $7,316,355,508 in economic output in the nation.

Table 37. Project Expenditure

Parameter	Value
Business Line	User Defined
Work Activity	Miami Back Bay
Year of Expenditure	2026
Current Expenditure	$2,659,500,000

Table 38. Spending Profile

	Spending Category	Percentage (%)
1	Dry floodproofing	26%
2	Residential elevations	74%
3	Total	100%

Table 39. Local Purchase Coefficients

IMPLAN Code	Industry	Expenditure ($1000s)	Local Purchase Coefficients		
			Local	State	US
51	Construction of new manufacturing structures	$691,470,000	100%	100%	100%
61	Maintenance and repair construction of residential structures	$1,968,030,000	100%	100%	100%
	Total	$2,659,500,000	100%	100%	100%

Table 40. Overall RECONS Summary

Area	Local Capture	Output	Jobs*	Labor Income	Value Added
Local					
Direct Impact		$2,659,368,584	11,434.2	$844,679,024	$1,245,303,462
Secondary Impact		$2,326,237,023	11,915.3	$717,598,409	$1,303,378,096
Total Impact	$2,659,368,584	$4,985,605,608	23,349.5	$1,562,277,433	$2,548,681,558
State					
Direct Impact		$2,659,368,584	11,937.6	$844,679,024	$1,245,303,462
Secondary Impact		$2,585,846,536	13,373.5	$785,261,203	$1,421,095,954
Total Impact	$2,659,368,584	$5,245,215,120	25,311.1	$1,629,940,228	$2,666,399,416
US					
Direct Impact		$2,659,499,816	11,938.2	$869,767,488	$1,245,715,937
Secondary Impact		$4,656,855,691	20,017.5	$1,415,613,314	$2,468,499,730
Total Impact	$2,659,499,816	$7,316,355,508	31,955.7	$2,285,380,802	$3,714,215,667

* Jobs are presented in full-time equivalence (FTE)

6 CONCLUSION

Miami-Dade County is highly susceptible to damage from storm surge. When factoring in the potential for sea levels to rise in excess of baseline projections, significant economic damage from coastal forces can be expected to increase dramatically.

In an effort to reduce as much damage as possible within the extents of the Focus Areas, the modeling team considered the most appropriate measures and alternatives to address the risks from storm surge. Years of technical expertise, best professional judgment and rigorous modeling efforts were all leveraged to determine a plan that maximizes benefits. In conclusion, Alternative 4 was carried forward as the RP, as it maximized comprehensive net public benefits and met the objectives of the study. The BCR is 0.51 and the net benefits are -$59,100,000. The plan is efficient, acceptable, and complete.

7 REFERENCES

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