APPENDIX CM-1

The following map series indicate the adopted coastal features not depicted on the 2020 Future Land Use Map. The following maps include ~~“Floodplains” and Coastal High Hazard Area”.~~: “CM-1: Flood Zones Federal Emergency Management Administration”, “CM-2: Coastal High Hazard Area, “CM-3: 2040 Inundation Risk”, and “CM-4: 2060 Inundation Risk”.

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Map CM-1: Flood Zones

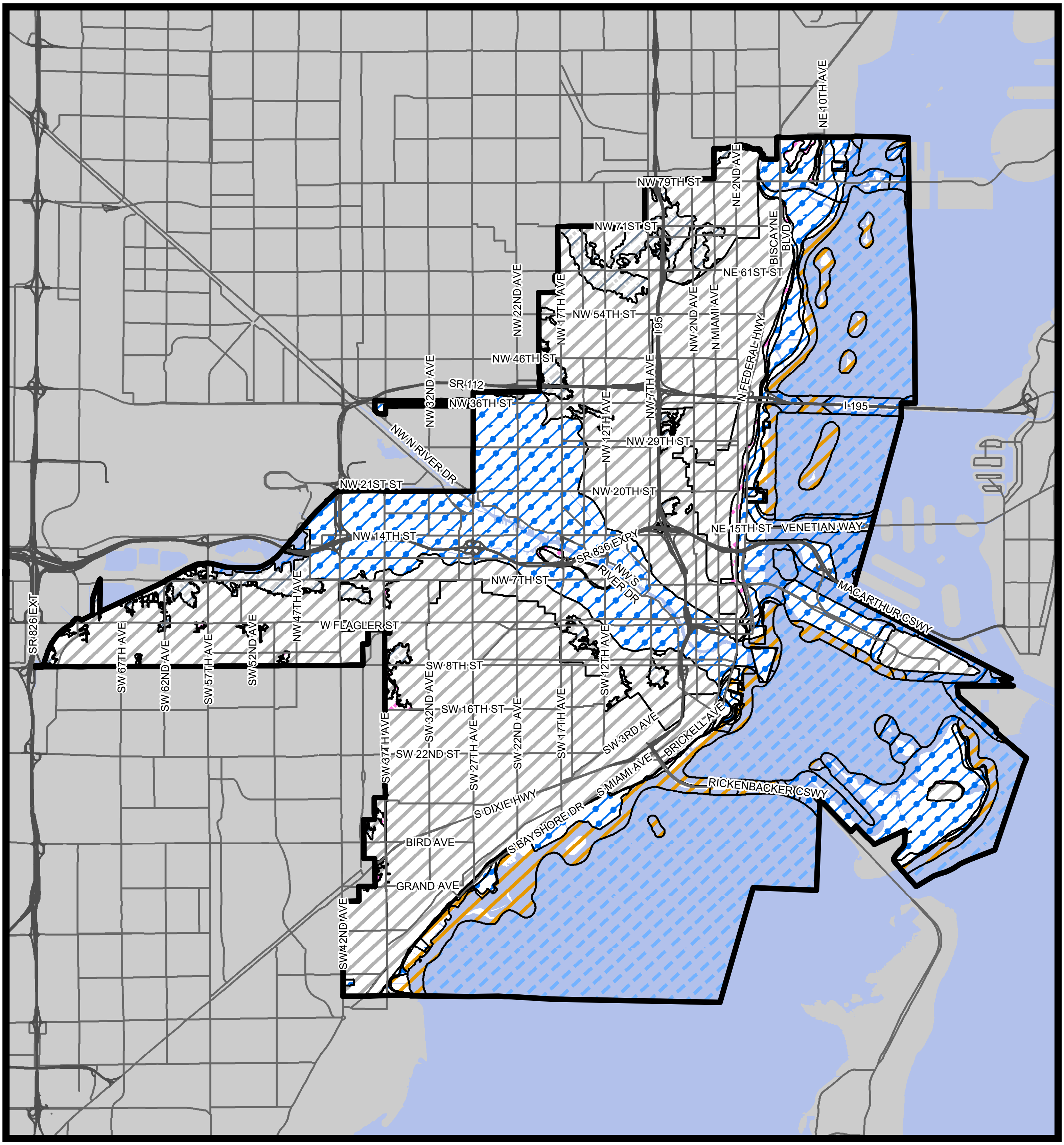
Federal Emergency Management Administration

OW
AE
VE
AH
X
X-500
PCT
City Boundary

N

0 1 2 Miles

Created by the City of Miami Planning Department
December 15, 2019
N:\Planning\GIS\Resilience_Mapping\MXD
Sources: Miami Dade County aerial and LiDAR



Map CM-2: Coastal High Hazard Area

Coastal High Hazard Area*

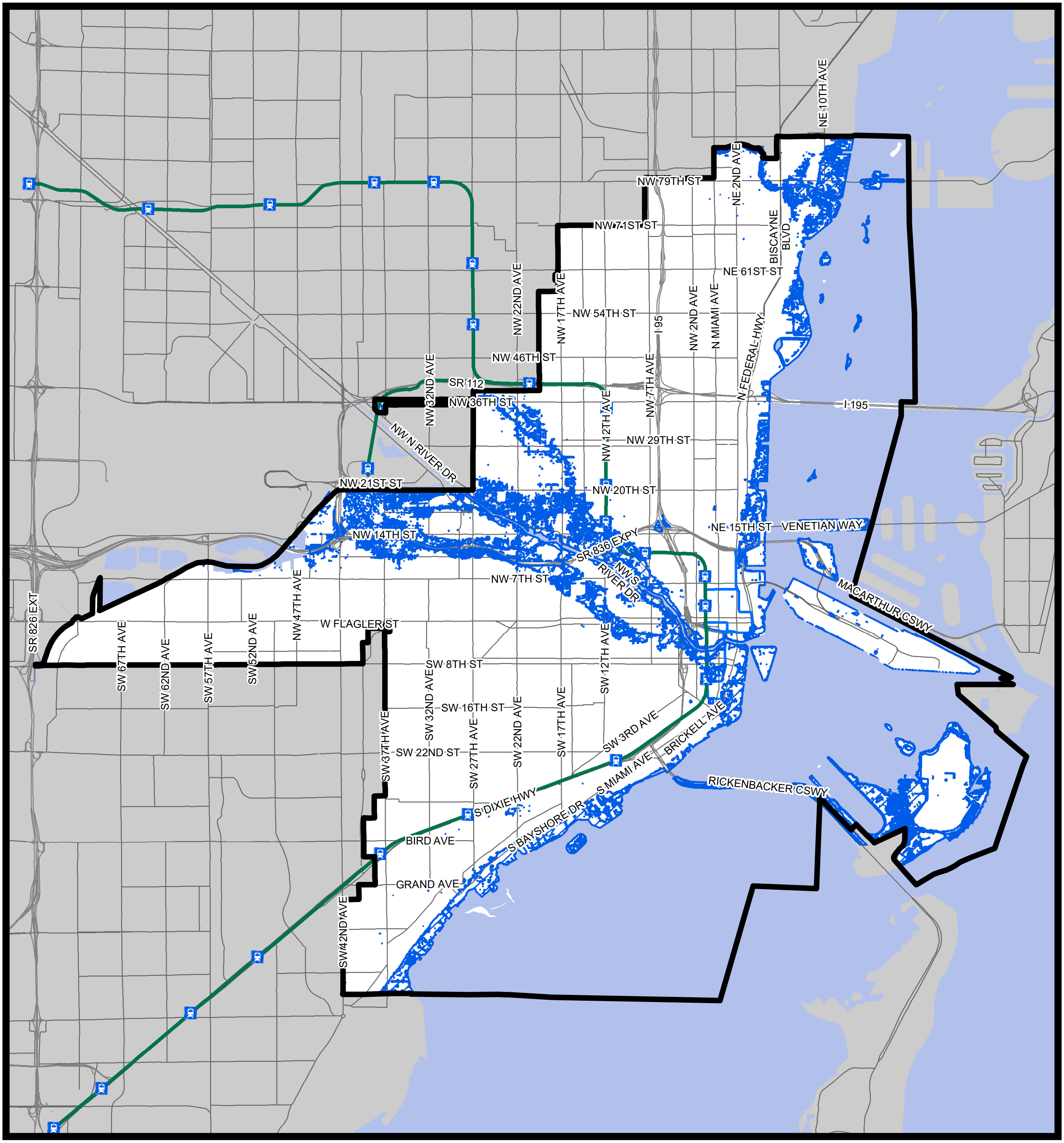
City Boundary

*As defined in Coastal Management Element Policy CM-4.1.2

N

0 1 2 Miles

Created by the City of Miami Planning Department
October 2022
N:\Planning\GIS\Resilience_Mapping\MXD
Sources: Miami Dade County LiDAR; SLOSH



Map CM-3: 2040 Inundation Risk

The Coastal High Hazard Area (CHHA), as defined in Section 163.3178(2)(h)9, Florida Statutes, covers the area that is below the elevation of the category 1 storm surge line. The CHHA is the area particularly vulnerable to the effects of tropical storm events. This map analyzes the extent of the CHHA, accounting for sea level rise, using the Unified Sea Level Rise projection from the Southeast Florida Regional Climate Change Compact.

IPCC 2040

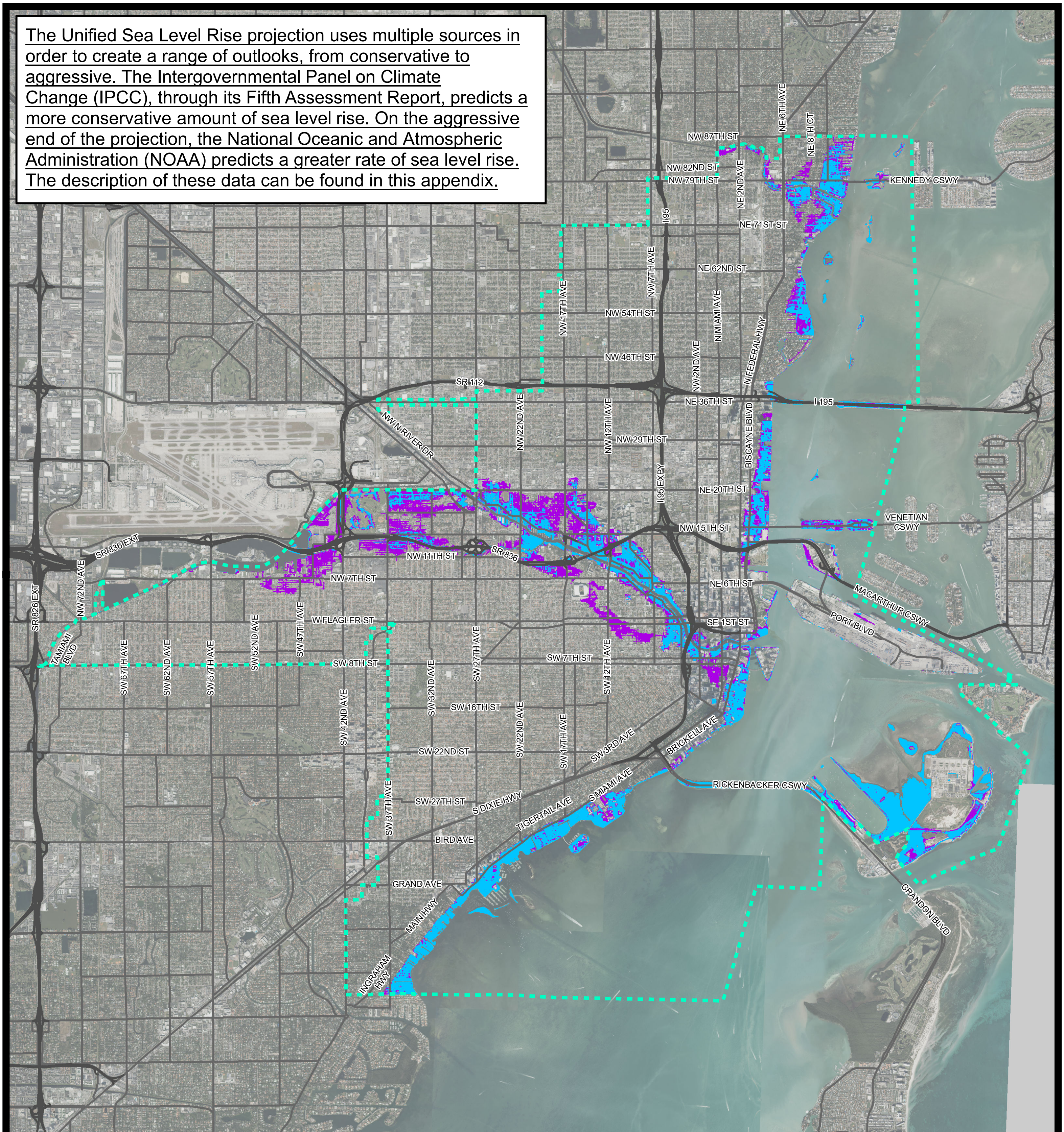
NOAA 2040

N

0 1 2 Miles

Created by the City of Miami Planning Department
September 2022
N:\Planning\GIS\Resilience_Mapping\MXD
Sources: Miami Dade County aerial and LiDAR

The Unified Sea Level Rise projection uses multiple sources in order to create a range of outlooks, from conservative to aggressive. The Intergovernmental Panel on Climate Change (IPCC), through its Fifth Assessment Report, predicts a more conservative amount of sea level rise. On the aggressive end of the projection, the National Oceanic and Atmospheric Administration (NOAA) predicts a greater rate of sea level rise. The description of these data can be found in this appendix.



Map CM-4: 2060 Inundation Risk

The Coastal High Hazard Area (CHHA), as defined in Section 163.3178(2)(h)9, Florida Statutes, covers the area that is below the elevation of the category 1 storm surge line. The CHHA is the area particularly vulnerable to the effects of tropical storm events. This map analyzes the extent of the CHHA, accounting for sea level rise, using the Unified Sea Level Rise projection from the Southeast Florida Regional Climate Change Compact.

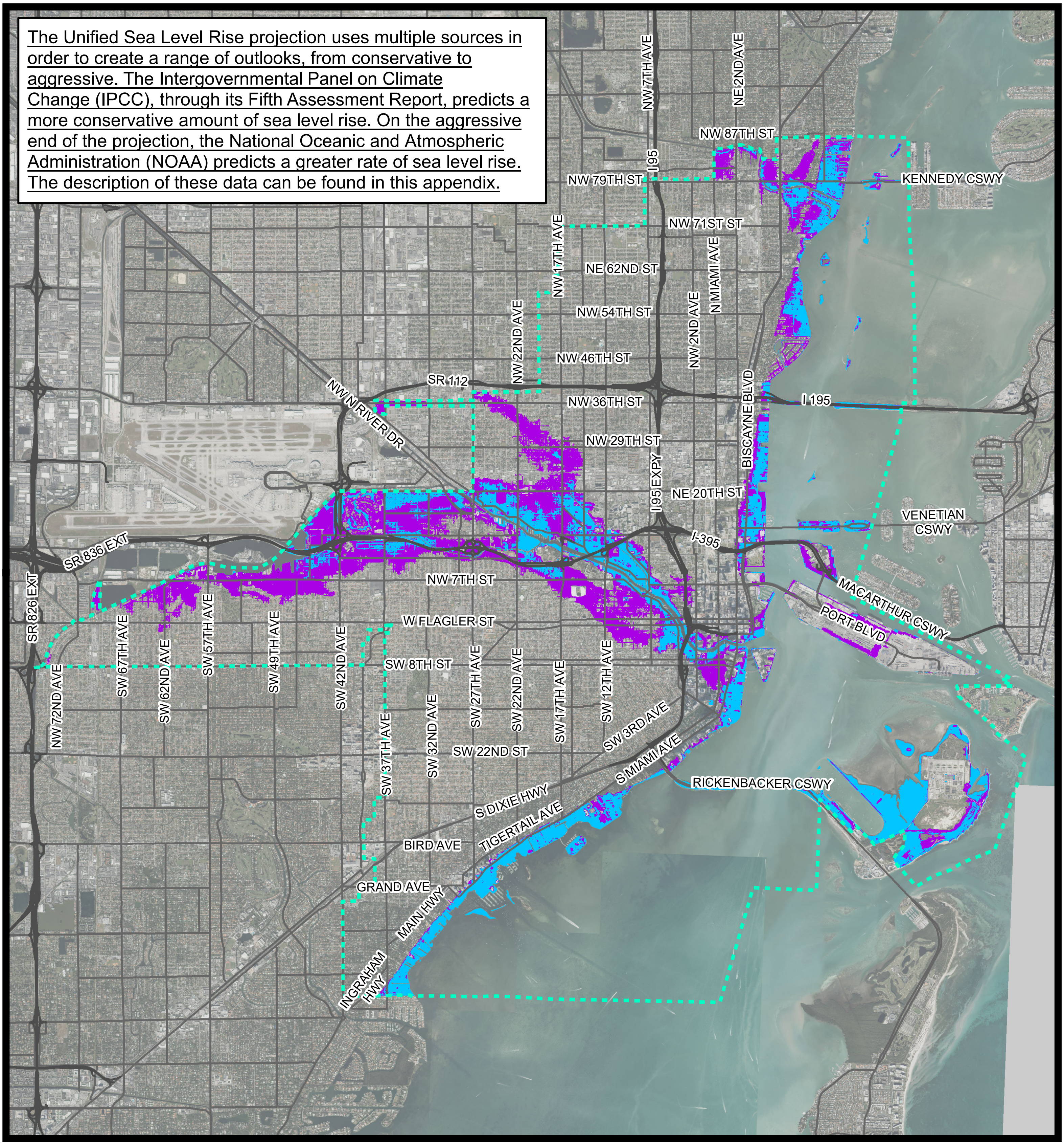
IPCC 2060

NOAA 2060

N

0 1 2 Miles

Created by the City of Miami Planning Department
September 2022
N:\Planning\GIS\Resilience_Mapping\MXD
Sources: Miami Dade County aerial and LiDAR



Updating the Coastal High Hazard Area and Projecting Sea Level Rise in the Miami Comprehensive Neighborhood Plan

1. Modeling the Coastal High Hazard Area

Florida Statutes require the designation of the Coastal High Hazard Area (CHHA) within every city with a Coastal Management Element in its comprehensive Plan, pursuant to Section 163.3178(2)(h), F.S. This section defines the CHHA thus:

> *[T]he area below the elevation of the category 1 storm surge line as established by a Sea, Lake, and Overland Surges from Hurricanes (SLOSH) computerized storm surge model.*

It is important to note here that this designation is entirely different and unassociated with the Federal Emergency Management Administration's own "Coastal High Hazard Area" designation, which is related to the specific flood zones applied to the Flood Insurance Rate Maps. The CHHA as designated here and defined by State statute is meant to be a planning tool for growth management in coastal areas.

The City of Miami's Coastal High Hazard Area (CHHA): Methodology

As required by the referenced statute, the CHHA is created using an inundation model (a SLOSH model from the National Weather Service), combined with high-resolution elevation data. A Geographic Information System was used to process the data and produce the maps by which the data are analyzed.

Data Sources

The main data are described below:

1. SLOSH Model – The Sea, Lake and Overland Surges from Hurricanes (SLOSH) Model from the National Weather Service estimates surge heights and the extent of storm surge at various points along coastal areas with chosen atmospheric conditions. The SLOSH model is a polygon feature comprised of grid cells with a numerical value representing storm surge heights. For this reason, SLOSH models alone are not sufficient to create the CHHA. Nevertheless, statue requires an examination of these data, assuming a Category 1 hurricane making landfall. This model is a generalized model and it does not take elevation or local hydrology into account. For more information about the SLOSH Model, please refer to the National Oceanic and Atmospheric Administration: https://www.nhc.noaa.gov/surge/slosh.php.

2. Elevation Data – For the creation of the CHHA, the City of Miami used high-resolution Light Detecting and Ranging (LIDAR) data. LIDAR is created using high-frequency lasers to measure elevation over an area. These data are accessible to the public through Miami-Dade County's Open Data portal: https://mdc.maps.arcgis.com/home/item.html?id=32f1de78447c4c958782b1b2b5d47369

3. Local Hydrology – The City of Miami and Miami-Dade County maintain local hydrology data, which maps local waterways and waterbodies. These data are accessible to the public through Miami-Dade County's Open Data portal: https://gis-mdc.opendata.arcgis.com/datasets/water-g?geometry=-80.237%2C25.768%2C-80.183%2C25.775

The process of creating the CHHA combines these three data to model the area that is likely to be inundated in a Category 1 hurricane making local landfall. The steps are as follows:

1. A SLOSH model is obtained for a direct landfall on the City of Miami by a Category 1 hurricane. Once retrieved, the SLOSH model must be converted into a point feature to interpolate the data. This allows the GIS to stitch together the storm surge heights that more accurately reflects the flow of water.

2. Using Spatial Analyst tools in ArcGIS, this model is then layered onto the LIDAR data to determine the extent of inundation over land. More specifically, the elevation data were "subtracted" from the interpolated SLOSH model, revealing those areas where the level of storm surge was above the ground elevation.

3. Once the extent of the inundation was produced from the combination of these two data, the resulting polygon was analyzed against the local hydrology. This was an important step in storm surge modeling, as it helped to differentiate low-lying areas that may experience some localized pooling of water from the low-lying areas that are directly exposed to open water, and thus, at risk from storm surge. At this point, areas that may have been modeled to be within the projected extent of surge but with no possible hydrological connection for the surge to follow were removed.

As updates to the data become available, the City will continue using this process to analyze the CHHA. This will allow the City to continue long-range planning efforts with the most up-to-date information.

2. Modeling Inundation Risk with Sea Level Rise

Future models for storm surge inundation are included here to account for sea level rise projections through 2040 and 2060, for future land use planning within the comprehensive plan. The method for the analysis is very similar to the method used to create the Coastal High Hazard Area. Below is a description of the additional steps and data needed to create these models, as well as a brief overview of the chosen projections for sea level rise.

Using the Unified Sea Level Rise Projection from the Southeast Florida Regional Climate Change Compact

The City of Miami is a member of the Southeast Florida Regional Climate Change Compact ("Compact"), a coalition of municipal agencies from Monroe, Miami-Dade, Broward, and Palm Beach Counties devoted to advancing policy to address the impacts of climate change, including sea level rise. The Compact adopts its Unified Sea Level Rise Projection[1] (USLRP) as the 1992 standard measure by which local agencies and municipalities can plan for their communities in the age of sea level rise in a way that is coordinated regionally. That projection uses models from multiple international agencies. The Intergovernmental Panel on Climate Change's Fifth Assessment Report contains a range of projections[2]. Of these projections, the median projection for sea level rise was chosen by the Compact as the lower end of the USLRP. The U.S. Army Corps of Engineers, with an overall more conservative projection, was chosen for its high-end projection as the mid-point for the USLRP. For the high end of the USRLP, the National Oceanic and Atmospheric Administration's own high-end projection was chosen.

Sea Level Rise (inches) at Key West

Time	IPCC AR5 Median (0.73m)	USACE High (1.5m)	NOAA High (2m)
	0.0	0.0	0.0
2000	0.8	1.0	1.1
2010	2.2	3.0	3.6
2020	3.8	5.9	7.2
2030	6.0	9.7	12.1
2040	8.4	14.4	18.2
2050	11.3	19.9	25.7
2060	14.4	26.4	34.2
2070	18.0	33.8	44.0
2080	22.0	42.0	55.1
2090	26.2	51.1	67.3
2100	30.8	61.2	80.9
2110	35.9	72.1	95.6
2120	41.3	83.9	111.5

Accounting for Sea Level Rise in the Storm Surge Inundation Models

The principal difference between the codified Coastal High Hazard Area and the 2040 and 2060 storm surge inundation models with sea level rise is the adjustment of Mean Sea Level for the data output from the SLOSH model:

Using the projections from the USLRP, in the table above, for the years 2040 and 2060, the SLOSH model output was adjusted to account for sea level rise. That is Mean Sea Level is adjusted for each of the projections, based on the chosen years. For the IPCC model, Mean Sea Level is adjusted for 8.4 inches of sea level rise. This adjustment is made to the raw SLOSH grid values for each of the models, based on the specific year. For this modeling, both IPCC Median and NOAA High projections are used, with the 2040 and 2060 values added to reflect the projected sea level rise.

[1] Accessed at: https://southeastfloridaclimatecompact.org/wp-content/uploads/2015/10/2015-Compact-Unified-Sea-Level-Rise-Projection.pdf Southeast Florida Regional Climate Change Compact, Unified Sea Level Rise Projection, October 2015

[2] This report is accessible at: https://www.ipcc.ch/assessment-report/ar5/.

3. Areas at risk in Miami

The maps included in Appendix CM-1, maps CM-2, CM-3 and CM-4, show areas at various degrees of risk of storm surge inundation. Map CM-2 is the current Coastal High Hazard Area and maps CM-3 and CM-4 use the same methods with the addition of projected sea level rise to model areas at risk in 2040 and 2060. The three maps together compare the changes as sea levels continue to rise, based on projections. On maps CM-3 and CM-4, the modeled storm surges based on the two, chosen sea level rise projections are represented by different colors: the International Panel on Climate Change in blue and the National Oceanic and Atmospheric Administration in purple.

The analysis, accounting for those low-lying areas with connection to the local hydrology, reveals the likeliest path of water from a storm surge. For example, a higher-elevation “ridge” runs parallel to the Miami River, along the south bank. This is illustrated by pockets of land that are not projected to be inundated by storm surge, despite sea level rise, up to 2060.

This analysis reveals the growing threat of sea level rise to neighborhoods across the City of Miami. Within the City of Miami’s boundaries, there are 23,086 acres of uplands around or above sea level. Of that area, approximately 2,944 acres are contained within the 2040 at-risk area and approximately 5,072 acres are contained within the 2060 at-risk area. The total breakdown of area covered by the various projections are listed in the table below:

City of Miami Storm Surge Risk Analysis with Sea Level Rise

	Acres (2040)	Percent (2040)	Acres (2060)	Percent (2060)
IPCC	1,760	8%	2,230	10%
NOAA	2,944	13%	5,072	22%

The table above shows the projected changes in sea level from the International Panel on Climate Change (IPCC), using its median projection, and the National Oceanic and Atmospheric Administration (NOAA), using its high projection. The two projections were chosen to show a range of potential impacts. The numbers are compared against the total acreage of upland areas in the city. Within city boundaries, there are 23,086 acres that are upland from Biscayne Bay and the Miami River.

The largest increase in areas projected to be inundated between the 2040 and 2060 time horizons are seen through the NOAA projection. While the IPCC Median only projects an increase of two percent of lands being inundated, the NOAA High projects an additional nine percent of land being inundated.

As illustrated on maps CM-3 and CM-4, areas along the Miami River will face these increasing threats from storm surge due to sea level rise over time. While sea level rise will exacerbate damage all along the City’s coast, the Miami River and Blue Lagoon areas will see the greatest increase in land threatened by storm surge. That is, of the total acreage of land that will face threats of storm surge in the future due to sea level rise where there was no threat before, the majority of that land lies along the Miami River and the Blue Lagoon.

The ridge running along coastal Miami, composed of oolite limestone, generally impedes any major extension of sea level rise induced storm surge. This is a natural protective barrier for areas behind that coastal ridge.

The same type of protective ridge is absent for most of the Miami River and Little River basins. There are a couple exceptions, like those mentioned above, where the limestone formation rises high enough to keep some land above the Category 1 threshold but these areas are not contiguous and do not provide a true barrier to storm surge, as the water may travel between them and inundate areas further inland.