Watershed Master Planning Initiative Pilot Program

Example Coastal Watershed Master Plan

Davie/Dania Beach Subwatershed

(South New River Canal-East)

HUC 12 digit: 30902061205

Draft v9

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Disclaimer

This document provides guidance for developing a specific watershed master plan. This document refers to regulatory provisions that contain legally binding requirements. However, this document does not impose legally binding requirements. Local government decision-makers retain the discretion to adopt or modify the approaches described in this document. Adoption of the suggestions or recommendations herein will not necessarily constitute approval during Community Rating System (CRS) cycle verification visits. Interested parties are free to raise their opinion about the appropriateness of the application of the guidance to a situation, and FDEM will consider whether the recommendations in this guidance are appropriate in that situation to make changes to this guidance document in the future.

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1.0 DEFINING THE WATERSHED PLANNING PROCESS

Watershed Master Plans (WMPs), as conceived by the National Flood Insurance Program (NFIP) Community Rating System (CRS) program, provide an outline for communities interested in reducing local flood risk. According to the CRS Coordinator's Manual (FEMA, 2017), "the objective of watershed master planning is to provide communities within a watershed with a tool they can use to make decisions that will reduce flooding from development on a watershed-wide basis." Successful watershed master plans consist of a series of activities in a given watershed. Among those that are relevant to this subwatershed are (Association of State Floodplain Managers, 2020):

1. Evaluation of the watershed's runoff response from specific design storms under current and projected future conditions
2. Assessment of the impacts of sea level rise and climate change
3. Identification of wetlands and other natural areas throughout the watershed
4. Specific mitigation recommendations to ensure that communities are resilient in the future
5. A dedicated funding source(s) to implement the mitigation strategies recommended by the plan (as applicable to different jurisdictions)

The United States Environmental Protection Agency (USEPA) notes six basic steps to develop and implement a watershed master plan (2013). The first step is to build partnerships with surrounding communities. Few communities can go alone to resolve such issues, since water may enter a community watershed from upstream to cause major impacts, or water may leave to overwhelm another downstream community's system. The second step is to characterize the watershed in terms of topography, water levels, soils, land use/land cover, precipitation, open space, waterbodies, stormwater infrastructure, etc. Note that understanding build-out and the impacts build-out has on drainage are factors that must be considered in modeling. The third step involves identifying existing measures that are in place to reduce impacts at the various scales (regional→local). At the watershed level, the scale is far larger than individual neighborhoods, but development of the data for the entire watershed should include the ability to drill down from the regional to the local level. For example, this watershed master plan is a drilldown of the larger Miami-Dade/Broward TMDL region, which involves several HUC 12 sub-watersheds (Figure 1).

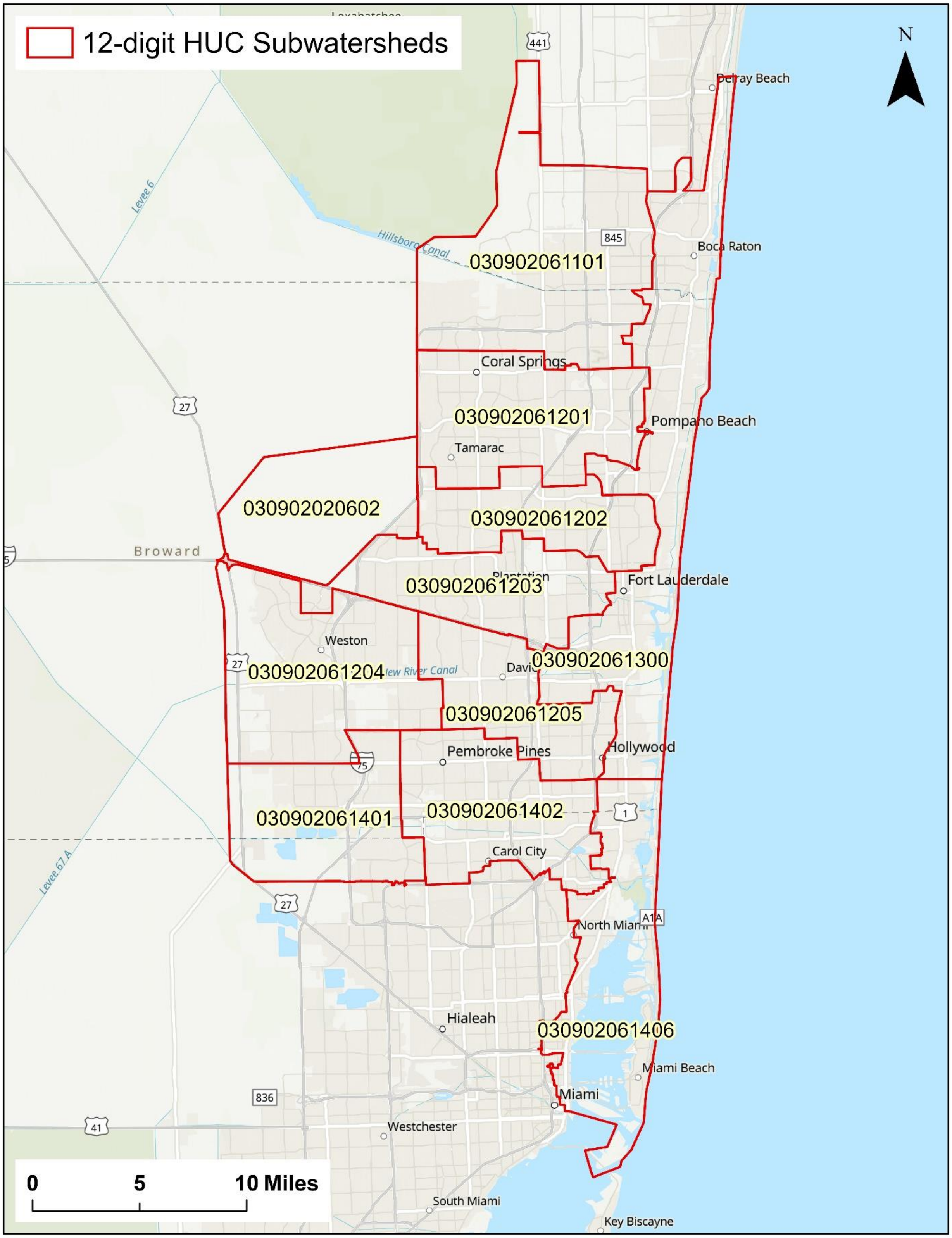

Figure 1. HUC 12 030902061205 Davie/Dania Beach subwatershed communities.

In Figure 2, the HUC 12 (030902061205) is zoomed in to show the communities that are included in the subwatershed.

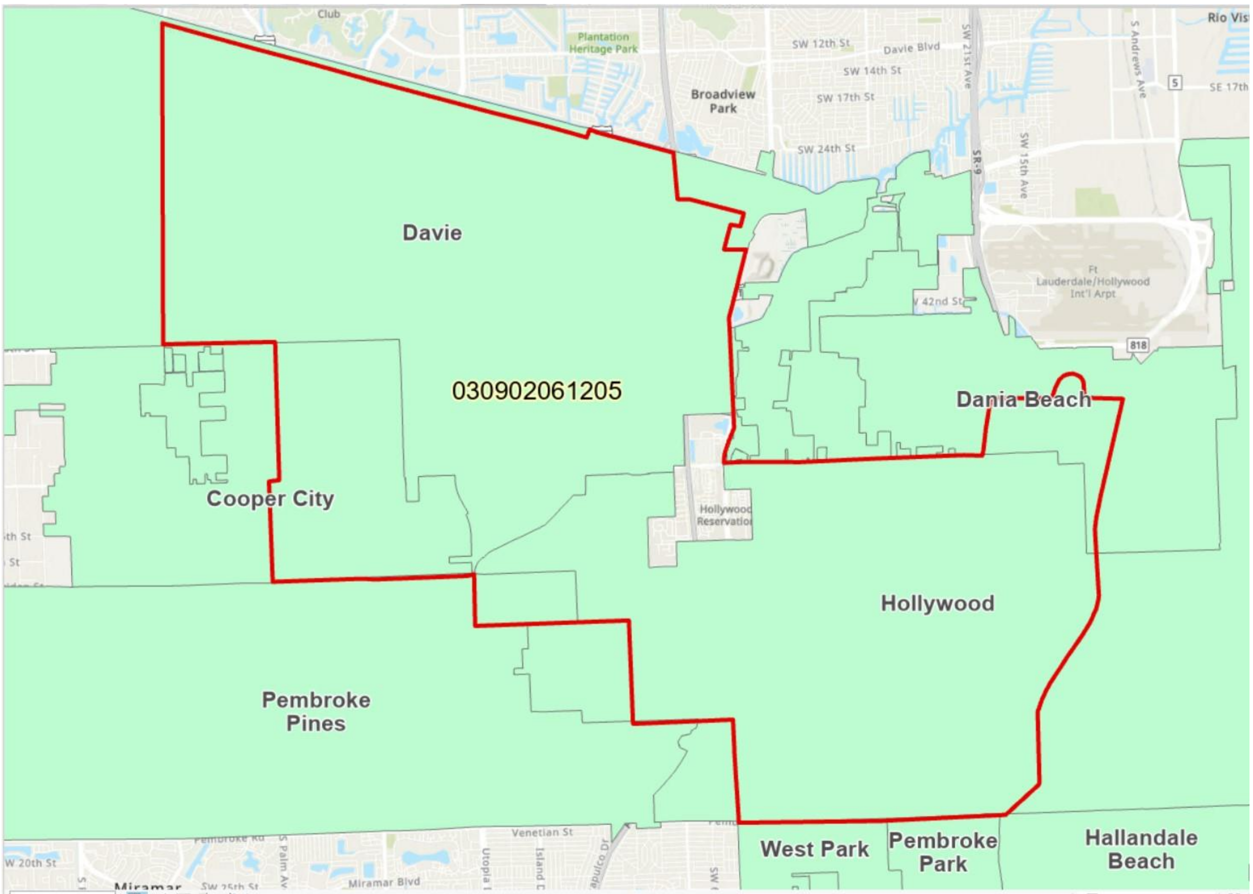

Figure 2. HUC 12 030902061205 Davie/Dania Beach subwatershed communities.

An inventory of existing management efforts is completed via the following measures:

- Review and evaluation of existing watershed data
- Establishment of a GIS database for watershed resource inventory
- Development of preliminary watershed model

Floodplain analysis includes developing a watershed model and identifying associated inundation polygons so that planning and management decisions can be formulated. Floodplain analysis may include the following tasks:

- Completion of the watershed resource feature and parameter inventory GIS database for the watershed using the acquired information
- Assembly of GIS database information into a specific format for a selected modeling software that predicts the watershed's response to the hydrologic cycle
- Watershed model development, calibration, and verification
- Floodplain delineation

The fourth step involves implementation, which means local communities participate in defining projects and solutions as well as the timing and means to fund them.

An example process that USEPA (2013) suggests for capital plans is:

1. Inventory existing infrastructure in the watershed, taking into account local priorities and institutional drivers.
2. Identify critical areas in the watershed where additional efforts are needed.
3. Identify new infrastructure, policy or management opportunities.
4. Develop screening criteria to identify opportunities and constraints.
5. Rank alternatives and develop candidate options

The final step involves monitoring progress so that updates can be made. The processes involved in watershed assessment, planning, and management are iterative and targeted actions might not result in complete success during the first or second cycle. The recommendation is to include a continuous improvement plan that evaluates measurable goals and includes a 5-year window to reassess the plan to make needed adjustments in light of new data or resource availability as well as evolving regulations and CRS requirements.

1.1 Overview of the Watershed

The focus of this watershed master plan is the Davie/Dania Beach subwatershed (HUC 030902061205), which is also known as the South New River Canal-East subwatershed. These two terms are used interchangeably in this document. The subwatershed is located in southeastern Broward County, south of I-595, and is characterized by low topography, strained water supplies, and dense development from the Intracoastal Waterway (and the Atlantic Ocean) to I-75 on the west.

In South Florida, water supply, water quality, and the health of the Everglades ecosystem (located just west of the urban corridor) are intrinsically linked. When attempting to evaluate the ecological health of Southeast Florida, the entire southern portion of the peninsula of Florida must be analyzed. Historically there were no barriers or canals to direct or control the path of water except a minor connection created by native Americans between the Caloosahatchee and

Lake Okeechobee for transportation purposes (Figure 3), which has little impact on the HUC 030902061205 Davie/Dania Beach subwatershed. However, the Everglades historically influences water supply and groundwater levels throughout southeast Florida. As a result, the study area is intrinsically linked to the larger regional watershed, so some discussion of the history of the Everglades basin, and the history of south Florida, has value.

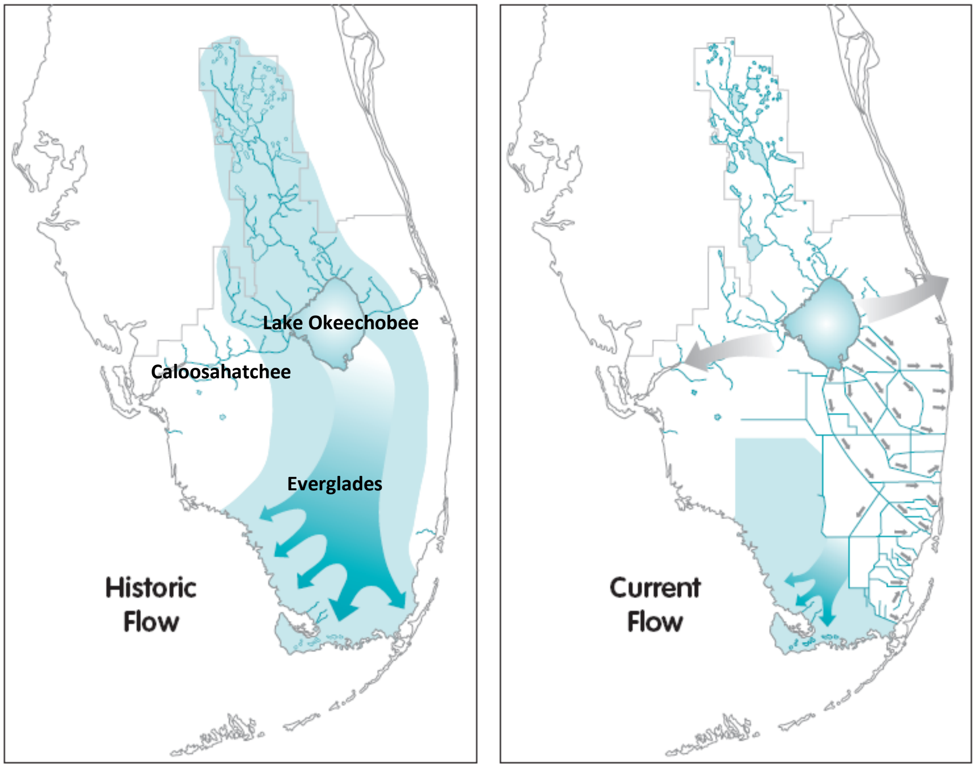

Figure 3. Change in natural flow paths in South Florida (SFWMD, 2020)

The first major anthropogenic modifications to the South Florida drainage landscape were constructed in the 1880s by Hamilton Disston with the dredging of the Caloosahatchee River and the creation of drainage canals in the Kissimmee Upper Chain of Lakes. The dredging was conducted in order to drain the land to facilitate agricultural production and urban development. The C-44 Canal and the associated locks and structures were constructed between 1916 and 1928. This canal provided a navigable connection between the east and west coasts of Florida by connecting Lake Okeechobee to the south fork of the St. Lucie River and creating the St. Lucie Estuary as one of the major outlets for water draining from the Upper Kissimmee and Lake Okeechobee basins.

The first efforts to contain Lake Okeechobee overflows involved construction of a low levee and three drainage canals running south from Lake Okeechobee, the Miami, North New River (in Fort Lauderdale), and Hillsborough canals between 1913 and 1917. In 1930, during the aftermath of the Storm of 1928, which pushed water out of the shallow lake and drowned thousands of people, the federal government authorized the US Army Corps of Engineers (USACE) to build the Herbert Hoover Dike (Figure 4).

Figure 4. Herbert Hoover Dike surrounding Lake Okeechobee

Over the next several years, a series of levees, culverts, and locks were built to contain the lake overflows, including 67 miles of dikes along the southern shore, effectively halting natural water flows out of the lake to surrounding areas. In 1938, USACE began to regulate lake levels, and lake inflows and outflows were altered to include structures and channelization to move water more effectively in and out of the lake (Figure 5). Modifications to the outlets on the east and the west sides of the lake made the Caloosahatchee and St. Lucie rivers the primary outlets from the lake.

Figure 5. Typical regional canal

However, due to a series of back-to-back hurricanes in 1946 and 1947 and resulting significant flooding in South Florida, the need for additional features to manage excess water became evident. In response to these conditions, the State of Florida requested assistance from the federal government resulting in the Central and Southern Florida Flood Control Project (C&SF Project) being authorized by the U.S. Congress in 1948. Subsequently, USACE produced a comprehensive water management plan for flood control to drain the land quickly to tide and allow for urban and agricultural development. It took approximately 20 years to implement the project features, canals, levees, pump stations, and other structures including the channelization of the Kissimmee River. By 1969, over 1800 miles of primary canals were constructed to reduce groundwater levels along the coast, which enabled the development of the southeast urban corridor that exists today. The canals serve as flood protection for low lying areas because they currently drain by gravity to the ocean. Figure 6 shows the canal networks in the South Florida Water Management District (SFWMD) service area. These areas would be flooded in the summer months without the canals. In addition, the need to control Lake Okeechobee levels requires discharges through the St. Lucie River and Caloosahatchee watersheds. The timing of these discharges is historically different than the natural system, creating disruptions in water quality and supply, but lowering groundwater artificially to permit development in the previous swamplands.

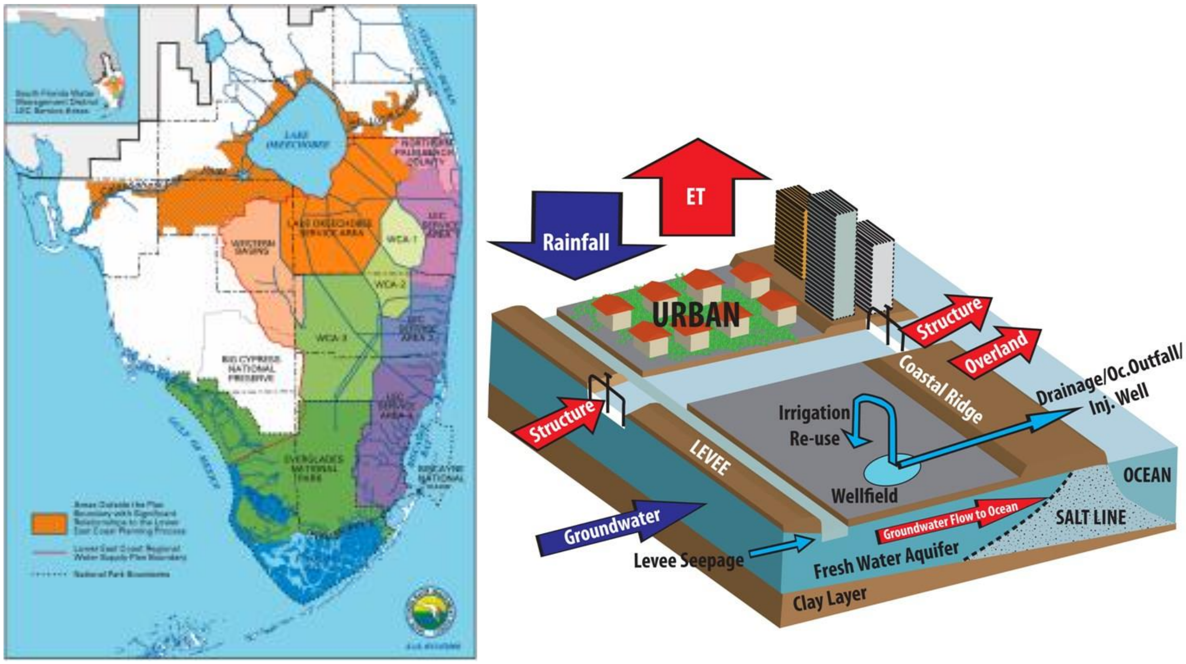

Figure 6. South Florida Water Management District Lower East Coast service area and drainage pattern after C&SF drainage improvements (SFWMD, 2020)

As a result, south Florida watershed landscapes have been dramatically altered by construction of this elaborate system of canals, dikes, levees, flow control structures, pumps, and other water control facilities. These changes have allowed southeast Florida to be one of the largest metropolitan areas in the United States with over 7 million people in 2020.

The Everglades reconstruction also affects local flood management. Currently, where development has taken place, rain falls on impermeable land, and the water collects in pools or runs off rapidly. Stormwater is collected locally in neighborhoods in swales (Figure 7), ponds (Figure 8), small lakes, ditches, small canals (Figure 9), and lagoons (Figure 10). These are connected through canals and conduits to the secondary system under the jurisdiction of local drainage districts or city or county governments, which in turn connects to the major waterways controlled by SFWMD and USACE. The highly engineered stormwater drainage system and water control structures have effectively enabled management (lowering) of water tables to permit development.

Figure 7. Typical swale

Figure 8. Typical retention pond

Figure 9. Typical localized canal

Figure 10. Typical aerated lagoons

1.1.1 Geomorphological Considerations

The HUC 030902061205 Davie/Dania Beach subwatershed is located in Broward County, FL, south of I-595. The communities in the study area include portions of Cooper City, Davie, Dania Beach, Hollywood, Pembroke Pines, unincorporated Broward County, and the Seminole Indian Tribe of Florida (Figure 11).

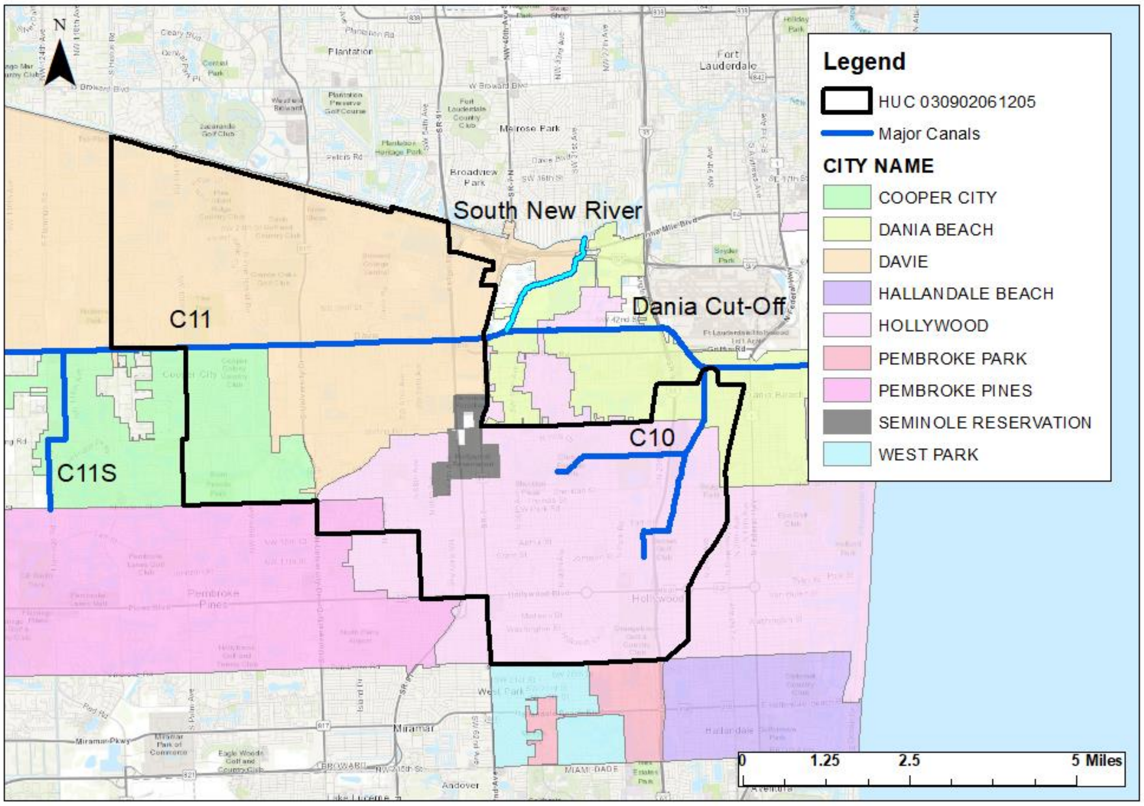

Figure 11. HUC 030902061205 Davie/Dania Beach subwatershed showing the communities and major canals in the study area

Table 1 shows the areas associated with each community that are part of the subwatershed studies in this document.

Table 1. Area of each community within the HUC 030902061205 Davie/Dania Beach subwatershed

Community Name	**Area in the Subwatershed**	**% of the Total Area of the Subwatershed**	**Area in the SFHA**	**% of the Total Area of the Subwatershed**
Cooper City, City of	2296	9.2%	331	1.3%
Davie, Town of	641	2.6%	49	0.2%
Dania Beach, City of	11670	46.7%	4035	16.1%
Hollywood, City of	9508	38.0%	2843	11.4%
Pembroke Pines, City of	335	1.3%	93	0.4%
Seminole Indian Tribe of Florida	497	2.0%	12	0.1%
Unincorporated Broward County	56	0.2%	4	<0.1%

The entire South Florida plain is underlain by beds of porous limestone that absorb water standing on the land during the wet season (mostly in the Everglades). These limestone formations contain large volumes of fresh water - perhaps more than in any other limestone formation in the eastern United States. More details are discussed in Sections 2.3-2.4.

In southeast Florida, the goal of a stormwater management system is to limit risk of damage due to flooding. The short-term impacts from stormwater include flooding in low-lying areas and standing water in areas with limited soil storage capacity. Less common, but of increasing frequency, is the potential for extensive inundation of some areas, especially low-lying areas, during periods with high groundwater levels and groundwater impacted by king tides and sea level rise. As a result, there is a need to understand the economic impact of flooding events and to create cost effective stormwater infrastructure and policy solutions for protecting property. This means preserving as much property and economic activity as possible without disrupting current activity or expending funds on inappropriate projects that provide limited long-term or social value.

Virtually all Broward County is completely developed, although there are pockets, like in Davie, where there are larger plots of land used for suburban ranching or agriculture. The communities are primarily residential, with small concentrations of light industry, shopping centers, and offices. The Town of Davie is located in Broward County, FL and has a population of 91,992 people based on the most recent census estimates. About half the HUC 030902061205 Davie/Dania Beach subwatershed is located in Davie, and it represents the upper extent of the subwatershed. The western boundary does not flow to the C-11 and Dania Cutoff Canals, but instead it flows west and north to the New River in Fort Lauderdale, as shown previously in Figure 11.

Just to the east of the Town of Davie is the City of Dania Beach, which was incorporated under the laws of the State of Florida in 1904. It is the oldest incorporated city in Broward County. The City has recently doubled its area to nearly 6 square miles, in large part due to annexation of over 3 square miles of unincorporated Broward County (previously known as the Broward 3A service area). The community is primarily residential, with small concentrations of light industry, shopping, offices, and some beachfront property within the corporate limits. A small light industrial sector was added in the most recent annexation.

The City of Cooper City borders the Town of Davie. It is an upper middle class suburban community of just over 35,000 people. The City of 8.6 square miles was incorporated in 1959. Most of Cooper City is in the HUC 030902061205 Davie/Dania Beach subwatershed. It is primarily a bedroom community.

The City of Hollywood is the largest community that is partially in the subwatershed. The central and western areas of Hollywood represent the upper extent of the C-10 canal spur that feeds to the Dania Cutoff canal. Founded in 1921, the City has a population of nearly 160,000 in its 30.8 square miles. Unlike the other communities, Hollywood has employment centers and a sizable downtown area along Hollywood Boulevard that connects to the coastal areas.

There is a very small portion of Pembroke Pines included in the subwatershed along the northeastern boundary with Hollywood. It was annexed to Pembroke Pines from unincorporated Broward County at the same time as portions of West Hollywood and is fundamentally no different. The Seminole Tribe of Florida, Hollywood Reservation is located wholly within the subwatershed. The Hollywood Reservation, formerly known as the Dania Reservation, is one of six Seminole Indian reservations governed by the federally recognized Seminole Tribe of Florida, located near Hollywood, Florida. The reservation is bordered by the communities of Hollywood and Davie, in Broward County and is 497 acres in size. As a designated reservation property, the Hollywood reservation is a sovereign nation within the United States. As a result, it is not subject to state and local requirements. The website for the reservation indicates no development of flood control requirements. Note that for the Tribe to enter into any agreements with state and local partners, the Bureau of Indian Affairs would need to be a party. The residents of the Hollywood Reservation are subject to certain federal laws as are other US citizens.

A summary of the existing CRS classifications for the communities in the study area is listed in Table 2.

Table 2. Community Rating System eligible communities as of April 1, 2021

Community Number	Community Name	CRS Entry Date	Current Effective Date	Current Class	% Discount for SFHA	% Discount for Non-SFHA
125093	Broward County	10/01/1992	10/01/2019	6	20	5
120032	Cooper City, City of	10/01/1992	10/01/2019	6	20	10
120035	Davie, Town of	10/01/1994	10/01/2005	7	15	5
120034	Dania Beach, City of	10/01/1993	05/01/2020	6	20	10
125113	Hollywood, City of	10/01/1992	05/01/2012	6	20	10
120053	Pembroke Pines, City of	10/01/1994	10/01/1998	7	15	5

Based on the 2009 Florida Land Use Cover Classification System (FLUCCS) Level 1 land use, over 83% of the land in the subwatershed is urban and built up (83.86%), and water makes up 7.73% of the land use, as shown in Table 3 (also refer to Section 2.5).

Table 3. Land use in the HUC 030902061205 Davie/Dania Beach subwatershed

Land use	Percentage
Agriculture	3.00%
Barren Land	0.04%
Transportation, Communication and Utilities	1.23%
Upland Forests	2.87%
Upland Nonforested	1.08%
Urban and Built Up	83.86%
Water	7.73%
Wetlands	0.16%
Total	**100.0%**

For context, the FIRM panel index of Broward County, which includes the study area and surroundings is shown in Figure 12.

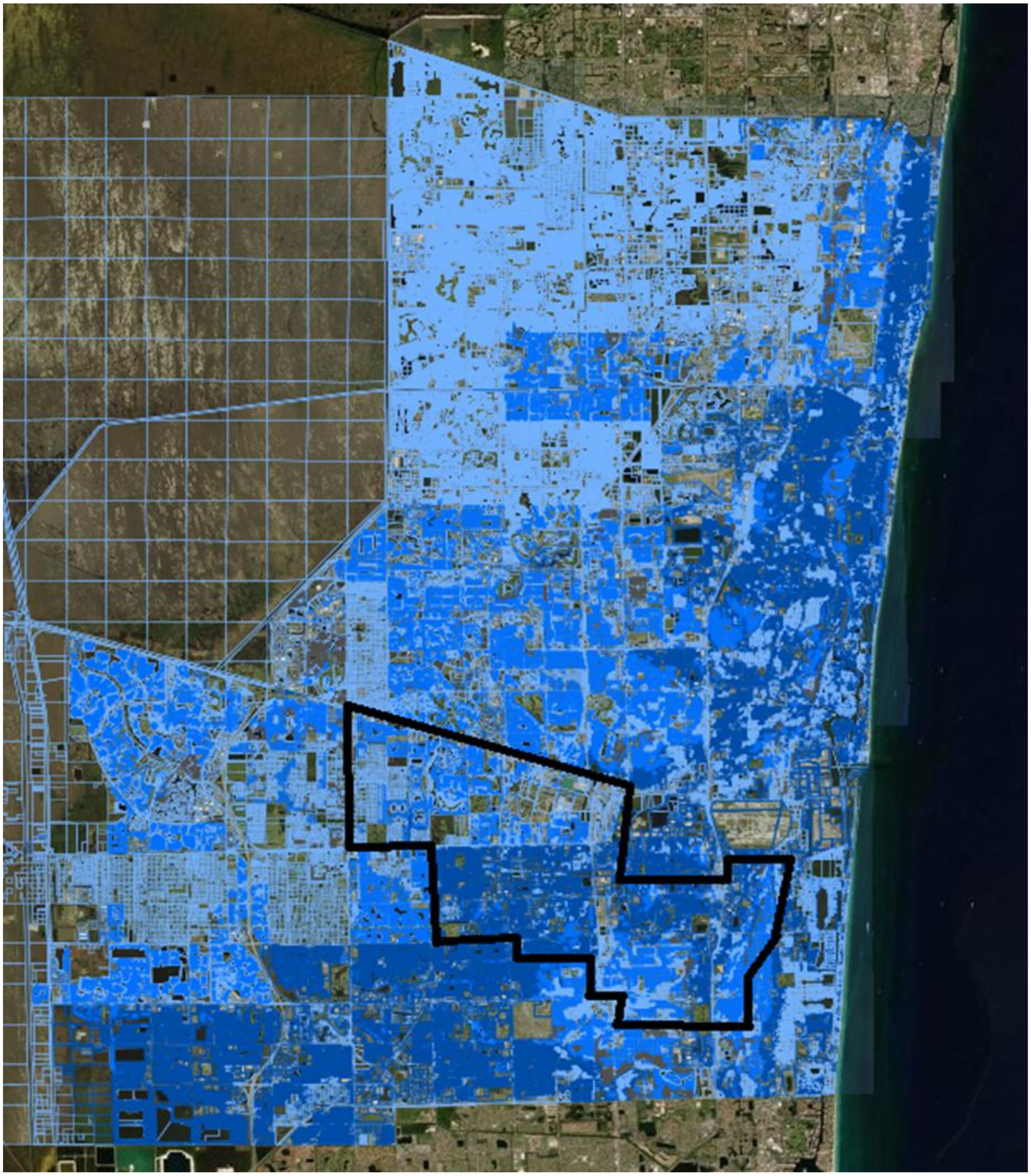

Figure 12. Broward County FIRM map (2020)

1.1.2 Waterway Features

The Atlantic Ocean is located just east of the subwatershed and controls the coastline and groundwater table elevations throughout the study area. In southeast Florida, reefs are located offshore, and water drops to over 100 feet in depth within a few miles east of the shore (Figure 13). The Port Everglades inlet channel (displayed in magenta) disrupts the southerly sand migration, creating issues on Dania Beach's beaches.

Figure 13. Coastal bathymetry map of the shores of Dania Beach and Hollywood, FL (https://oceancurrents.rsmas.miami.edu/sfo/bathymetry.html)

Numerous tributaries exist throughout both the freshwater and estuarine portions of the subwatershed and can influence overall hydrology of the area depending on rainfall and regional hydrological conditions. The network of secondary and tertiary canals throughout the sub-watershed permits urban development (Figure 14).

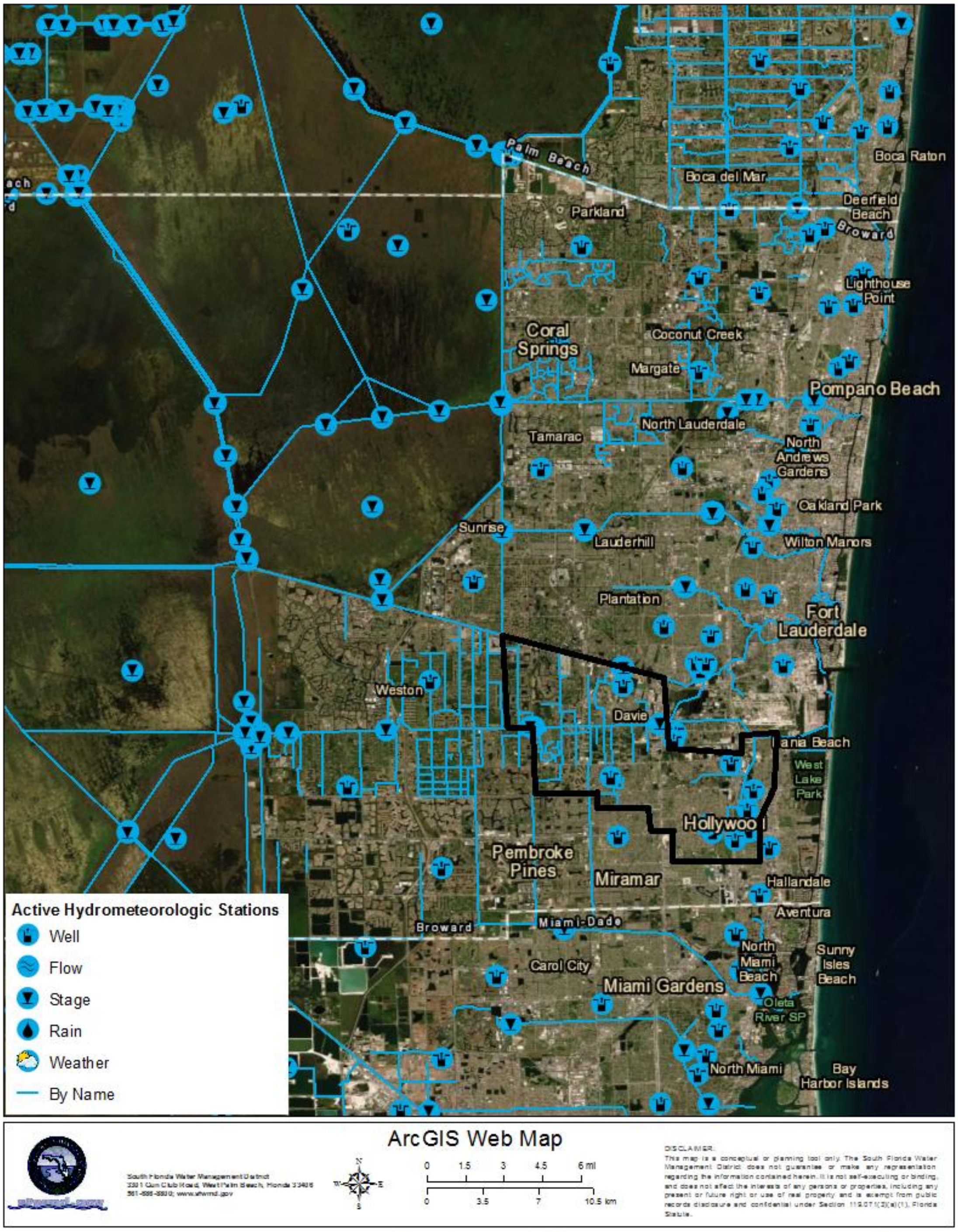

Figure 14. Flow paths for Broward County (SFWMD.gov)

1.1.3 Hydrologic Boundaries

USGS designates drainage areas as subwatersheds (including smaller drainages) numbered with 12-digit hydrologic unit codes (HUCs). The study area boundaries for HUC 030902061205 Davie/Dania Beach subwatershed were shown previously in Figure 11. The major waterbodies in the subwatershed (discussed later in Section 2.9) are the C-11 canal in Davie, C-10 canal spur in Hollywood, the Dania Cutoff Canal in Dania Beach, and the Atlantic Ocean.

Given that stream flow data are critical for estimating flooding, Figure 15 shows the relationship between historical rainfall and streamflow in the basin. Such data are useful in assessing relationships between precipitation and stream flow, potentially an important indicator of watershed development.

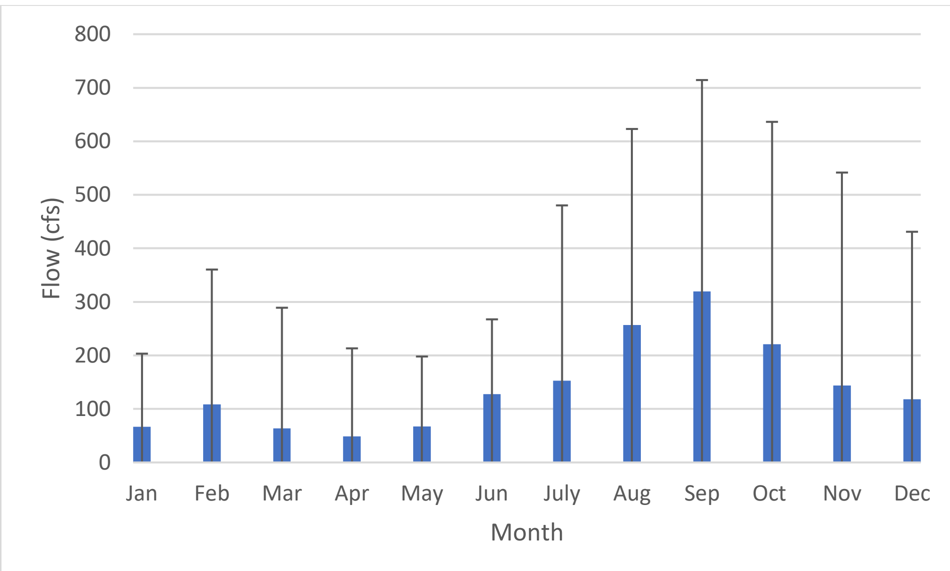

Figure 15. Average flow for the Dania Cutoff Canal 2009 to 2019 (SFWMD, 2020)

1.1.4 Wetlands and Natural Areas

Wetlands serve many purposes, including acting as recharge areas, filters for contaminants, and buffers that mitigate temperature changes in adjacent areas. In South Florida, as a result of hydrologic modifications over the past 100 years, the natural storage and buffering capacity of wetland areas in this study region have decreased such that water levels can rise substantially in short periods of time, and the water levels occur outside desirable ranges either too high or too low with rapid water level fluctuations. The only two small wetland areas are shown in Figure 16 as developed from the FLUCCS database for land cover as developed by SFWMD.

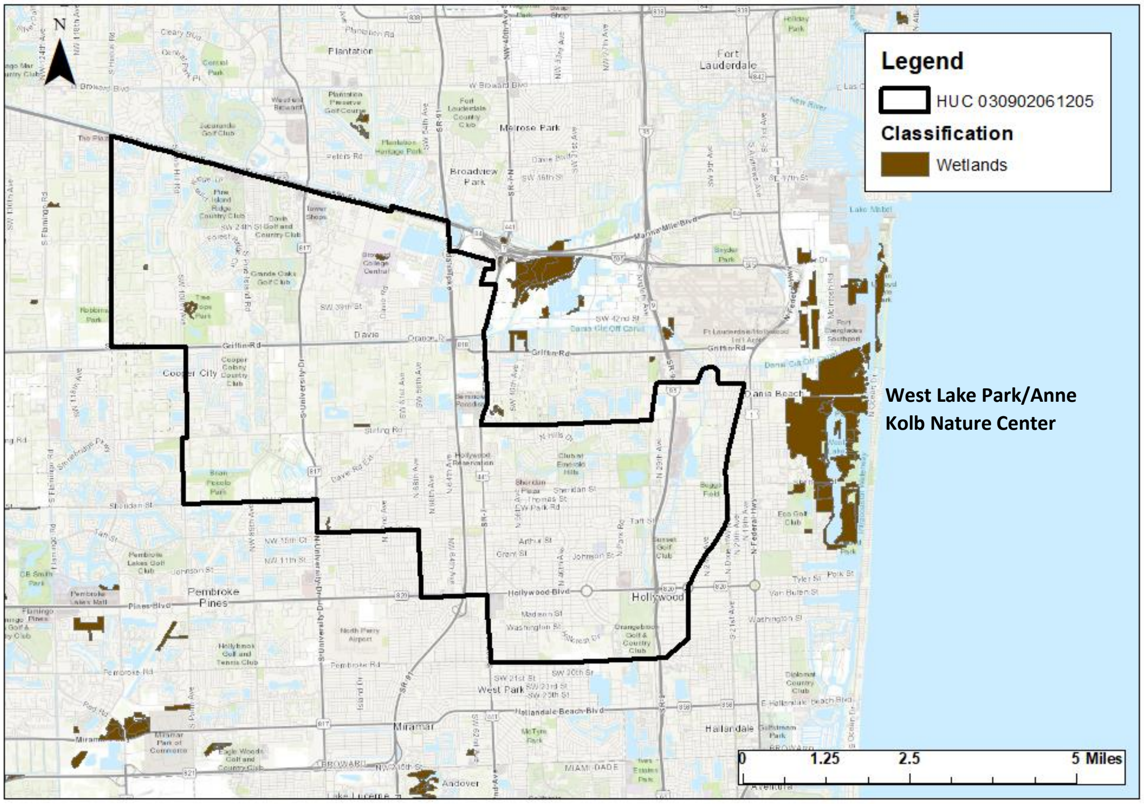

Figure 16. Wetlands in the HUC 030902061205 Davie/Dania Beach subwatershed (SFWMD, 2012)

Upland areas, such as pines and palms, that provide habitat for certain species, are shown in Figure 17. Many of these areas are either protected or have limitations on development (see Chapter 3). There is a major area of protected mangroves just east of the subwatershed in Dania Beach (large brown area on the coast is West Lake Park, a County park, and the Anne Kolb Nature Center, also a County facility).

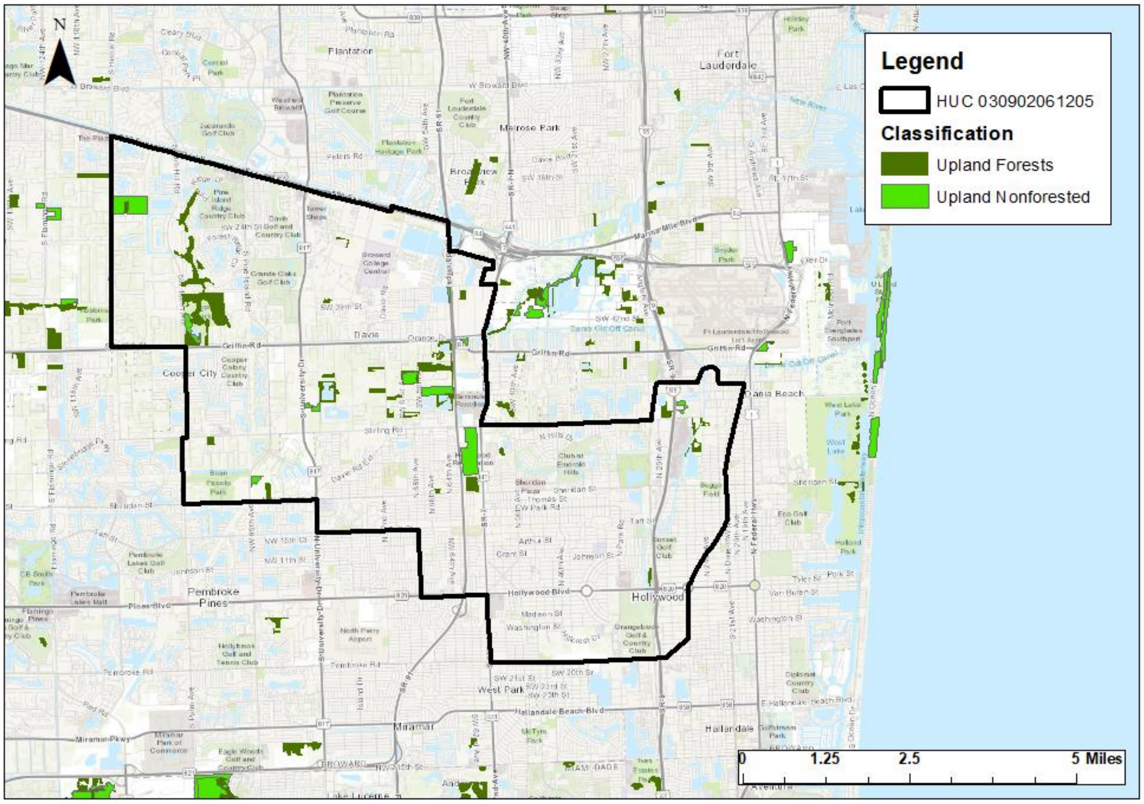

Figure 17. Uplands in the HUC 030902061205 Davie/Dania Beach subwatershed (SFWMD, 2012)

Figure 18 shows the conservation areas in Broward County, which has a robust plan to acquire certain lands.

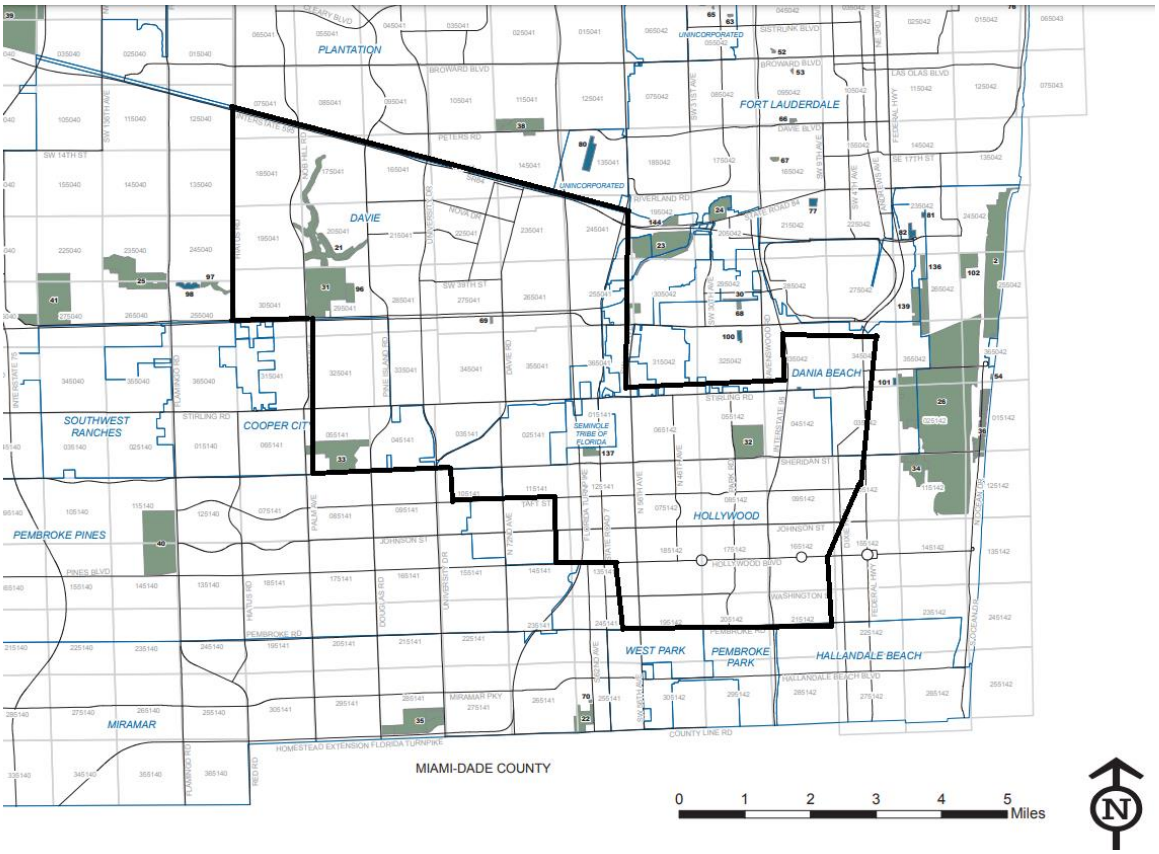

Figure 18. Conservation lands in Broward County with the HUC 030902061205 Davie/Dania Beach subwatershed study area highlighted

1.1.5 Floodplains

The FEMA flood maps for the HUC 030902061205 Davie/Dania Beach subwatershed are shown in Figure 19 with large portions of the study area in Zone X.

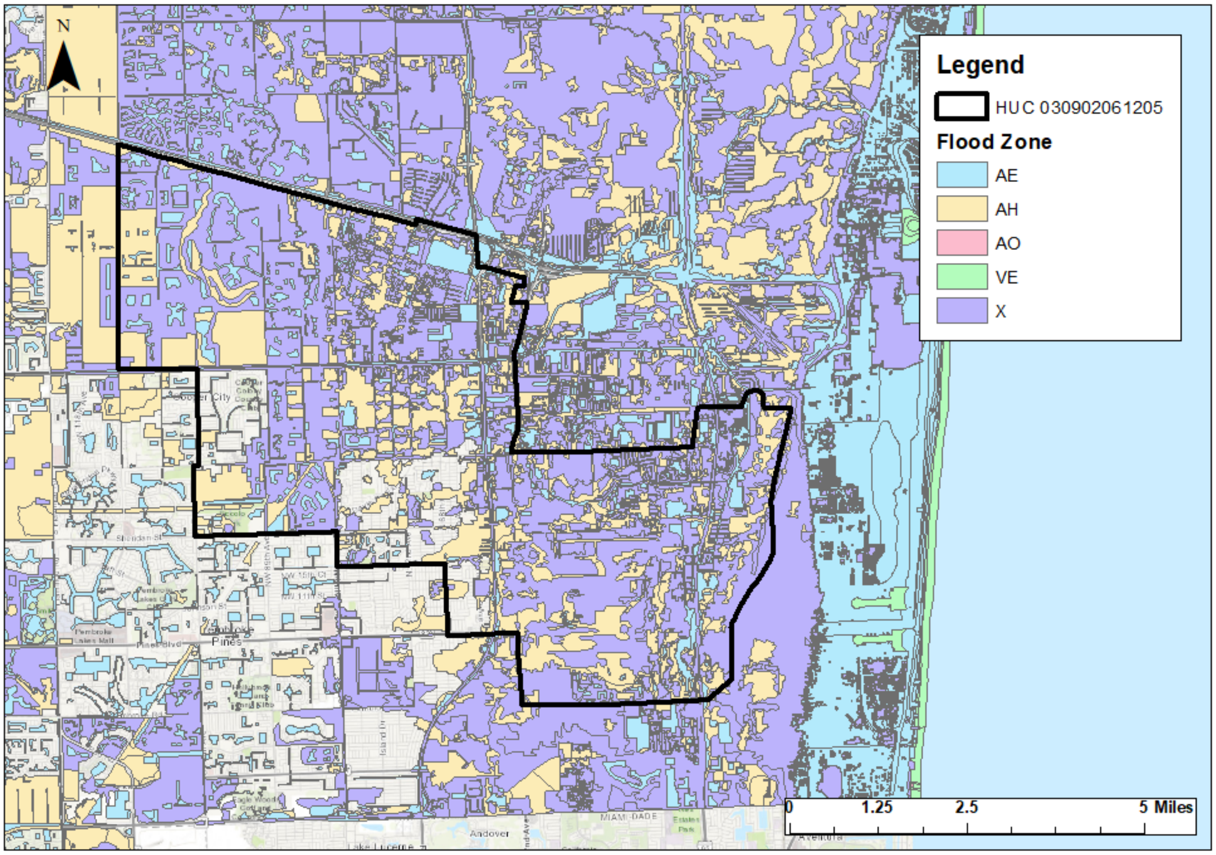

Figure 19. HUC 030902061205 Davie/Dania Beach subwatershed flood insurance rate map. Areas not colored are not in a flood zone.

To provide a national standard without regional discrimination, the 1% annual chance (100-year) flood has been adopted by FEMA as the base flood for floodplain management purposes. Flood risk is evaluated based on factors such as known flood hazards and projected impact on the built environment. In the 2019 Local Mitigation Strategy (LMS) document for Broward County, engineering analyses were performed for each flooding source to calculate its 1% annual chance flood elevations. The models are generally done by community, not by the County. Davie has a plan for the Town prepared by Florida Atlantic University that modeled the 1-day, 100 year, 3-day, 25-year, and 1-day, 10-year storm events and identifies, from a macro-scale, the funding needs to protect the Town. It notes that a systematic change to flood control needs to occur at the SFWMD pumping station at US 441 in order to address sea level rise over 2.5 feet. Otherwise, the sea is at a higher level than the flood gates. More discussion of this plan and examples are articulated in Chapters 3 and 6 of this document. None of the other communities in the study area have a flood insurance study (FIS) or stormwater master plan (although Dania Beach and Cooper City are in the planning stages).

1.1.6 Flow Paths and Natural Channels

Figure 14 in Section 1.1.2 showed the canal system for the subwatershed used for the modeling conducted by Florida Atlantic University (FAU) in the study area.

1.2 Planning Goals and Scope

The primary purpose of a watershed master plan is to guide watershed coordinators, resource managers, policy makers, and community organizations to restore and protect the quality of lakes, rivers, streams, and wetlands in their jurisdiction. The specific goals for the WMP process for the study area are to identify:

- Existing physical and natural features of the subwatershed (Sections 2.1-2.11)
- Existing flood protection infrastructure, including that which is close to failure or inadequate (Section 2.12)
- Existing policy frameworks and local regulatory constraints (Chapter 3)
- Dedicated funding for projects (Section 3.5)
- Locations and value of flood prone areas (Chapter 4)
- Proposed flood protection projects (Chapter 5)

Table 4 shows the ultimate planning goals derived from the related plans in other south Florida communities that apply to this subwatershed.

Table 4. Goals related to flood protection at the subwatershed level

Goal	Quantitative Indicator	Management/Project
Increase intergovernmental communication	• Increasing number of attendees to periodic meetings • Increasing number of website viewers	• Coordination of projects
Reduce overbank flooding	• Decreasing number of incidents per year • Decreasing number of repetitive loss claims	• Improved management strategies for discharges • Bypass flood waters to offsite reservoirs
Restore wetlands	• Increasing wetlands areas in the inventory map • Increasing wetland species	• Restore water flow • Increase regulatory protection • Acquire properties
Increase water supply	• Decreasing water use restrictions imposed by the SFWMD	• Construct upstream reservoirs and store water in wetland areas to increase natural recharge
Reduce flood frequency	• Decreasing number of incidents per year • Decreasing number of repetitive loss claims	• Improve management strategies for discharges • Locally, install pump stations, piping, stormwater treatment areas, and develop additional green strategies • Changes to flood maps

1.3 Public Outreach

The key stakeholders in the study area include the county government, the municipal governments, the water management district, agriculture, recreation (fishing/hunting), tourism interests, and environmental interests that may have more concerns associated with timing of flood releases and water quality. Public works agencies and the Florida Department of Transportation (FDOT) should also be included as a part of the process because roadways, bridges, and culverts are major components of stormwater conveyance.

The goals of the public outreach program reflect the steps required to solicit public input and build awareness of the project throughout diverse communities. Public information must be straightforward, factual, and designed to be appreciated by non-technical audiences. The goals of this plan are as follows:

- Communicate effectively with the diverse communities and stakeholders

- Create public forums and collateral materials that provide clear, concise, and easy-to understand information to enable the public to provide input and make informed decisions about the project
- Publish and distribute materials for review and also notify the public, elected officials and other stakeholders of upcoming community meetings and public hearings
- Develop a comprehensive list of public and regional benefits that the project will generate
- Create and implement a meaningful public involvement process, and evaluate the public involvement process on a regular basis
- Create measurable objectives tied to the milestones that are required for the successful conclusion of the project.
- Respond to public and stakeholder feedback in an accurate, consistent, and timely manner

To facilitate community participation, there is a need to develop a database of specific stakeholders (community groups, residents, local and regional business owners, labor, environmental organizations, employers, employees, academia, cultural and entertainment attractions, emergency responders, media, surface transportation industry, policy leaders, other institutions, etc.) to make sure that each is represented in the WMP process. Then the outreach program should be applied to the stakeholders to:

- Develop corollary key messages that are consistent with the goals and objectives of the planning process
- Assess attitudes and perceptions among target audiences
- Identify barriers, opportunities, and levels of support

The meetings must be public, and all input recorded. Each meeting should be developed with an agenda that includes:

- Date/times
- Locations
- Attendance
- Meeting formats
- Speakers/presenters
- Content of presentation material

A website should be created to provide documentation for all meetings including:

- Agendas
- Notices/ads

- Meeting materials
- Meeting summaries
- Minutes
- Public comment logs
- Plan documents
- Action items

Because many stakeholders cannot attend daytime meetings in person, options to provide input should include:

- Comment tool on the webpage
- Virtual meetings
- Blogs/discussion boards
- Survey platforms
- Electronic news outlets

Such forums must be monitored to incorporate findings into the plan. All outreach should incorporate a news media outlet – for this basin, the *South Florida Sun-Sentinel* is the most widely read newspaper. In addition, the following government websites should be considered good hosting places as well:

- Broward County (https://www.broward.org/Pages/Welcome.aspx)
- Town of Davie (https://daniabeachfl.gov/)
- City of Dania Beach (https://www.davie-fl.gov/)
- City of Cooper City (https://www.coopercityfl.org/)
- City of Hollywood (http://www.hollywoodfl.org/)
- City of Pembroke Pines (https://www.ppines.com/)
- Seminole Tribe of Florida, Hollywood Reservation (https://www.semtribe.com/stof/enterprises/hollywood-reservation)

A list of potential stakeholders for the WMP process include:

- SFWMD
- FDEP
- FEMA/FDEM
- Broward County
- Town of Davie
- City of Dania Beach
- City of Cooper City
- City of Hollywood

- City of Pembroke Pines
- Seminole Tribe of Florida, Hollywood Reservation
- Florida Atlantic University
- Nova Southeastern University
- Greater Fort Lauderdale Alliance
- University of Florida (IFAS)
- The Nature Conservancy
- Audubon of Florida
- Sierra Club
- Riverwatch
- Federal Bureau of Indian Affairs

2.0 WATERSHED CHARACTERIZATION

Despite historical water management conflicts and periodic disruptions, south Florida will remain a desirable place to live, so the interconnectedness of waterbodies will require a more integrated solution to resolve water quantity and quality issues. Making thoughtful, long-term decisions will be important because infrastructure and development typically have an expected life cycle of at least 50 years or more. While uncertainties in the scale, timing and location of climate change impacts can complicate decision-making, response strategies can be effective if planning is initiated early. To characterize the physical and hydrologic aspects of the study area, historical and up to date data were collected from various key sources for the following:

- Topographic data (LiDAR)
- Groundwater levels
- Relevant waterway locations and levels
- Soils data
- Land uses including vacant land, wetlands, etc.
- Precipitation
- Open space and impervious areas
- Natural resources
- Demographics
- Stormwater infrastructure locations and conditions

In addition, the FEMA flood maps were obtained, and the storms of interest were identified for screening purposes (1-day, 10-year; 3-day, 25-year; and 1-day, 100-year storm event to achieve class 4 in the CRS Manual). Table 5 is a summary of datasets available at cwr3.fau.edu that were used to construct this plan.

Table 5. List of datasets collected by FAU as of List of datasets collected by FAU for the project (12/20/2020)

Data Category	Dataset Name	Original Source	Spatial Coverage/ Resolution	Temporal Coverage/ Resolution	Link to the Dataset on our Server (physical location)	Dataset size and Format	Native or FAU Processed dataset
Topography	USGS_NED	USGS	Part of Florida, raster image in 1 m	Created by USGS in 2016	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\LiDAR_DEM\DEM_1m	3.28G bytes, raster images	Native
	USGS_NED	USGS	Part of Florida, raster image in 3m	Created by USGS	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\LiDAR_DEM\DEM_3m	40.9G bytes, raster images	Native
	USGS_DEM	USGS	Florida, Raster data in 10m	Created by USGS	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\USGS_DEM	22.6 G bytes, raster images	Native
	DEM_3m_merged	USGS	3m in tiff		\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\LiDAR_DEM\DEM_3m_merged	186G bytes, raster images	FAU Processed
	SRTM_30m	NASA	30m Raster		\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\LiDAR_DEM\SRTM_30m_UCF_Chang	607M bytes, raster images	Native
Groundwater	FL_GW	South FL Water Management District	Florida, Excel	Daily, 1980-2020	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\FL_GW\South Florida District	140 M bytes, excel	Native
Surface Water and Tides	Tidal	NOAA's Tides and Currents CO-OPS SOAP Web Services	State of Florida, Excel	Every 6 minutes since 1920, excel	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\Tidal\	1.37 G bytes, excel	FAU Processed
Soil	FL_Soil	FY2019 USDA Soil SSURGO gSSURGO) Database https://sdmdataaccess.nrcs.usda.gov/	Florida, Raster data is in 10m	Released by USDA in 2019	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\FL_soil Processed data for water holding capacity ratio is at: \\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\FL_soil\aws0_150_whc1.tif	107G bytes, both vector and raster	FAU Processed

Data Category	Dataset Name	Original Source	Spatial Coverage/ Resolution	Temporal Coverage/ Resolution	Link to the Dataset on our Server (physical location)	Dataset size and Format	Native or FAU Processed dataset
Land Cover	USGS_LC	USGS	Conterminous United States, raster format, 30m derived from satellite	Created by USGS in 2016 (Most recent)	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\USGS_LC\NLCD_2016_Land_Cover_L48_20190424	20G bytes, raster	Native
	Impervious Surface	USGS	Florida, 30m derived from satellite	Created by USGS in 2016 (Most recent)	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\Impervious\NLCD_2016_Impervious_descriptor_L48_20190405\	24.6G Bytes, Raster Image	FAU Processed
	Open Space	USGS	Florida, 30m derived from satellite	Created by USGS in 2016 (Most recent)	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\FL_LCLU\NLCD2016_OpenSpace\	21G bytes, raster	FAU Processed
Precipitation Records	FL_NOAA14_Precipitation	NOAA Atlas 14 Database	Florida, raster in 800m	Most recent release from NOAA	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\FL_NOAA14_Precipitation\se25y3d_inch.tif	34 M bytes, raster images	FAU Processed, 3 day-25 year and 3 day-100 year

2.1 Surface Topography

Topography is a key parameter that influences many of the processes involved in flood risk assessment, and thus, up-to-date, high-resolution, high-accuracy elevation data is necessary. In order to meet the requirements for FEMA Risk Mapping, Assessment, and Planning (RiskMAP), 1-meter (2015 to present) and 1/9 arc-second (~ 3-meter) (2010 - 2015) LiDAR digital elevation models (DEMs) were acquired. The 3 m × 3 m LiDAR tiles were kriged to create a topographic map of the study area (Figure 20). This accuracy meets the 3DEP Quality Level 2 vertical root mean square error accuracy threshold of ±10 cm for FEMA (Arundel et al., 2015). The LiDAR used for this basin was 2016.

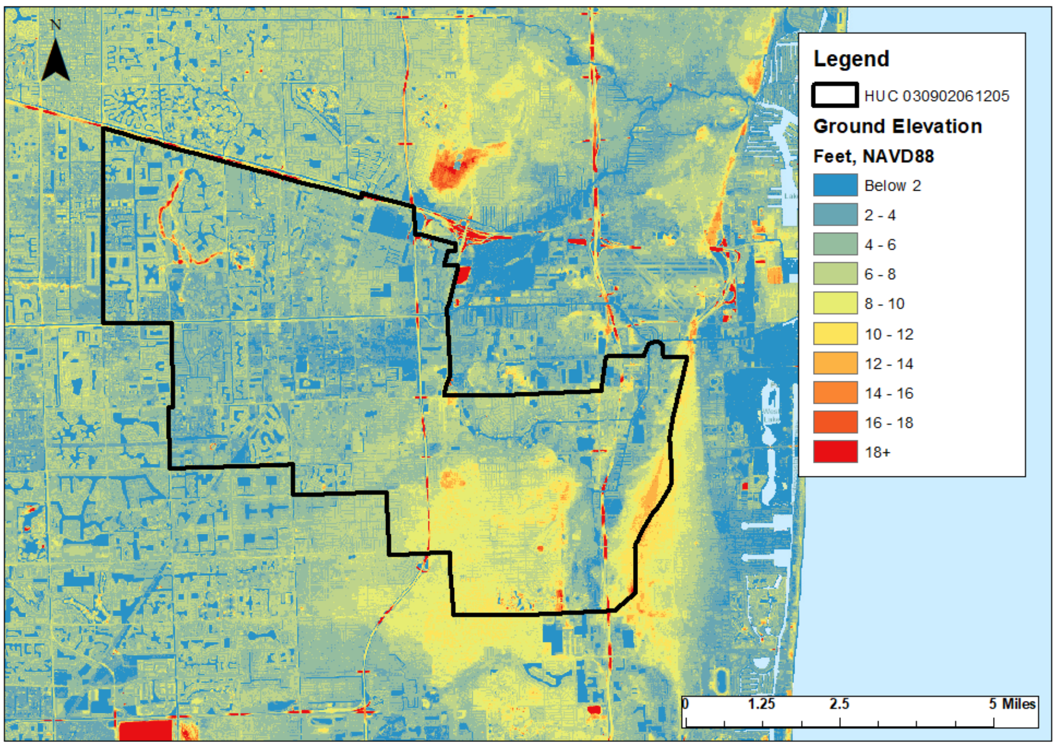

Figure 20. Topographic map of the HUC 030902061205 Davie/Dania Beach subwatershed processed by FAU (2016 flight). Note this represents areas outside the basin.

2.2 Groundwater

A geologic profile of study area has been developed based on drilling data from Broward County, the United States Geological Survey (USGS), and the City of Hollywood (Figure 21). Southeast Florida is underlain by a series of interspersed rock formations with varying permeability. The uppermost formation generally encountered along the southeast coast is the Pamlico Sand formation of the Biscayne Aquifer. This surficial, Pleistocene Age deposit occurs throughout most of south Florida and consists predominantly of fine to medium-grained quartz sand, with varying amounts of shell, detrital clays, and organic constituents. Thickness of the sand is variable in the area but averages approximately 40 feet. Under the surficial sand lies a series of fossiliferous, sandy limestones, which are part of the Anastasia or Fort Thompson formation (Meyer, 1989). These also date to the Pleistocene Age and often occur interwoven with each other and the Key Largo Limestone, making distinction difficult. Together with the Pamlico Sand layer these formations compose the wedge-shaped Biscayne Aquifer, which gains thickness as it approaches the coast, where it can be as much as 400 feet deep (but generally less than 200 feet).

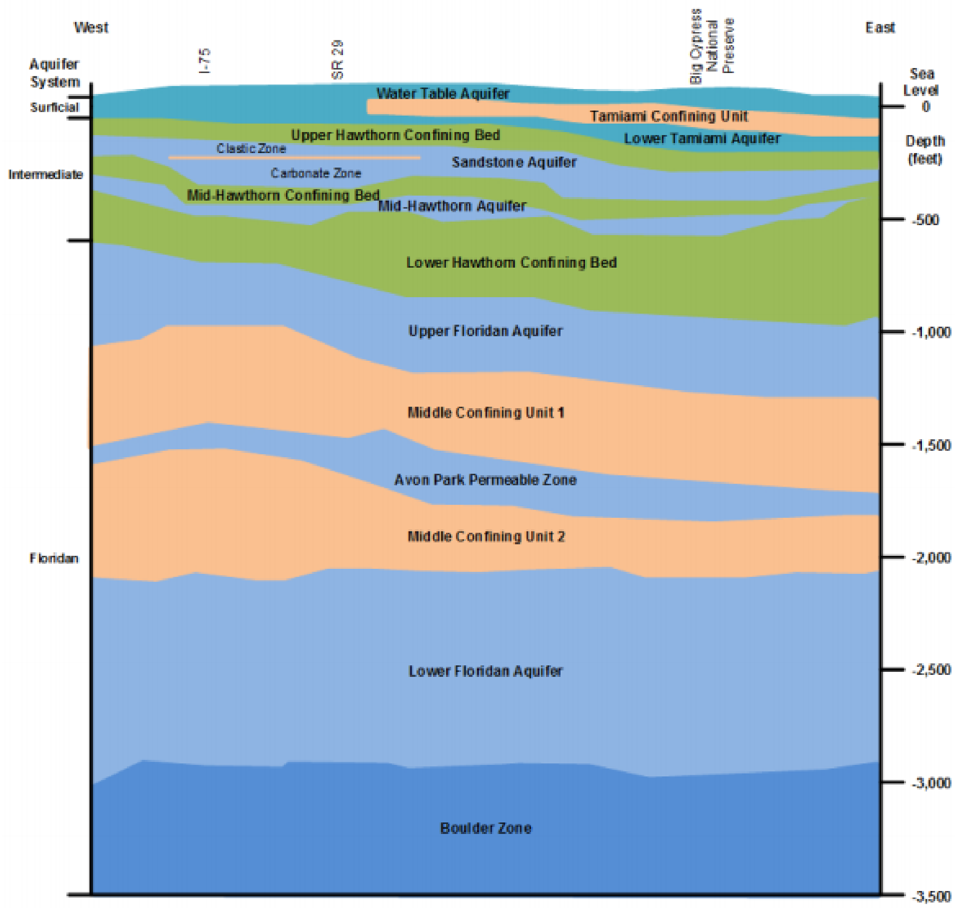

Figure 21. Hydrogeological Profile (Meyer, 1989)

The Biscayne aquifer is a highly productive aquifer since its components are all very permeable and full of water. Beneath the City of Dania Beach, the Biscayne Aquifer often contains two distinct sandy, limestone beds that are generally separated by 40 to 50 feet of sand. The upper bed occurs between 40 and 100 feet below land surface (bls), and the lower bed occurs between 110 and 200 feet bls. In Dania Beach, the latter is brackish due to saltwater intrusion.

The water levels in the Biscayne Aquifer fluctuate in response to rainfall, drainage and withdrawal for irrigation and potable use. Since the Biscayne Aquifer is exposed to the surface with little in the way of confinement, the only major recharge in the area is rainfall, most of which occurs between June and October. During the winter months the aquifer's water level continues to decline without some form of supplemental recharge. The SFWMD canals are designed to provide flood protection, but also serve to limit drawdown induced by the canals by delivering water stored in Lake Okeechobee during the dry season. Western Broward wellfields benefit due to their proximity to the water conservation areas operated by SFWMD, but little help is available for eastern wellfields, such as in the City of Dania Beach. As a result, the aquifer levels in eastern wellfields steadily decline during the winter months, which subject the Biscayne Aquifer to contamination from saltwater intrusion and surficial sources. Several areas of the Biscayne Aquifer already have saltwater intrusion problems, the most extensive occurring along the coast and the canals connected directly to the coast without salinity barrier/control structures. Generally, the water level in the Biscayne Aquifer averages 1 to 2 feet NGVD, except during extremely wet and dry periods. The Biscayne is the only fresh aquifer system – the aquifers below it contain brackish or salt water. Beneath the Biscayne Aquifer, is a thick, confining layer known as the Hawthorn Group. It is comprised of clay and tilts toward the Atlantic Ocean in southeast Florida. The Hawthorn Group prevents the movement of water vertically between the Biscayne aquifer and lower, brackish formations (upper and lower Floridan).

For situations in which groundwater is under the influence of surface water, it is necessary to collect groundwater table elevation data to calculate soil storage capacity. Since well density varies considerably, interpolation of data was required to create a groundwater surface developed using groundwater data from 2005 to 2018. Surficial wells were noted across the area (Figure 22). A common date for the 99th percentile water level was also found. To establish a common date for modeling purposes, the recorded groundwater table elevations were sorted in ascending order to determine the 98th -100th percentile date of occurrence in Excel®, following the manual procedure detailed in Romah (2011). In this study, the manual procedure was automated using a python code to process the groundwater data more efficiently. Outliers and anomalous groundwater levels in the database are initially identified (e.g. catastrophic storm events) and replaced by region-specific mean values based on observations available from the nearest wells. Missing date-specific data are estimated using simple temporal interpolation based on observations available in time. If a station (or monitoring well) data contains missing data, it was not used.

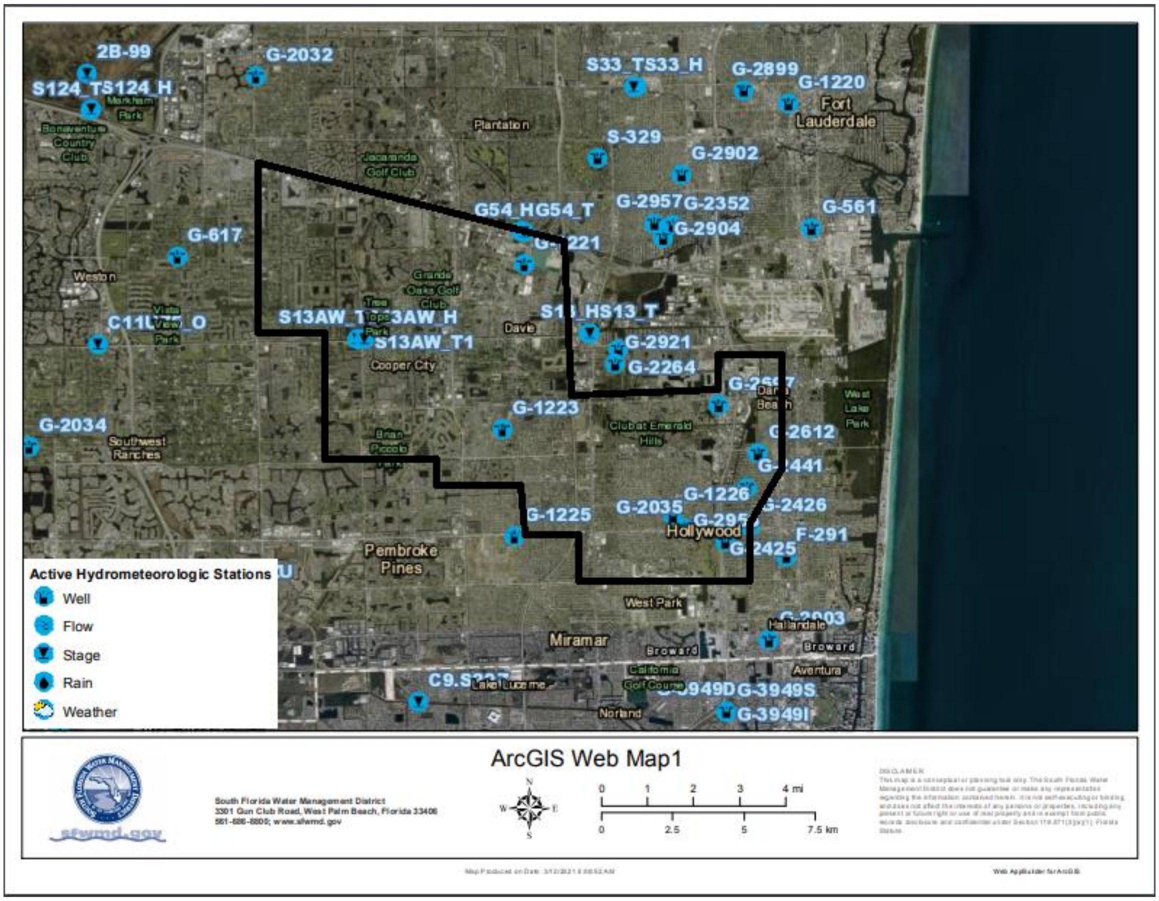

Figure 22. Groundwater stations maintained in the HUC 030902061205 Davie/Dania Beach subwatershed

2.3 Surface Water/Tides

Historically, surface water and tides have been an important factor in determining how much freshwater is delivered, how fast this water enters wetlands and estuaries, and the quality of that water. Evapotranspiration and rainfall do not coincide (Figure 23), which makes water supply planning difficult (Bloetscher, 1995).

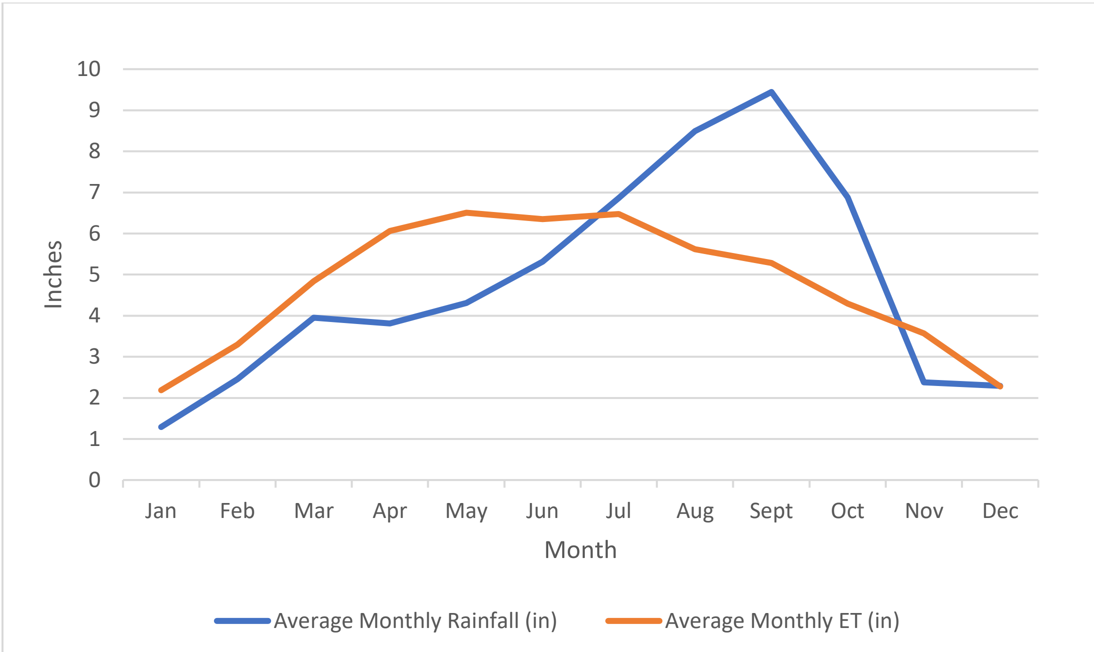

Figure 23. Comparison of rainfall and evapotranspiration for southeast portions of Florida (Bloetscher, 1995)

While the topography (Section 2.1) and native soil (discussed later in Section 2.4) create an environment that is highly permeable and capable of infiltrating significant percolation into the soil, changes in land use and land cover (refer to Section 2.5) have resulted in water falling on impervious areas, where the water collects in pools or runs off rapidly, in direct contrast to the natural condition. This runoff flowing over impermeable regions can lead to larger scale flooding.

In this region of Florida, there is a direct interaction between groundwater and surface water. In addition to low land elevations and topographic relief, the groundwater and surface water are controlled by the canals, rivers, and tides. Since there is a limited number of groundwater monitoring stations (refer to Figure 22), the strong relationship between groundwater and surface water was leveraged to develop a 99th-percentile surface of the water table elevation for mapping purposes. To establish a common date for modeling, the recorded groundwater table elevations were sorted in ascending order to determine the 98th -100th percentile date of occurrence in Excel®, following the procedure detailed in Romah (2011), which was automated for this effort using a python code to process the groundwater data more efficiently as described in Zhang et al. (2020). Outliers and anomalous groundwater levels in the database are initially identified (e.g. catastrophic storm events) and replaced by region-specific mean values based on observations available from the nearest well. Missing date-specific data are estimated using simple temporal interpolation based on observations available in time. If a station (or monitoring well) data contains large amounts of missing data, it was not used in the generation of the groundwater surface.

Many stations are located along canals and rivers, which assists in determining the water levels across open and connected surface waterbodies. As shown previously on the map in Figure 22, there are a total of 39 stations with observations available. Data outside the study area was needed to properly krig across the boundary of the basin for the groundwater layer, adding another 40 points. This is because the study area is primarily developed. All daily mean surface water level observations on the common date (October 29, 2017) were gathered from monitoring stations in the DBHYDRO database.

Tidal data can be gathered from NOAA tidal gages and other gages monitored by local governments. The location of tide gages is important to ensure they accurately depict tides, as opposed to inland waters. To set a boundary for the coastal areas, the high tide on the common date of 10/29/2017 was chosen. Figure 24 shows the locations of the existing tide gages in Florida. The Virginia Key tide station was used for this exercise.

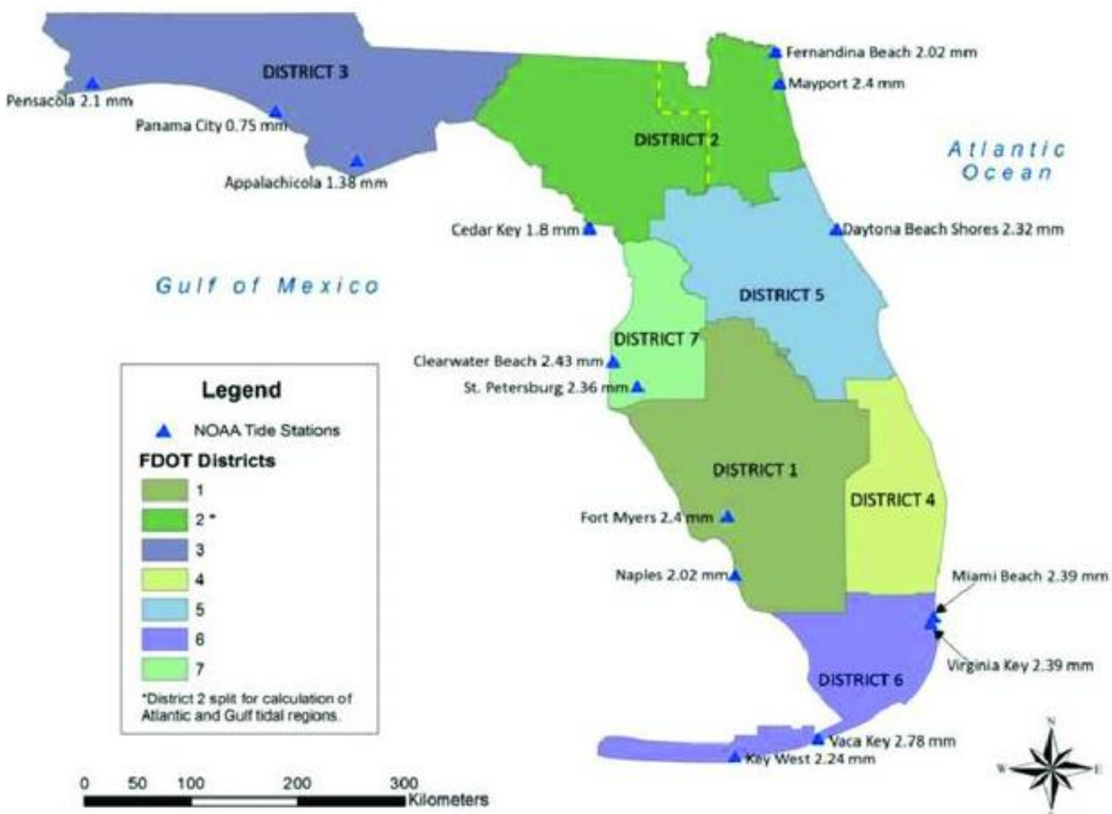

Figure 24. Locations of Florida tidal stations maintained by NOAA in FDOT Districts (Butler et al., 2013)

Once a common time period is determined across the majority of shallow groundwater wells, canal data can be gathered for that common date (and two days prior, in the event the canals were deliberately lowered). Data is obtained from the SFWMD DBHYDRO site for surface waters (https://www.sfwmd.gov/science-data/dbhydro). Between stations, an ArcGIS tool permits a line to be drawn to replicate the canals and establish points in a gradient between stations. The canals form boundary conditions for the screening tool on the edges of the basin and affect localized groundwater elevations. The same is true for the ocean, but it is a constant head boundary. Using water levels in the groundwater and canals, the only remaining boundary is the Atlantic Ocean. The tide issue is resolved by using the common date for high tide. Eight groundwater stations were located in the basin, mostly located to the east. As a result, these eight stations plus stations outside the study area, were used in conjunction with the surface water stations to krig a groundwater surface layer for the basin across the HUC 030902061205 Davie/Dania Beach subwatershed boundary, resulting in Figure 25.

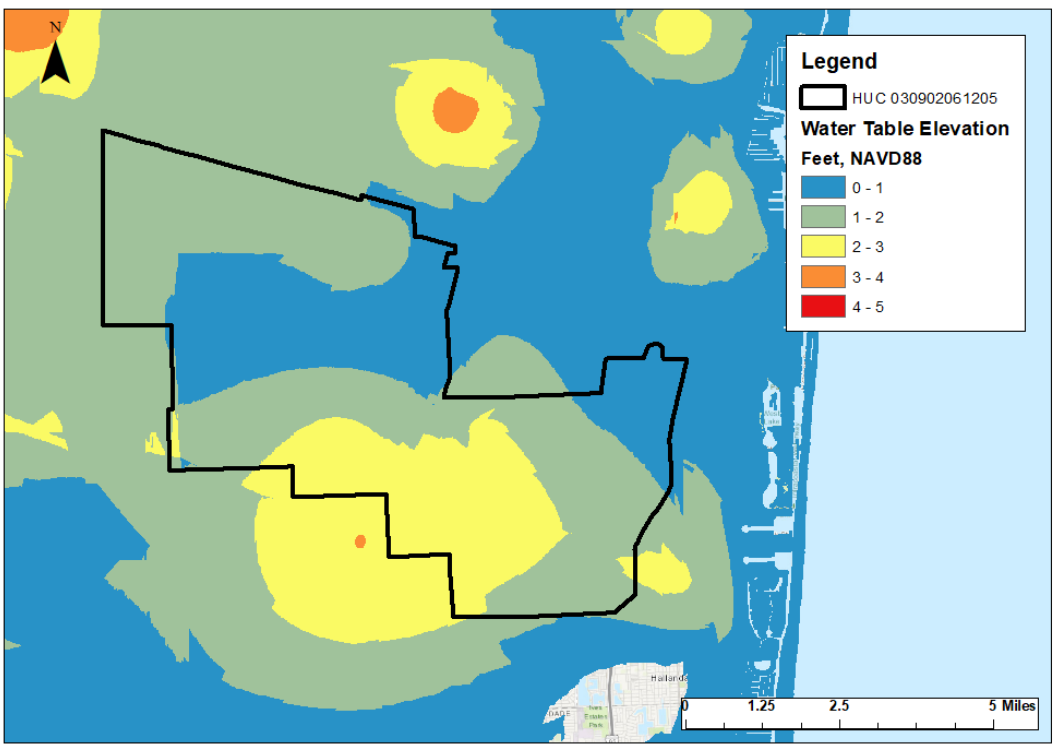

Figure 25. Elevation of the top of the surficial groundwater layer for the HUC 030902061205 Davie/Dania Beach subwatershed created by multiple linear regression analysis – elevation NAVD88, as processed by FAU

2.4 Soils

Soil can store water if there is adequate distance between the topographic surface and the groundwater, and the soil types are capable of infiltrating the water. Soil storage capacity is the volume of soil pores in the unsaturated zone that is available to store stormwater (Gregory et al., 1998). Throughout Florida, it is common to have large volume storm events that fill the voids in the unsaturated zone as shown in Figure 26.

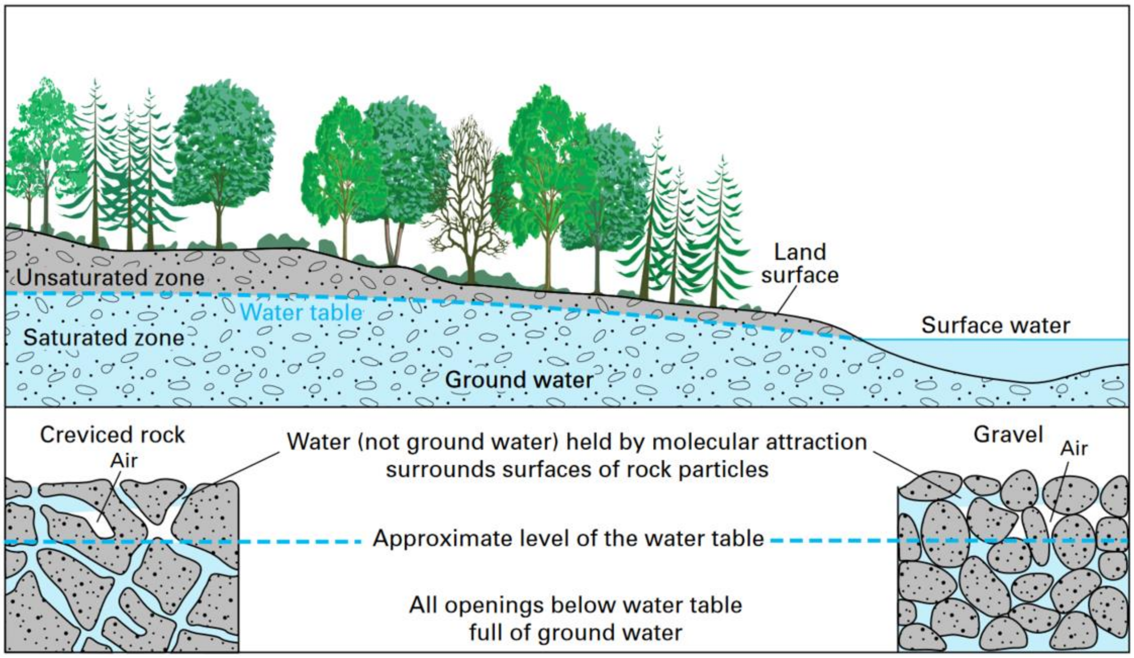

Figure 26. Depiction of zones where underground water exists (USGS, 2020)

The unsaturated zone is the portion of the subsurface above the water table that contains soil/rock and air and water in its pores as shown in Figure 27. This zone affects the rate at which the aquifer gets recharged by controlling water movement from the surface of the land downward towards the aquifer. During rain events, the soil voids fill up quickly resulting in the water table rising to the surface, and the surplus rainfall becomes runoff.

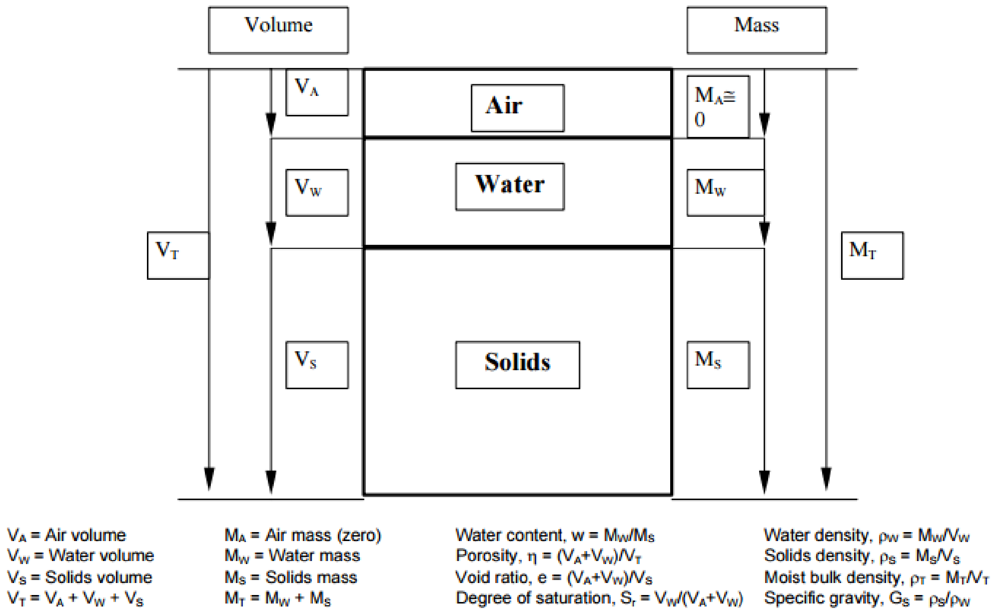

Figure 27. Saturated zone soil phase diagram and definitions (Gregory et al., 1998)

Soil data is available from the United States Department of Agriculture (USDA) or other agencies in the form of maps that can be incorporated as a GIS layer. The Gridded SSURGO (gSSURGO) dataset from USDA is chosen. This dataset is similar to the standard product from USDA Natural Resources Conservation Service (NRCS) Soil Survey Geographic (SSURGO) database, but is in the Environmental Systems Research Institute, Inc. (ESRI®) file geodatabase format. A file geodatabase allows for statewide or even Conterminous United States (CONUS) tiling of data. The gSSURGO dataset contains all of the original soil attribute tables in SSURGO. All spatial data are stored within the geodatabase instead of externally as separate shape files. Both SSURGO and gSSURGO are considered products of the National Cooperative Soil Survey (NCSS).

The statewide available water storage from USDA derived for the soil layer (0-150 cm or 0-5 ft) is shown in Figure 28, which covers most of Florida with a spatial resolution of 10 m. The unit of available water storage is in cm.

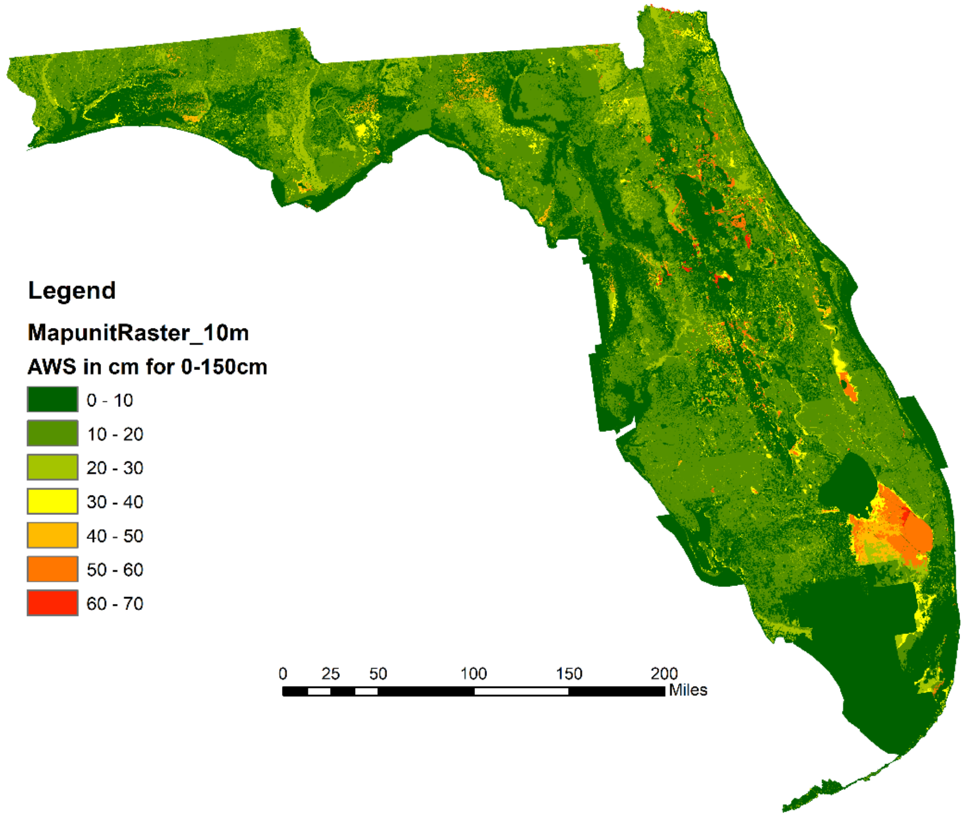

Figure 28. Available water storage derived from the gSSURGO soil database for all of Florida, as processed by FAU

Water holding capacity refers to the amount of water held between field capacity and the wilting point. Available water storage (AWS) is that portion of the water holding capacity that can be absorbed by a plant. As a rule, plant available water is considered to be 50% of the water holding capacity. The water holding capacity (ratio) is calculated using the following equation:

$$\text{Water holding capacity} = 2 \times (\text{AWS for a soil layer of 0-150 cm}) / 150\text{ cm}$$

To find the unsaturated zone, the groundwater layer as influenced by the surficial canals is subtracted from the topographic layer in GIS to create an apparent unsaturated zone depth layer. In Broward County, much of the area is expected to show minimal differences between the ground surface and the water table elevations in the fall, except along the coastal ridge. The unsaturated zone depth layer is then multiplied by the water holding capacity ratio layer (Figure 29) to create the soil storage capacity layer (refer to Figure 30 and also to Section 4.2.1), which gives the actual amount of water that can enter the soil before filling it. Much of the basin has very limited soil storage capacity.

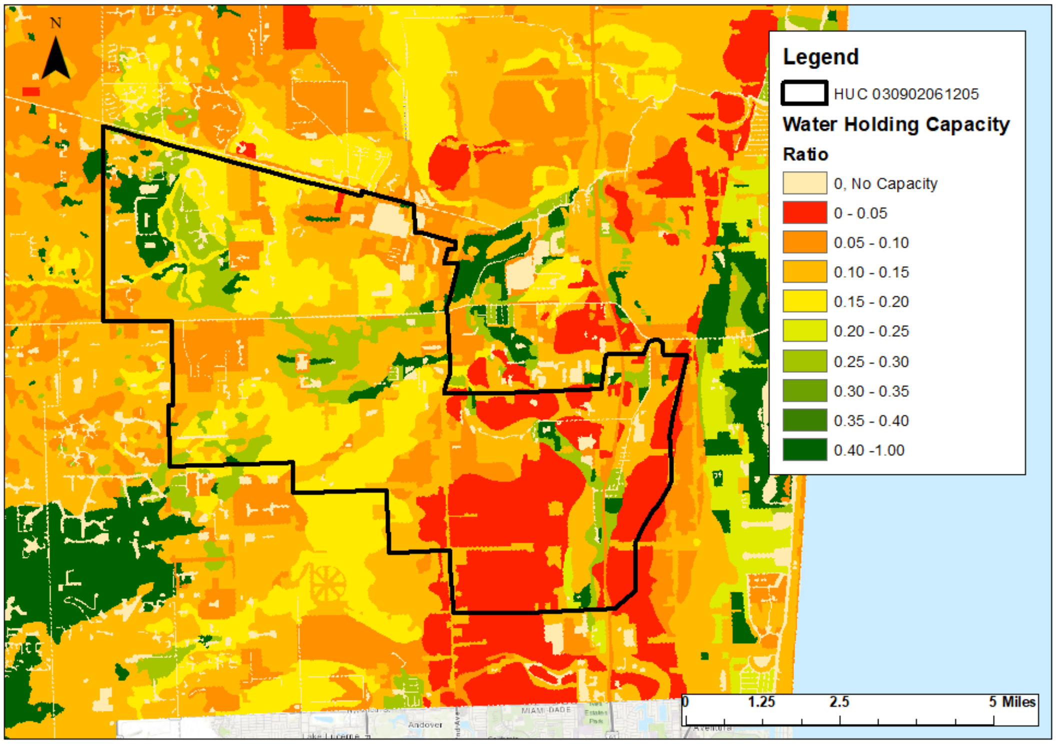

Figure 29. Water holding capacity ratio of soil for the HUC 030902061205 Davie/Dania Beach subwatershed, as processed by FAU

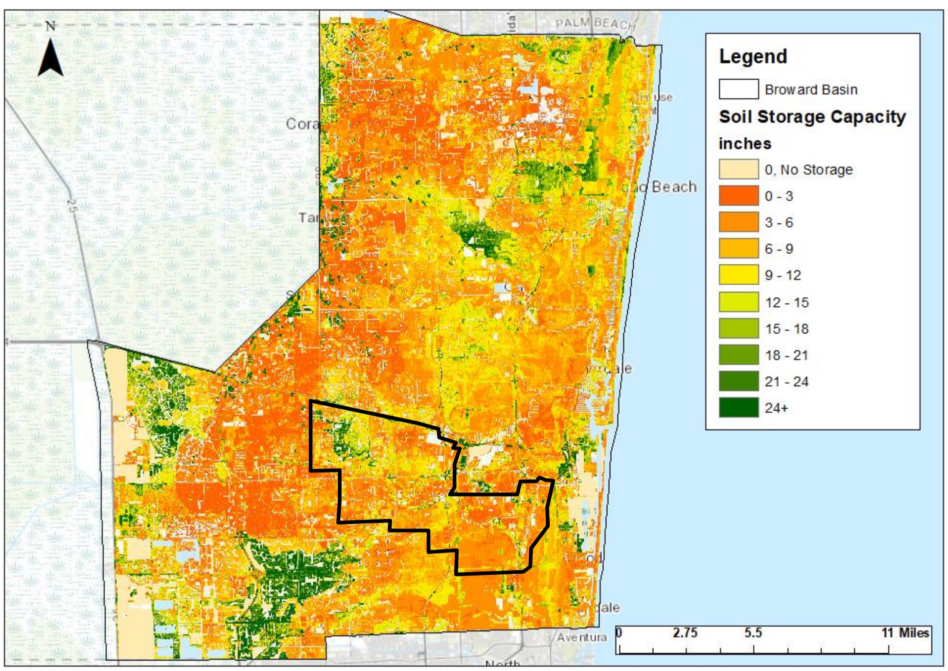

Figure 30. Unsaturated zone map for HUC 030902061205 Davie/Dania Beach subwatershed, as processed by FAU

2.5 Land Cover

The most accurate current land use dataset is derived from the Florida Land Use Cover Classification System (FLUCCS), which is digitized by photo-interpretation on county-based aerial photography with varying resolution in the range of 4 in - 2 ft pixel. The land cover/land use map for the study area used the SFWMD dataset (refer to prior Section 1.1.1 and 1.1.4). A close-up view is provided in Figure 31. For modeling purposes, the values on Table 6 were used as needed. The future land use maps discussed in Chapter 4 and summarized in Figure 32 were used for the final land cover, as adjusted for future stormwater improvements set by regulatory standards.

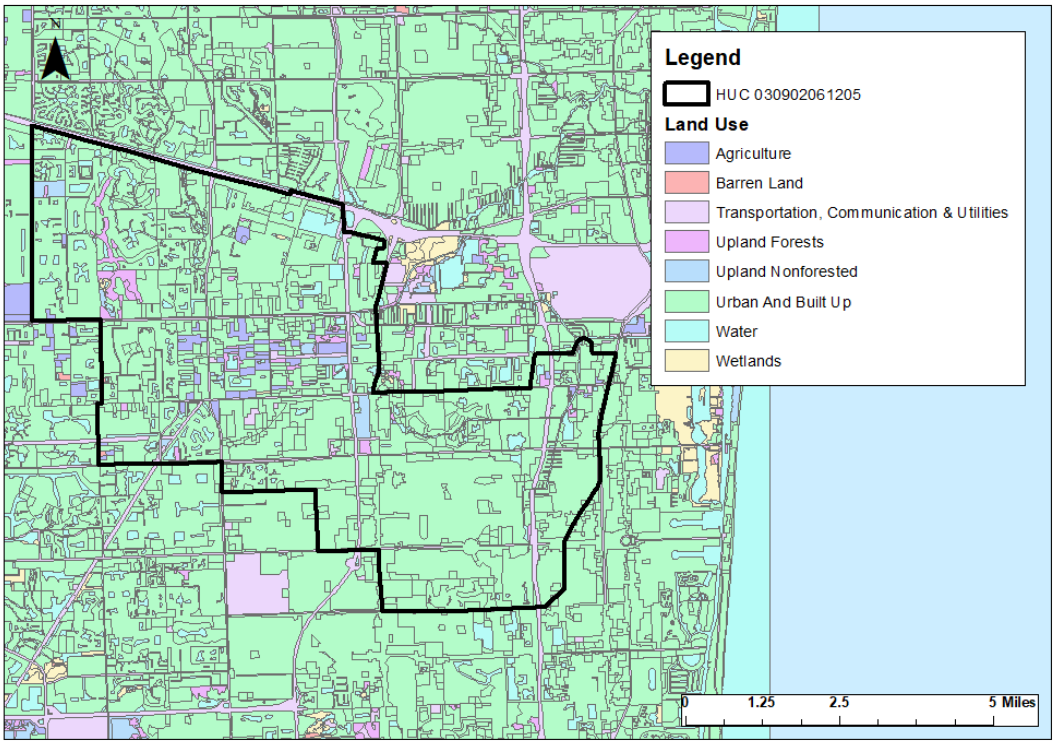

Figure 31. Current land use in the HUC 030902061205 Davie/Dania Beach subwatershed (from the SFWMD 2016 database).

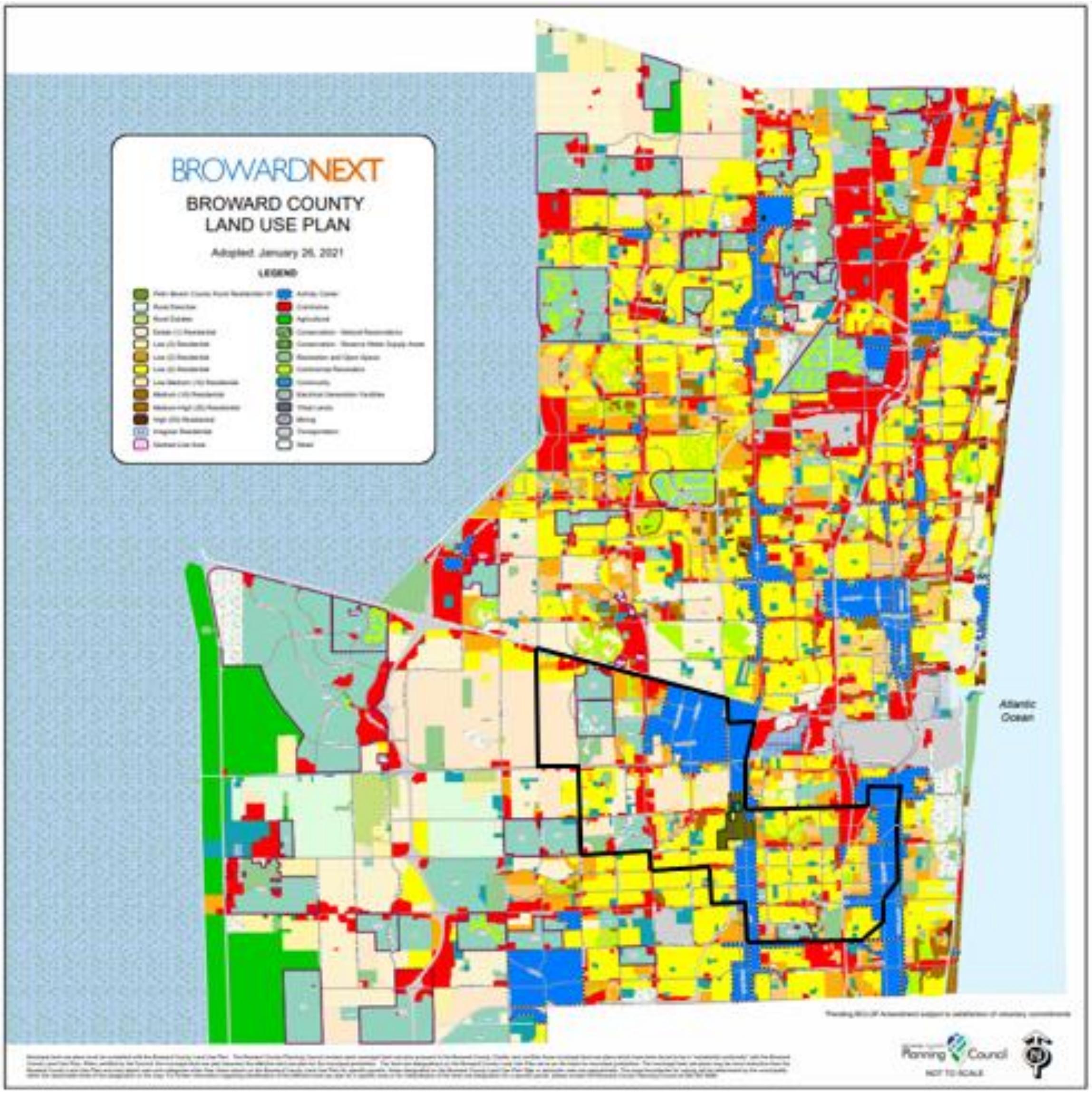

Figure 32. Future land use map highlighting the HUC 030902061205 Davie/Dania Beach subwatershed boundary.

Table 6. Impervious percentage and roughness coefficients by land use code

DOR Code	Use	Impervious %	Roughness Coefficient
0	Vacant	0	0.400
1	Single Family	29	0.250
2	Mobile Homes	21	0.050
4	Condos	60	0.050
7	Vacant – to be developed	0	0.400
8	Multifamily	60	0.050
TH 101	Townhomes	91	0.025
94	Road Right-of-Ways	50	0.080
	Open Water	100	n/a
All others	Commercial, etc.	50	0.070

2.6 Precipitation

Rainfall used in the screening tool is initially based on the SFWMD 3-day, 25-year storm, but was modified for other rainfall events using the accumulated rainfall table obtained from NOAA Atlas 14 Point Precipitation Frequency Estimates (https://hdsc.nws.noaa.gov/hdsc/pfds/pfds_map_cont.html). In this study, all storm events described in Section 3.2 were analyzed. Figure 33 shows the 3-day, 25-year rainfall map based on the NOAA Atlas 14 dataset for the whole state.

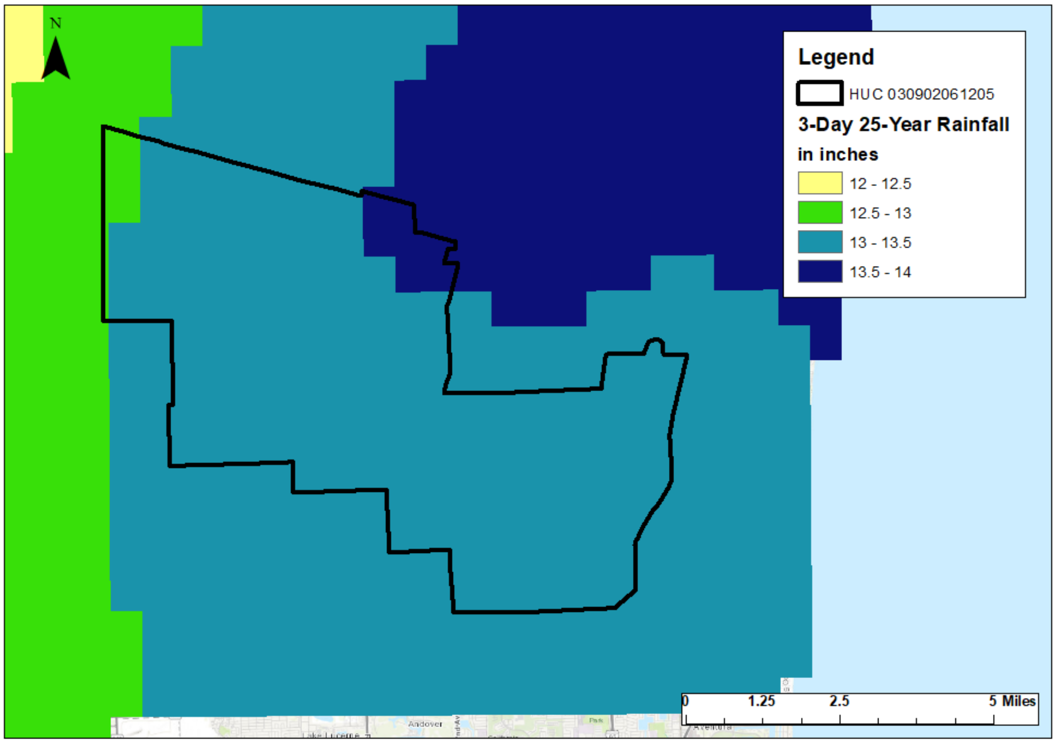

Figure 33. Rainfall distribution map across the HUC 030902061205 Davie/Dania Beach subwatershed for the 3-day, 25-year storm, as processed by FAU

The historical monthly rainfall differences from 01/01/2010 to 03/21/2021 between several DBHYDRO stations are shown in Figure 34.

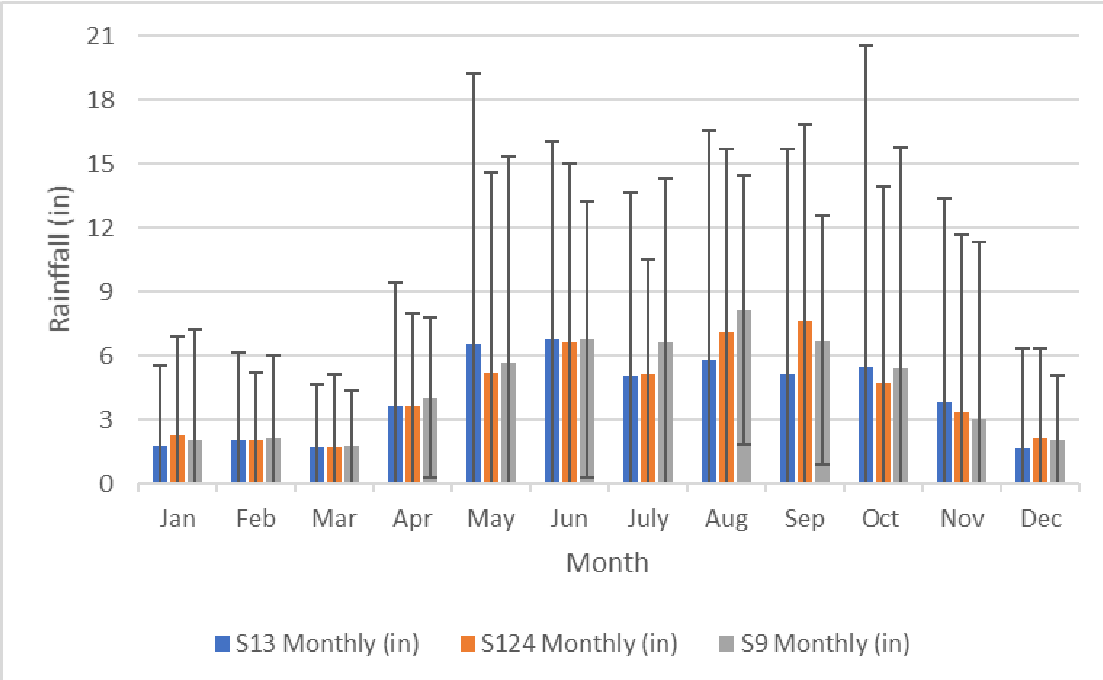

Figure 34. Variation of average monthly rainfall at three locations from 01/01/2010 to 03/21/2021 (SFWMD, DBHYDRO accessed 03/11/2021) showing generally consistent rainfall across the HUC 030902061205 Davie/Dania Beach subwatershed

2.7 Open Space

Open space is defined as areas that are exempted from development. Generally this means one or more of the following qualifiers exist:

1. Land that is valuable for recreation, forestry, fishing, or conservation of wildlife or natural resources
2. Land that is a prime natural feature of the state's landscape, such as a shoreline or ridgeline
3. Land that is habitat for native plant or animal species listed as threatened, endangered, or of special concern
4. Land that is a relatively undisturbed example of an uncommon native ecological community
5. Land that is important for enhancing and conserving the water quality of lakes, rivers, and coastal water
6. Land that is valuable for preserving local agricultural heritage
7. Proximity to urban areas or areas with open space deficiencies and underserved populations
8. Vulnerability of land to development
9. Stewardship needs and management constraints

10. Preservation of forest land and waterbodies that naturally absorb significant amounts of carbon dioxide

Permanent protection of sensitive areas can provide critical water quality protection and can be achieved through partnerships with landowners, municipalities, land trusts and state agencies. There is land in the study area that has been protected via acquisition by federal, state, or local agencies, has conservation easements or is designated as wetlands (Figure 16 in Section 1.1.4) or areas of critical concern. These are primarily shown on the conservation maps noted in Figure 18 in Section 1.1.4. Agricultural land and other land cover will come from the land cover map (refer back to Figure 31 in Section 2.5). Added to this will be the waterbodies discussed in Section 2.9, which serve a related condition to open space.

2.8 Impervious Areas

Impervious areas do not permit the infiltration of rainfall to groundwater, and because the water cannot infiltrate, it runs off faster. Faster runoff means that flows to waterbodies and storm sewers occur faster and with higher peaks. The result is a potential disruption of the natural and planned hydrology. Impervious areas include pavement, buildings, and other areas that reduce runoff capacity. In other words, developed areas have much higher imperviousness than open spaces that are natural or agricultural.

The NLCD2016 provides nationwide data on land cover and land cover change at a 30-m resolution to help understand both current and historical land cover and land cover change to enable assessment of trends. Using the NLCD 2016 dataset, a layer was created by using only three categories (namely, primary roads in urban areas, secondary roads in urban areas, and tertiary roads in urban areas) out of the 13 to identify impervious areas. The new layer was then converted to match the 3-meter spatial resolution from the DEM and the standard State Plane Coordinate system. Figure 35 shows the impervious areas.

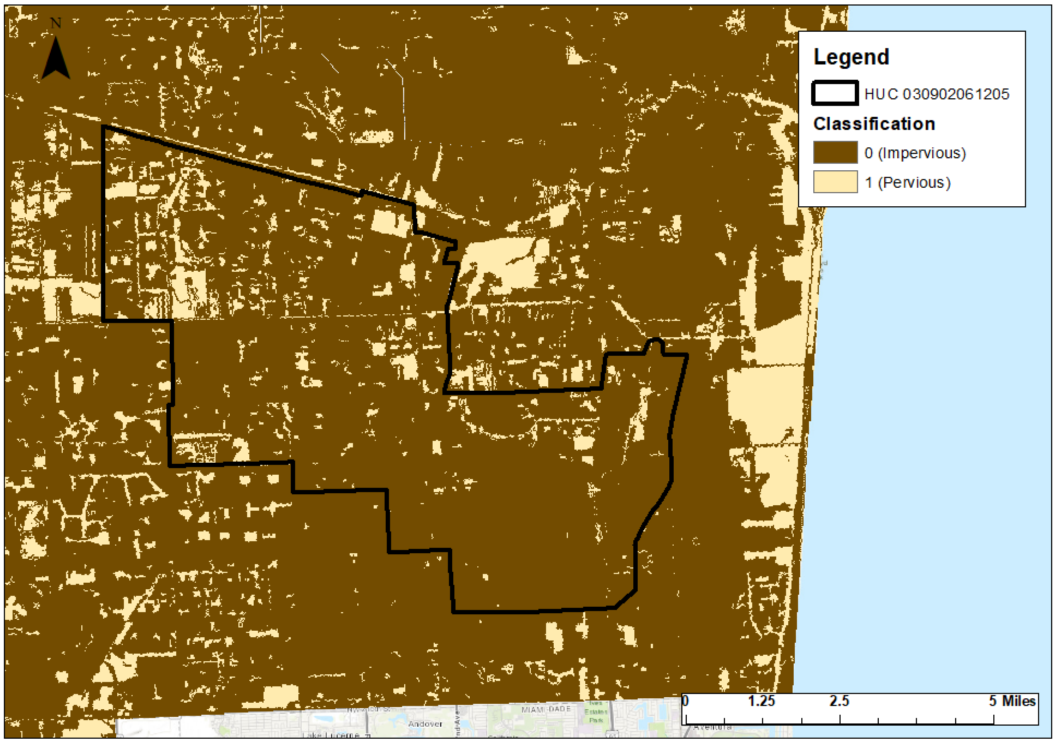

Figure 35. Impervious area map for the HUC 030902061205 Davie/Dania Beach subwatershed, as processed by FAU

2.9 Waterbodies

Waterbodies were defined in the statewide land use land cover dataset to set soil water holding capacity to zero in model simulations (Figure 36). Note that tiny waterbodies may be missing from the maps. Soils were discussed previously in Section 2.4.

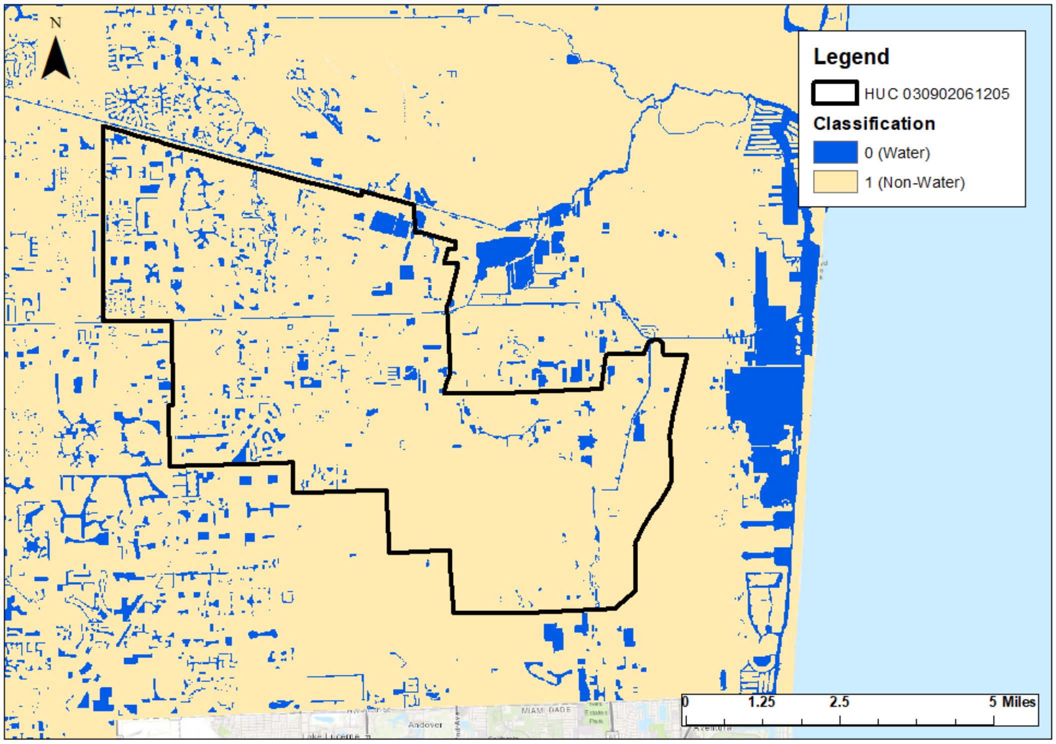

Figure 36. Waterbodies map for the HUC 030902061205 Davie/Dania Beach subwatershed as processed by FAU

2.10. Natural Resources

Understanding the study area's natural resources is critical to identifying potential sources of water quality degradation and areas to designate for conservation, protection, and restoration. USGS maintains important sources of information on physical and geographical features as well as soil and mineral resources, surface and ground water resources, topographic maps, and water quality monitoring data. The USDA's Natural Resources Inventory (NRI) (www.nrcs.usda.gov/technical/NRI) is a survey of information on natural resources on non-federal land in the United States that captures data on land cover and land use, soil erosion, prime farmland soils, wetlands, habitat diversity, erosion, conservation practices, and related items. Since 2001, the NRI has been updated continually with annual releases of NRI data from all 50 states. The information provided can be used for addressing agricultural and environmental issues down to the county or cataloging unit level. Therefore, this data can be used to determine erosion and site-specific soil characteristics for certain land uses such as croplands, pasturelands, forestlands, etc., but the data is typically provided as inventories, not GIS layers. Much of this information is primarily covered in Section 1.1 and earlier parts of this chapter and will not be repeated here.

2.11 Demographics

Demographics data is important for determining several key indicators for watershed master planning such as the ability to pay for improvements, social justice issues, land acquisition costs, property/land use, and communication strategies. The US Census has databases at the census tract level. Based on the census data for the study area, Table 7 outlines population and racial composition demographics.

Table 7. Demographics and Housing Characteristics of selected communities within the HUC 030902061205 Davie/Dania Beach subwatershed, noting that only portions of these communities are within the subwatershed (US Census 2010)

Demographic Parameter	Davie	Dania Beach	Cooper City	Hollywood
Area in square miles	35.78	8.33	8.34	30.80
Population	106,306	29,639	28,547	140,768
No. of Households	37,306	15,671	9,912	59,673
Med. Household Income	$47,014	$34,125	$78,172	$55,849
Median Age	36	40	37	39
White	80.1%	69.6%	85.1%	72.7%
Black, African American	8.0%	21.8%	4.9%	16.7%
American Indian, Native	0.3%	0.3%	0.3%	0.4%
Asian	4.6%	2.1%	5.5%	2.4%
Other Race	3.8%	3.2%	1.8%	4.5%
Two or More Races	3.1%	2.6%	2.4%	3.2%
Hispanic or Latino (Regardless of Race)	29.1%	22.4%	22.8%	32.6%

2.12 Stormwater Infrastructure Inventory

Local community stormwater systems consist of drainage ditches, storm sewers, retention ponds and other facilities constructed to store runoff or carry it to a receiving stream, lake, ocean, or other waterbody. Other man-made features include yards and swales that collect runoff and direct it to the storm sewers and ditches. When most of these systems were built, they were designed to handle the amount of water expected during a 10-year storm, but for modeling purposes it was assumed that the storm of interest would occur during the wet season when the majority of these facilities are at their maximum level (i.e. the canals are full) as opposed to being empty to start. Larger storms overload them, and the resulting backed-up sewers and overloaded ditches produce shallow flooding. Another urban drainage problem occurs in the areas protected by levees. Being in floodplains, they are flat and do not drain naturally, especially when a levee blocks the flow to the river. To drain these areas, channels have been built and pumps installed to mechanically move the water past the levee. Often, these man-made systems do not have the capacity to handle heavy rains or intense storms.

Another challenge with stormwater infrastructure is related to recordkeeping. It is not uncommon for stormwater data to be incomplete in most jurisdictions and completely lacking in others. Quality of data differs from jurisdiction to jurisdiction; some are on GIS formats, while others are paper maps or as-builts that represent the infrastructure at a macroscale level. The condition and maintenance history of the assets is incomplete. Where data is incomplete, it is recommended to develop a complete inventory of the assets, a condition assessment and complete maps in communities where this may be lacking – note Cooper City, Dania Beach and Davie all had inventories developed and asset assessed in the last 5 years).

SFWMD and USACE infrastructure exerts a far larger impact at the watershed level compared to local infrastructure on the waterways indicated on Figure 14 in Section 1.1.1. Key stormwater assets for the study area are shown in Figure 37 and include the following:

- ST13 Pumping Station
- ST13A Weir at 4.5 ft NAVD88
- Dania Cutoff Canal/C-10/C11 canal

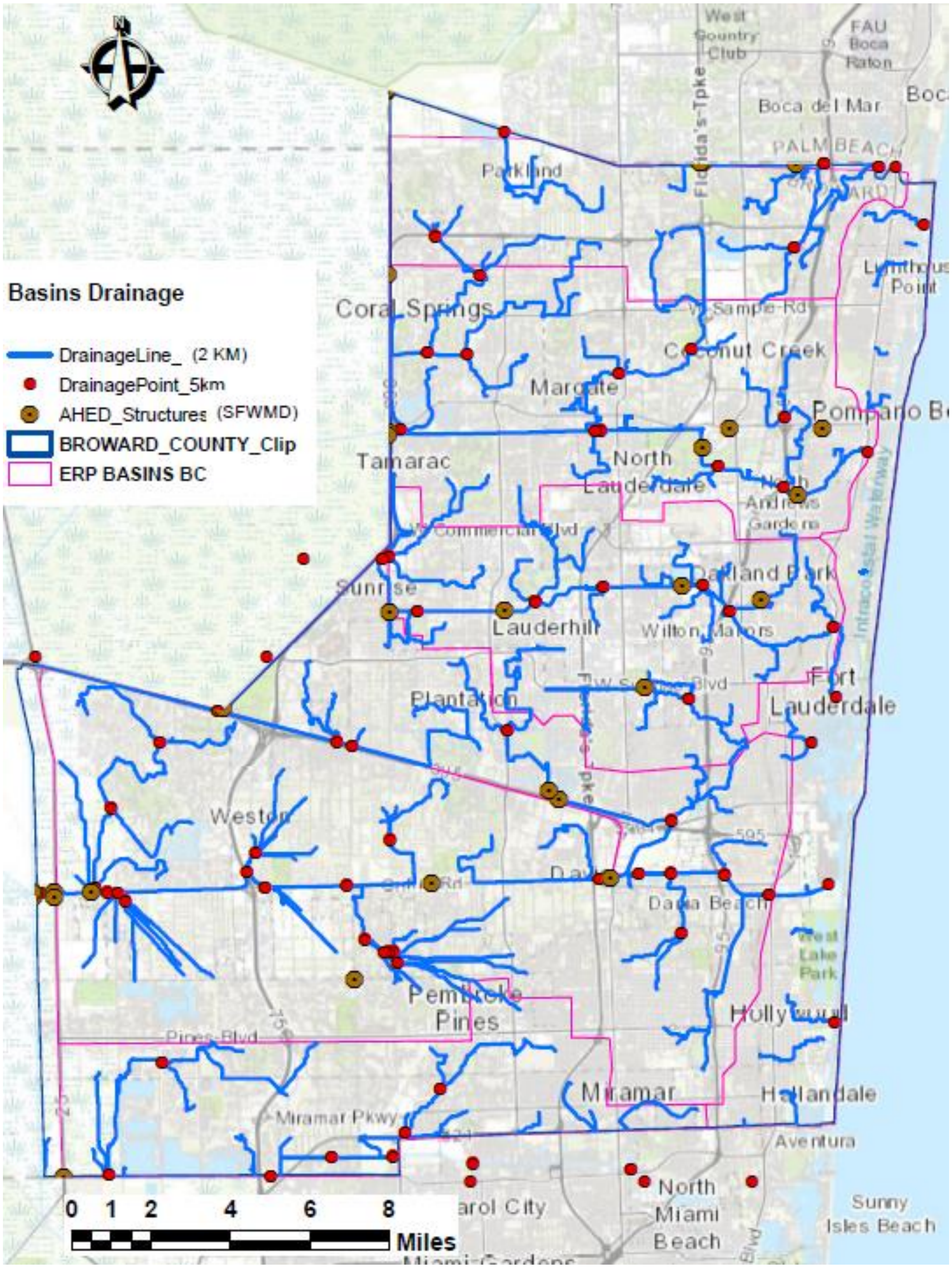

Figure 37. Location of major watershed level stormwater infrastructure in Broward County (used in modeling with Cascade 2001) (SFWMD, 2020)

The City of Dania Beach has an active stormwater program funded by assessments. The City has a GIS map of all stormwater elements (Figure 38).

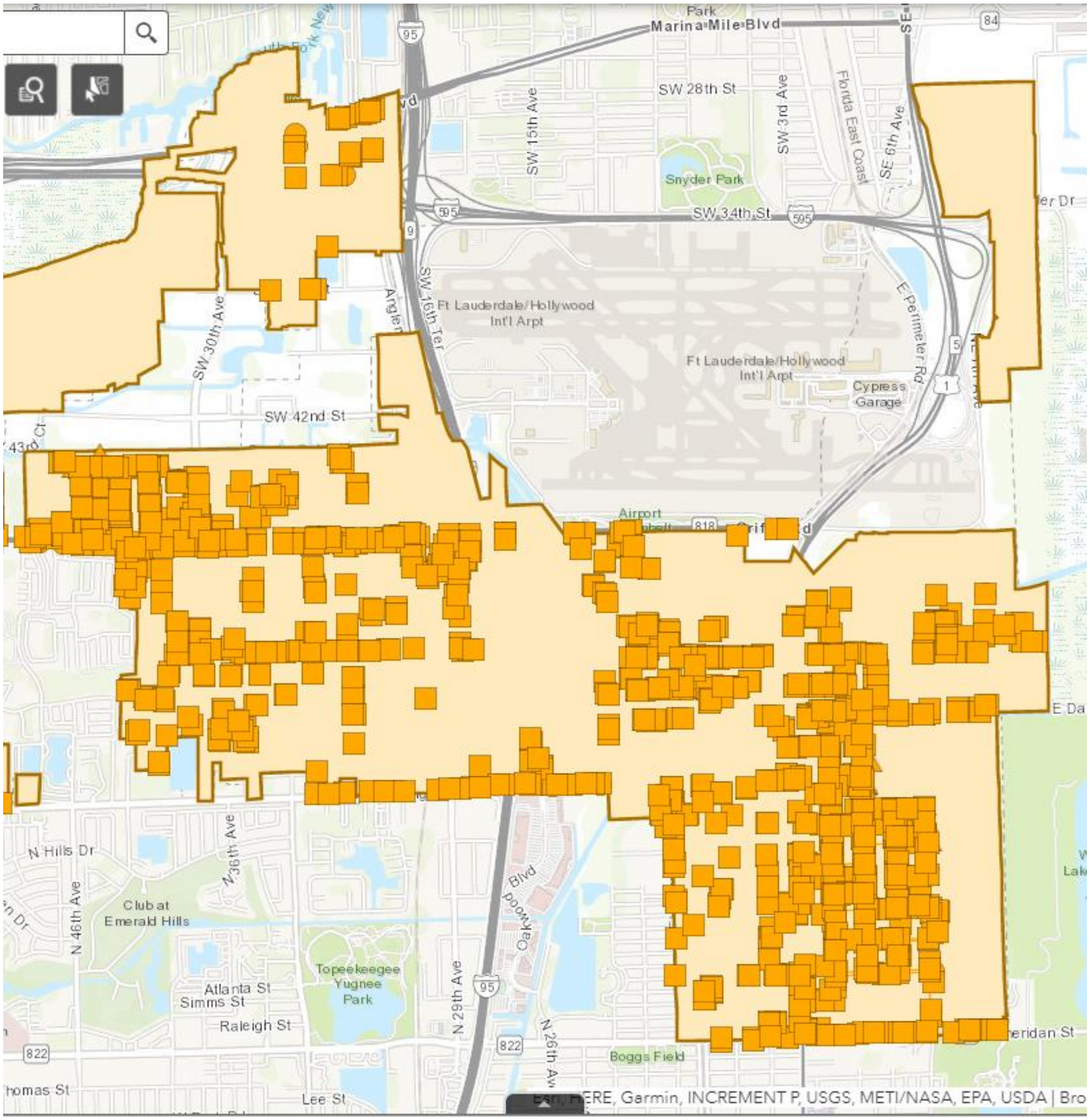

Figure 38. Dania Beach Stormwater infrastructure (2020)

The City's stormwater structures include catch basins, curb inlets, culverts, canals, swales, pump stations, ditches, and manholes. The City's stormwater system must maintain compliance with Broward County's MS4 stormwater permit, which requires additional record-keeping, policy development, inspections and maintenance than is currently being performed. The City has identified the following stormwater enterprise goals and priorities:

- Address detention pond maintenance;
- Mitigate flooding to the extent practical;
- Maintain compliance with current and future regulatory requirements and permits;
- Maintain a functional stormwater drainage system;
- Maintain the health and quality of life for residents;
- Create and maintain an adequate, stable, and reliable funding methodology to fund the stormwater program through the use of the City's Stormwater Enterprise Fund

In order to categorize and maintain these structures an asset management plan needs to be developed.

The Town of Davie has a stormwater atlas and an asset management plan to help organize and identify critical stormwater infrastructure (Figure 39). The stormwater conveyance system within the town limits includes primary, secondary, and tertiary canals operated by others. The C-11 canal operated by SFWMD, while other canals are operated by local drainage districts. The canal systems pump the stormwater west to the Everglades and east to the Atlantic Ocean. The C-11 has three stages: the ocean, ST13 pump station and ST13A weir with a stage at 4.5 ft. The Town has identified the following stormwater enterprise goals and priorities:

- Address detention pond maintenance;
- Address water quality concerns in the Town;
- Mitigate flooding to the extent practical;
- Maintain compliance with current and future regulatory requirements and permits;
- Maintain a functional stormwater drainage system;
- Maintain the health and quality of life for residents;

In order to categorize and maintain these structures, an asset management plan needs to be developed. The existing stormwater infrastructure is shown in Figure 39.

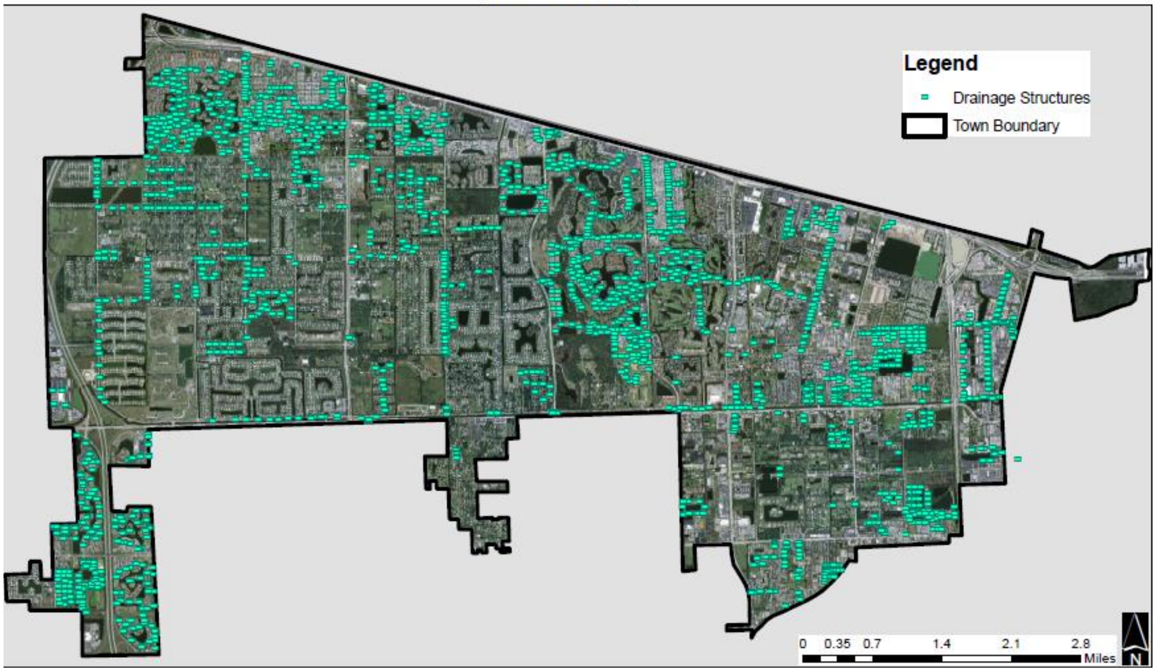

Figure 39. Town of Davie stormwater infrastructure (2017)

The City of Cooper City has a more structured stormwater system than the Town of Davie. It consists of curb inlets and piping that help channel the stormwater to canals, retention areas and directly into the ground to help resupply the groundwater. The City's stormwater system must maintain compliance with Broward County's MS4 stormwater permit, which requires additional record-keeping, policy development, inspections and maintenance than is currently being performed, just like Dania Beach and Davie. Cooper City's stormwater map is shown Figure 40.

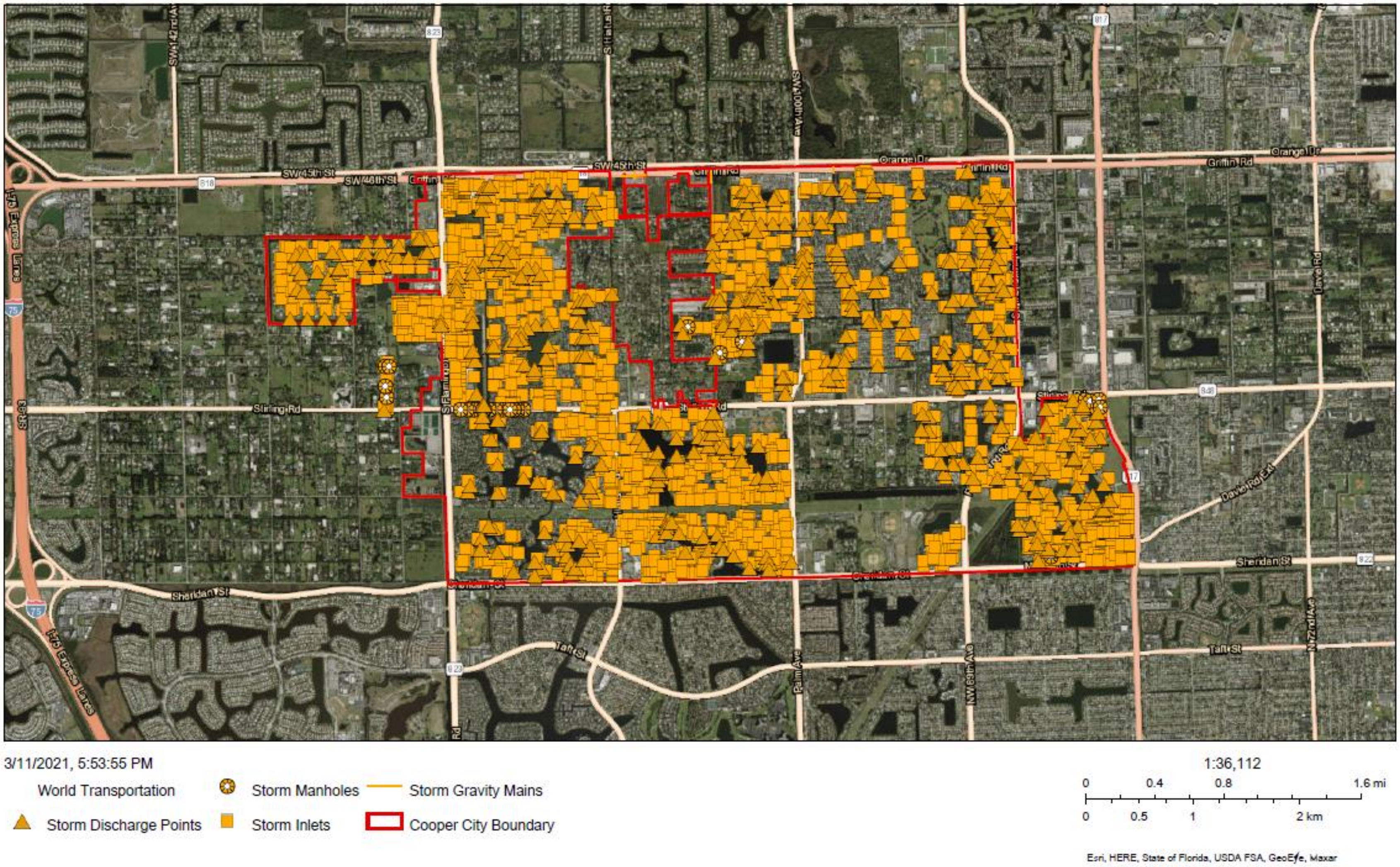

Figure 40. Cooper City stormwater infrastructure map (2021)

The City of Hollywood has a more structured stormwater system compared to any of the other communities in the study area. The system consists of curb inlets and piping that help channel the stormwater to canals, retention areas and directly into the ground to help resupply the groundwater. The City's stormwater system is permitted under its own MS4 permit, not with Broward County's MS4 stormwater permit, which requires additional record-keeping, policy development, inspections, and maintenance The City did perform a waterways plan for eastern Hollywood in 2013, at a cost of $200 million, but only a small portion of that work appears to have been completed. No stormwater facility/infrastructure map was readily available, but the City has a series of coastal pumping stations to address king tide and nuisance flooding.

2.13 Data Gaps

There is only one data gap for the area – a map of Hollywood's local stormwater system was not available, nor was the information for the reservation. All larger infrastructure is accounted for. The missing localized infrastructure will have more impact on local flooding results than on larger subwatersheds.

3.0 POLICY FRAMEWORK

In this section, the available planning documents applicable to the study area are discussed as they relate to watershed master planning.

3.1 Existing Regulations

It is important that the WMP identify the control actions, management practices, and regulations as well as the agencies that have authority and jurisdiction in the study area. These will include regulatory standards for new development such that peak flows and volumes are sufficiently controlled and regulations that prohibit development, alteration, and modification of existing natural channels. The universe of existing regulations includes federal, state, tribal, regional, and local rules.

3.1.1 Federal Regulations

The federal and state (of Florida) rules have been interconnected since the 1980s with delegation of enforcement and administration of the major environmental protection rules to the states. In response to increased flood damage, the escalating costs of disaster relief for taxpayers, and the lack of affordable flood insurance, Congress enacted the National Flood Insurance Act (NFIA) in 1968 (Public Law Number 90-448, 82 Stat. 572 (August 1, 1968). Codified, as amended, at 42 U.S.C. §4001), which established the National Flood Insurance Program (NFIP). Property located in a flood area where the community participates in the NFIP is subject to the NFIA's requirements.

Flood insurance compliance requirements for federally regulated financial institutions began in 1973, when Congress enacted the Flood Disaster Protection Act of 1973 (FDPA - Public Law Number 93-234, 87 Stat. 975.). Section 102(b) of the FDPA amended the NFIA to require the Board of Governors of the Federal Reserve System (Board), the Federal Deposit Insurance Corporation (FDIC), the Office of the Comptroller of the Currency (OCC), and the National Credit Union Administration (NCUA) to issue regulations directing lending institutions under their supervision not to make, increase, extend, or renew any loan secured by improved real estate or mobile homes located, or to be located, in a Special Flood Hazard Area (SFHA) where flood insurance is available under the NFIP unless the building or mobile home and any personal property securing the loan are covered by flood insurance for the term of the loan.

Congress subsequently enacted the National Flood Insurance Reform Act of 1994 (Reform Act - Title V of the Riegle Community Development and Regulatory Improvement Act of 1994, Public Law Number 103-325 (September 23, 1994), which made comprehensive changes to the NFIA and FDPA. The changes include obligating lenders to escrow all premiums and fees for flood insurance required under the NFIA. In part because the NFIP incurred large deficits from paying claims for major floods, Congress enacted the Biggert-Waters Flood Insurance Reform Act of 2012 (BWA) to ensure the NFIP's fiscal stability and for other purposes. To make the program self-sustaining, the BWA phased out both subsidized rates, which apply to approximately 20% of policyholders (Pub. L. No. 112-141, 126 Stat. 916 (2012). The BWA also directed FEMA to implement full-risk pricing for all policies.

USACE has rules associated with federal works that apply to dredging, and other activities on navigable waters, which also includes wetlands. Discharging into surface waters is one of the oldest methods of disposing of waste from the point of generation. Downstream, reduction of the waste occurs due to dilution and natural degradation processes. Given sufficient treatment prior to discharge, these mutual processes work to reduce the waste to relatively minimal levels. Failure to treat adequately will overload the natural attenuation ability of the waterbody, resulting in noticeable pollution. As a result of major issues with pollution in the 1960s, Congress passed the Clean Water Act (CWA). The preamble for the CWA is as follows:

> *"The objective of this act is to restore and maintain the chemical physical and biological integrity of the Nation's waters…"*

Congress further stated that the discharge of pollutants in toxic amounts must be prohibited. As a result, the Clean Water Act regulates surface discharges to fresh waters, ocean discharges by wastewater plants, disposal of concentrated process waters from water plants (such as concentrate from membrane facilities), and disposal of residuals (sludge). Implicit is that stormwater and agricultural runoff issues may affect potable water supplies and are potentially subject to regulation.

Legislation was first directed to wastewater because discharging to a stream or surface waterbody made it the source water for downstream communities. Hence, if wastewater could be treated before it was discharged into the rivers, this might reduce the amount of treatment necessary for drinking water. Thus, the focus was primarily on wastewater treatment plants. At the same time, there were a variety of other issues that were addressed such as the attempt to reuse wastewater for beneficial uses like irrigation, to deal with industrial pretreatment so that metals and other contaminants that would disrupt the wastewater treatment process would not be discharged to the sewer system as well as the idea that stormwater might contribute to overflows. Since 1990, the focus has shifted from wastewater (mostly addressed) to agricultural and urban nonpoint source stormwater runoff (nutrients). USEPA developed MS4 and other permitting systems to address area runoff. A municipal separate storm sewer system (MS4) is a publicly owned conveyance or system of conveyances (i.e., ditches, curbs, catch basins, underground pipes, etc.) designed or used for collecting or conveying stormwater and that discharges to surface waters of the state. Examples of MS4 operators include, but are not limited to, municipalities, counties, community development districts, universities, military bases, or federal prisons. Operators of large, medium, and regulated small MS4s are required to obtain NPDES permit coverage to discharge to waters of the state.

Runoff continues to be a regulatory challenge at the federal level, so much of the enforcement has been delegated to the states and regional/local governments. In Florida, the state has delegated much of this effort to FDEP and the water management districts. As implemented by Chapter 62-624, F.A.C., Phase I addresses discharges of stormwater runoff from "medium" and "large" MS4s (i.e., those MS4s located in areas with populations of 100,000 or greater). Under Phase II, the program regulates discharges from certain MS4s not regulated under Phase I, and that meet designation criteria set forth in Chapter 62-624, F.A.C.

Changes to any water channel or canal requires a USACE general permit. Processing such permits involves evaluation of individual, project-specific applications in what can be considered three steps: 1) pre-application consultation (for major projects), 2) project review, and 3) decision-making. Per the USACE website (https://www.lrl.usace.army.mil/Portals/64/docs/regulatory/Permitting/PermittingProcessInformation.pdf), the process for the general permit is as follows:

1. A pre-application consultation is recommended
2. The applicant submits ENG Form 4345 and plans electronically or to the appropriate USACE regulatory office
3. USACE notifies the applicant if additional information is required to complete the application
4. A public notice is issued within 15 days of receipt of a complete application to solicit comments from the public, adjacent property owners, interested groups and individuals, local agencies, state agencies, and Federal agencies
5. The public notice comment period is 15-30 days, depending upon nature of activity
6. USACE provides the applicant an opportunity to respond to comments received in response to the public notice
7. USACE considers all comments and the applicant's responses to those comments, including any proposed modifications of the project
8. A public hearing is held, if necessary

9. USACE conducts a public interest review evaluation and, if necessary, a section 404(b)(1) guidelines evaluation
10. USACE decides on the permit application and explains its decision in a decision document. This decision document may include an environmental assessment or environmental impact statement, a statement of findings or record of decision, a Section 404(b)(1) guidelines evaluation (if necessary), and a public interest review evaluation
11. If USACE issues the permit, a copy is sent to the applicant for signature, otherwise an explanation of permit denial is sent
12. If the applicant refuses to sign the permit because he or she does not agree with the conditions in the permit, or if the permit is denied, the applicant can request an administrative appeal of the permit decision

Pre-application consultation is suggested to provide for informal discussions about a proposed activity. This invaluable feedback gives the applicant insight into the viability of alternatives available to accomplish the project goal and provides opportunities to discuss measures for reducing impacts and to inform the applicant of the factors USACE must consider in its decision-making process.

The following general criteria are considered in evaluating all applications (https://www.lrl.usace.army.mil/Portals/64/docs/regulatory/Permitting/PermittingProcessInformation.pdf):

1. Relevant extent of public and private need for the proposed work
2. Where unresolved conflicts of resource use exist, the practicability of using reasonable alternative locations and methods to accomplish the objective of the proposed structure or work
3. The extent and permanence of the beneficial and/or detrimental effects the proposed structure or work is likely to have on public and private uses to which the area is suited

The decision to issue or deny a permit is based on the public interest review and, where applicable, a Section 404(b)(1) guidelines analysis or an analysis of the ocean dumping criteria. The public interest review involves an analysis of the foreseeable impacts the proposed work would have on public interest factors, such as navigation, general environmental concerns, wetlands, economics, fish and wildlife values, land use, floodplain values, and the needs and welfare of the people. The permit decision document includes a discussion of the environmental impacts of the project, the findings of the public interest review process, and any special evaluation required by the type of activity, such as determining compliance with the Section 404(b)(1) guidelines. Because every project is subject to regulations and permitting requirements, preparing a comprehensive up-to-date list may be problematic. Therefore, it is recommended to conduct pre-application meetings with the pertinent regulatory agencies (USACE, FDEP, WMDs, and the counties) to identify the appropriate permits and guidelines for regulatory compliance.

3.1.2 State Regulations

The Florida Legislature enacted the Florida Watershed Restoration Act (FWRA) in 1999 to protect Florida's water resources from excessive pollution loading. It focuses on the Total Maximum Daily Load (TMDL) program that is required by the federal Clean Water Act and discusses specifics of how this program should be implemented in Florida. It does not address water quantity directly. A TMDL is the total amount of pollution discharge from all sources that a waterbody can assimilate and still meet water quality standards. This value is typically represented in lb/year allocations. For more information on water quality standards, consult Surface Water Quality Standards - Chapter 62-302. The TMDL program protects state waters by coordinating the control of pollution from point and nonpoint sources.

Waterbodies that do not meet water quality standards are identified as "impaired," and implementation plans must be developed describing how the point and nonpoint sources of pollution will meet their discharge allocations. This implementation plan is referred to as Basin Management Action Plan (BMAP). FDEP identified the following basic steps for the TMDL program (the bulleted list below is a direct quotation from the website at http://www.dep.state.fl.us/water/tmdl/):

- Access the quality of surface waters—Are water quality standards being met?
- Determine which waters are impaired or are not meeting water quality standards for particular pollutants?
- Establish and adopt, by rule, a TMDL for each impaired water for the pollutants of concern
- Develop, with extensive local stakeholder input, Basin Management Action Plans (BMAPs)
- Implement the strategies and actions of BMAPs
- Measure the effectiveness of BMAPs, both continuously at the local level and through a formal re-evaluation every five years
- Adapt BMAPs to local conditions by changing the plan and changing the actions if things are not working
- Reassess the quality of surface waters continuously

FDEP is the lead agency in establishing TMDLs and for enforcing the FWRA when addressing point source and nonagricultural nonpoint source pollution, while the Florida

Department of Agriculture and Consumer Affairs (FDACS) is the lead agency for enforcing the FWRA when it comes to agricultural nonpoint source pollution. FDEP is required to coordinate with the water management districts, FDACS, soil and water conservation districts, environmental groups, regulated parties, and local stakeholders during all phases of the TMDL process, which includes:

- Development of a TMDL assessment. The methodology includes determination of what information is required for the TMDL assessment, the acceptable methods of data collection, and analysis and quality control requirements.
- Development of an approved list of waterbodies or segments for which TMDLs will be applied, including a priority ranking and schedule for analyzing such waters.
- Calculation and implementation of TMDLs, accounting for seasonal variations and including a margin of safety to reflect uncertainties about pollution loading effects on water quality. A TMDL should be allocated among pollution sources in a reasonable and equitable manner (accounting for the availability of treatment technologies, existing treatment levels, and the costs/benefits of achieving allocation).

FDEP in coordination with the water management districts may develop a BMAP to achieve the TMDL. BMAPs can include such strategies as construction of regional treatment systems or voluntary trading of water quality credits. BMAPs should include water quality improvement milestones, and the progress with achieving these milestones should be evaluated every five years. FDEP can implement TMDLs under existing water quality protection programs, such as:

- Permitting and other existing regulatory programs, such as water-quality-based effluent limitations
- Non-regulatory and incentive-based programs, such as cost-share, best management practices, and public education
- Trading of water quality credits or other agreements
- Public works, including capital facilities
- Land acquisition

Section 303(d) of the Clean Water Act allows USEPA to assist states, territories, and authorized tribes in listing out any and all impaired waters and developing their respective TMDLs. A TMDL is the restoration goal of a specific watershed. FDEP checks the quality of watersheds across the State of Florida and determines if they are within an acceptable TMDL of pollutants (Figure 41).

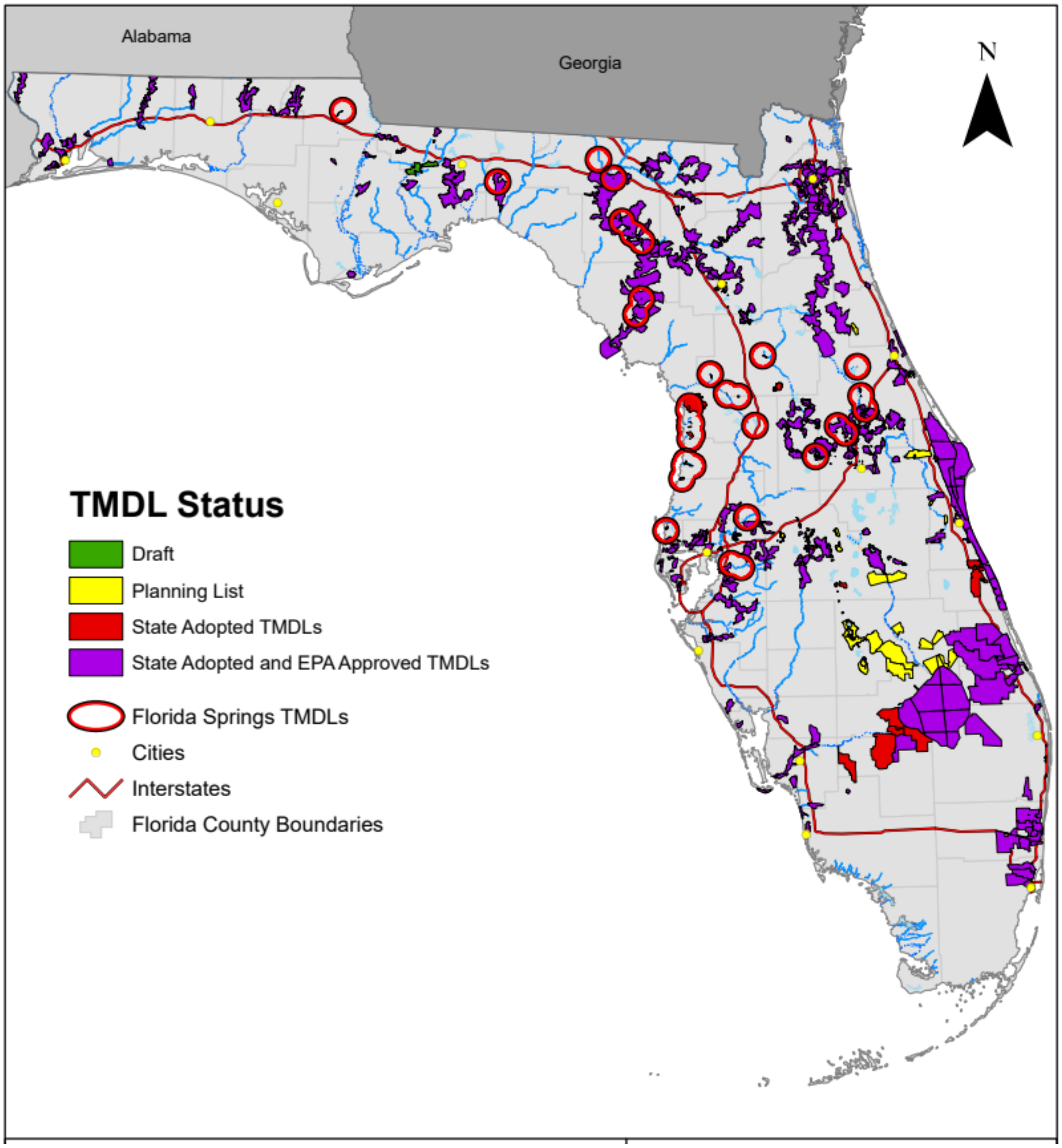

Figure 41. TMDLs across the state of Florida (https://www.cwp.org/wp-content/uploads/2019/05/Caloosa-Presentation.pdf)

There are state adopted and USEPA approved TMDL regions in the study area. Figure 42 is a close-up view of the southeast region. It shows there are 3 TMDL subregions in the HUC. There are no BMAPs in the HUC 030902061205 Davie/Dania Beach subwatershed. However, there are a series of TMDLs on the C-11-East basin in Davie. BMAPs are the primary mechanism through which TMDLs are implemented in Florida (see Subsection 403.067[7], F.S.).

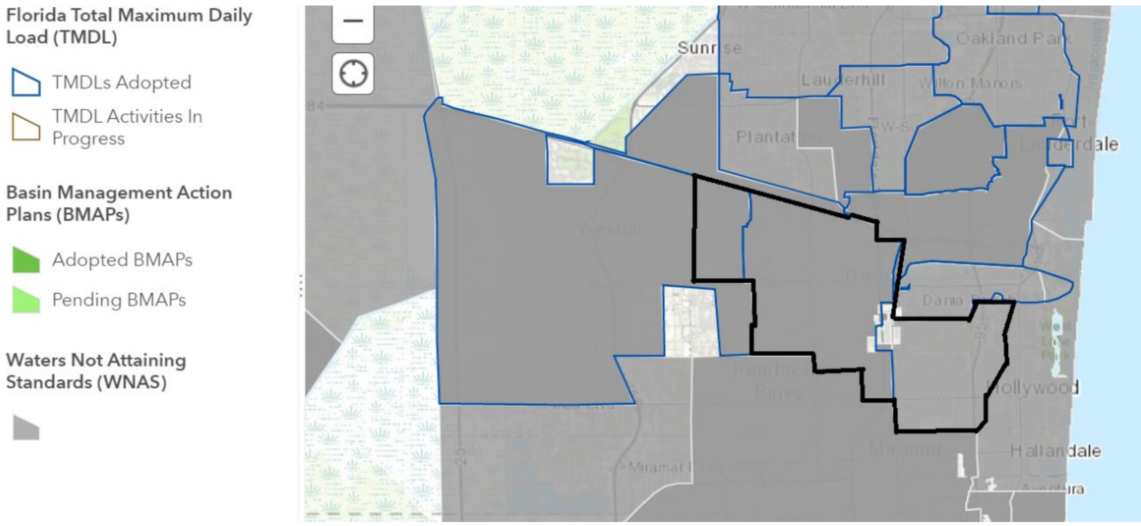

Figure 42. TMDL plans adopted and compliance states (https://floridadep.gov/dear/water-quality-restoration/content/impaired-waters-tmdls-and-basin-management-action-plans)

For the C-11 basin in Davie, FDEP reported in 2012 elevated fecal coliform concentrations and exceedance rates observed during every quarter, with exceedance rates greater than 50% during the second, third and fourth quarters (57.1%, 62.5%, and 57.1%, respectively). Episodic exceedances in fecal coliform concentrations occurred throughout the period of observation (2003–2010). Excluding March, April, July, and December, exceedances in fecal coliform concentrations were observed during every month, with all monthly exceedance rates ranging between 14.3% and 100%. The highest monthly average fecal coliform concentration (3,450 counts/100 mL) was observed in June. The impact of rainfall on monthly and quarterly exceedances is observed. In addition, FDEP deemed the waterbody to be impaired for fecal coliforms and is being placed in category 4a because there is a FDEP-Adopted/USEPA-Approved Fecal Coliform TMDL. However, the fecal coliform indicator is no longer the applicable water quality parameter for this waterbody classification. *Escherichia coli* is the indicator of interest in the Strategic Monitoring Plan for this waterbody.

On the C-10 flowing towards Hollywood there was no strong correlation between the monthly exceedance rate and monthly total rainfall, although high exceedance rates (above 80%) were observed during the wettest months. However, the state's TMDL website notes that the C-10 is deemed impaired (https://floridadep.gov/dear/water-quality-restoration/content/impaired-waters-tmdls-and-basin-management-action-plans) for fecal coliform based on data in the verified period. Moving forward, enterococci will be the new indicator of interest included in the Strategic Monitoring Plan. The TMDL is complete on the Dania Cutoff Canal with respect to fecal coliforms (https://floridadep.gov/dear/water-quality-restoration/content/impaired-waters-tmdls-and-basin-management-action-plans). However, with respect to copper, this waterbody has insufficient data available during the verified period but planning period data indicate this parameter is impaired.

3.1.3 Regional Regulations

Stormwater management systems in the study area are regulated by SFWMD. These regulations apply to the design of stormwater management systems that require a permit as described in Chapter 62-330, F.A.C., or Section 403.814(12) F.S. SFWMD published the Environmental Resource Permitting Manual (ERP) that contains SFWMD-specific appendices for regionally-specific criteria such as basin maps for cumulative impact assessments (see Applicant's Handbook Volume I, Section 10.2.8), mitigation bank service area determination (refer to Chapter 62-342, F.A.C), and above ground impoundments. Projects that qualify for a general permit in Section 403.814(12), F.S., are not regulated under Chapter 62-330, F.A.C. Volume II contains design and performance standards that are relevant to the design of projects that qualify for that general permit. The ERP provides specific, detailed water quality and quantity design and performance criteria for stormwater management systems regulated by SFWMD through the ERP program authorized under Part IV of Chapter 373, F.S, which is found at:

https://www.sfwmd.gov/sites/default/files/documents/swerp_applicants_handbook_vol_ii.pdf.

Unless otherwise specified by previous permits or criteria, a 3-day, 25-year storm is used in computing off-site discharge rates (Figure 43). Applicants are advised that local drainage districts or local governments may require more stringent design storm criteria. An applicant who demonstrates unusual site-specific conditions may, as a part of the permit application process, request an alternate discharge rate.

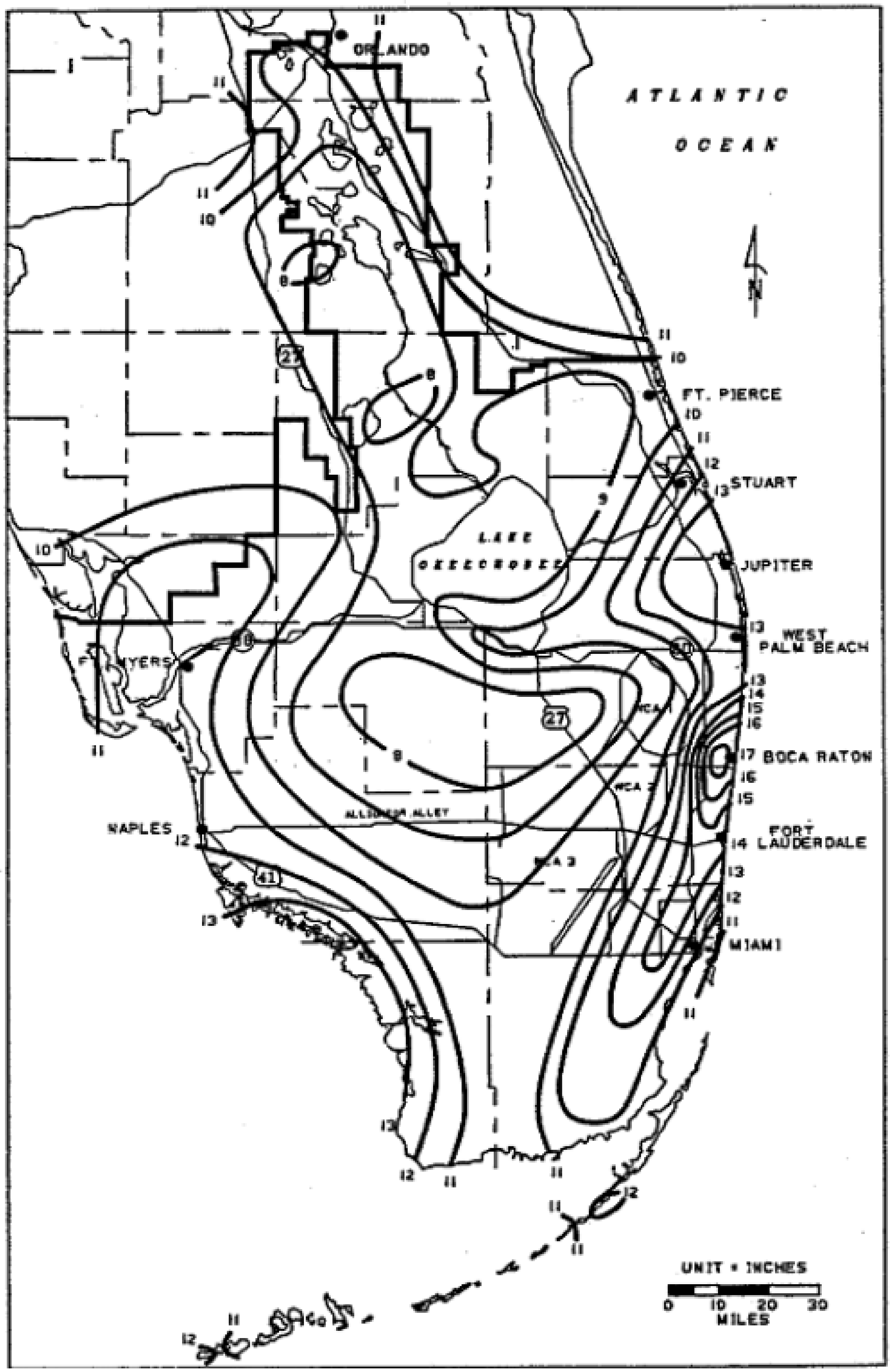

Figure 43. 3-day, 25-year rainfall map (SFWMD, 2014)
https://www.sfwmd.gov/sites/default/files/documents/swerp_applicants_handbook_vol_ii
.pdf

As the guidelines are promulgated throughout the SFWMD, they are applicable to all basins within their jurisdiction. For example, the ERP indicates that off-site discharge rates are limited to not causing adverse impacts to existing off-site properties, and: a) historic discharge rates; b) rates determined in previous permit actions; or c) rates specified in SFWMD criteria. An acceptable peak discharge analysis typically consists of generating pre-development and post-development runoff hydrographs, routing the post-development hydrograph through a detention basin, and sizing an overflow structure to control post-development discharges at or below pre-development rates. Acceptable design techniques also include the use of grassed waterways, and any other storage capability that the particular system may have. SFWMD normally uses the 3-day, 25-year storm for permitting purposes (Figure 43), but the Florida Building Code and certain peak event permits use the 1-day, 100-year event (Figure 44) or the 1-hour, 100-year storm (for roof drains). For full CRS credit, the 1-day, 10-year storm event is also of interest (Figure 45). All new development must be constructed so as to retain water that meets these requirements, thereby minimizing the impact of development on flood protection.

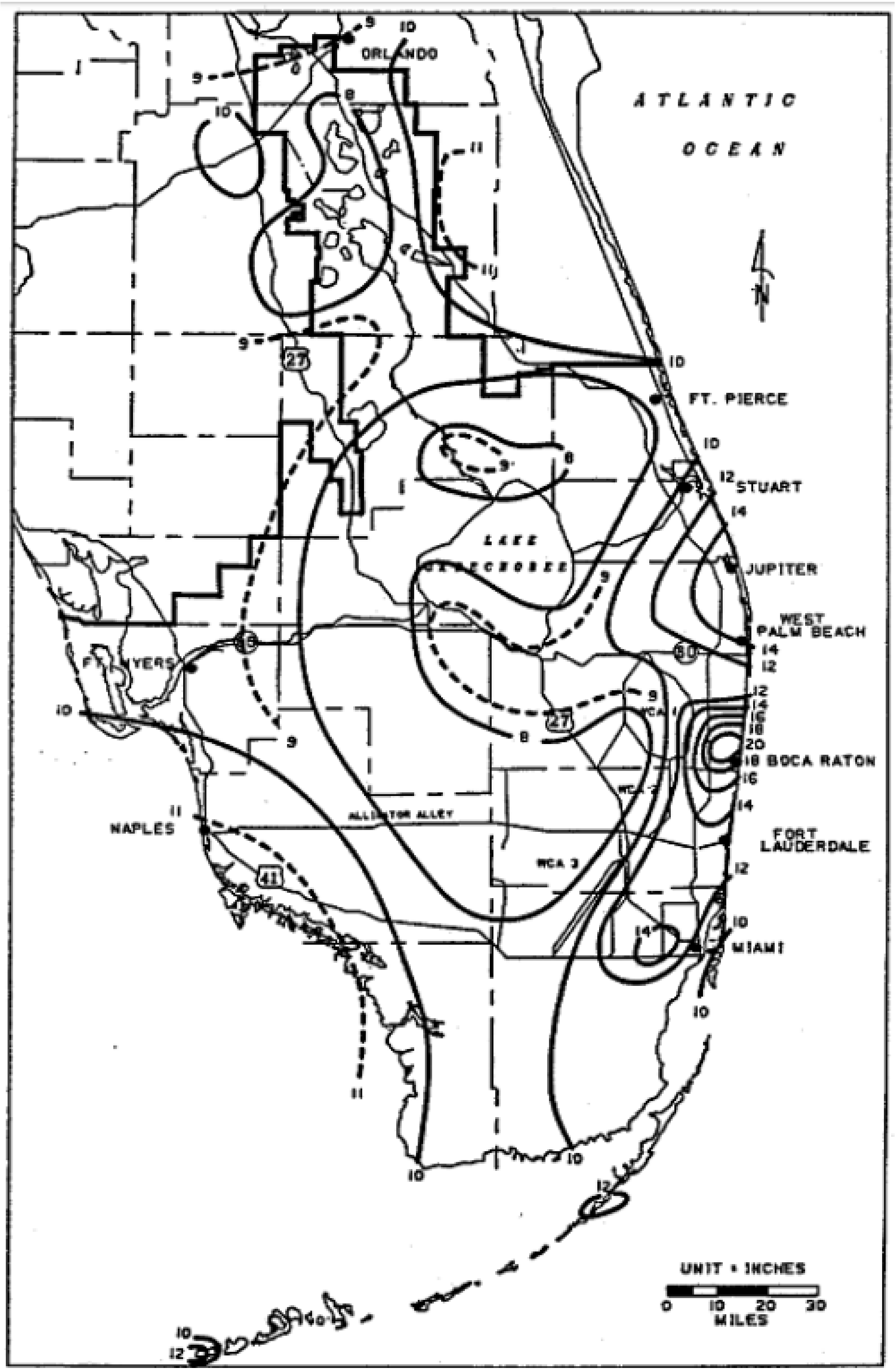

Figure 44. 1-day, 100-year rainfall map (SFWMD, 2014)
https://www.sfwmd.gov/sites/default/files/documents/swerp_applicants_handbook_vol_ii.pdf

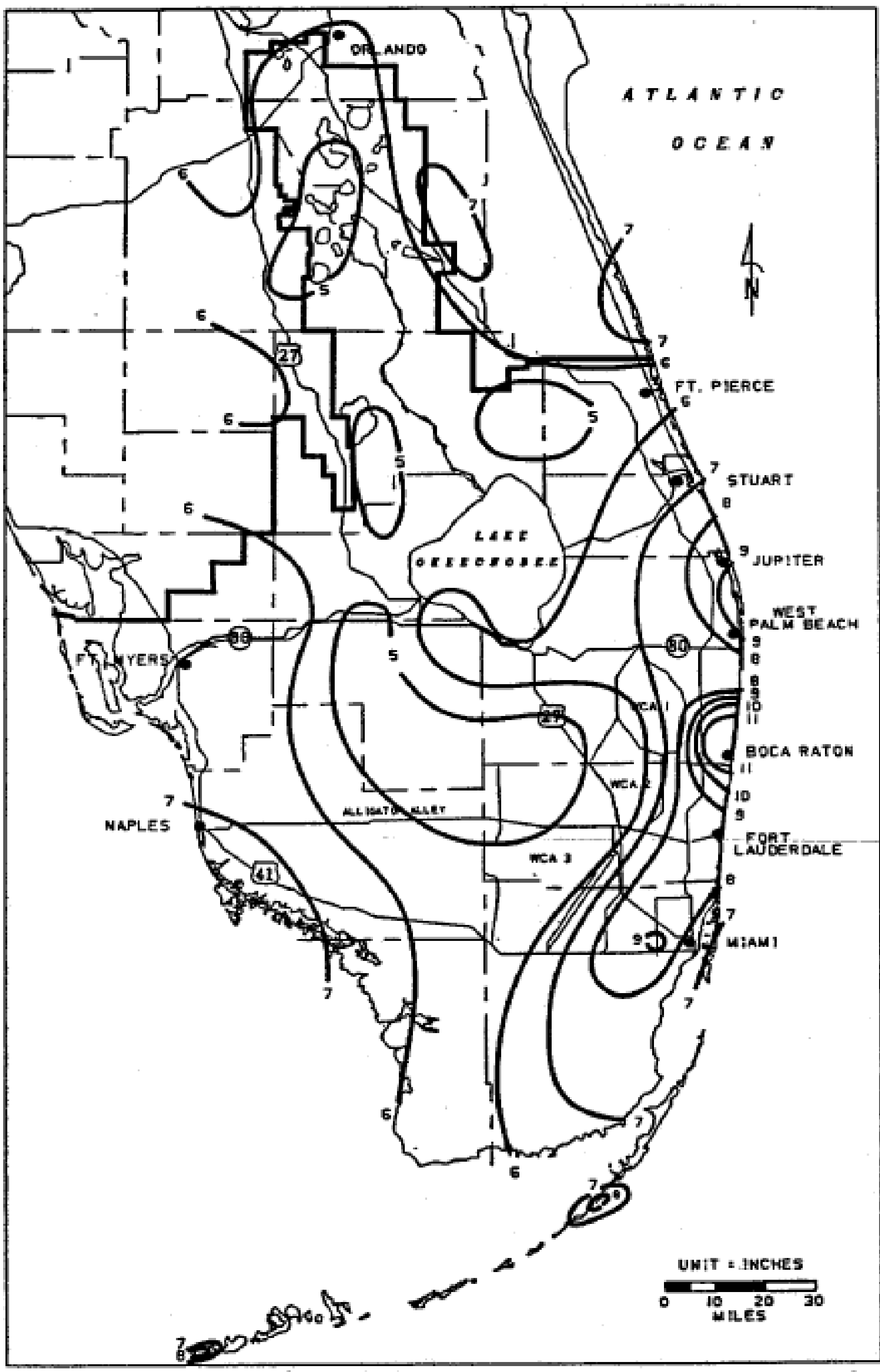

Figure 45. 1-day, 10-year rainfall map (SFWMD, 2014)
(https://www.sfwmd.gov/sites/default/files/documents/swerp_applicants_handbook_vol_ii.pdf)

The regulations note that peak discharge computations shall consider the duration, frequency, and intensity of rainfall, the antecedent moisture conditions, upper soil zone and surface storage, time of concentration, tailwater conditions, changes in land use or land cover, and any other changes in topographic and hydrologic characteristics. Large systems should be subdivided according to artificial or natural drainage boundaries to allow for more accurate hydrologic simulations. Peak discharge calculations must make proper use of the Soil Conservation Service (SCS) Peak Rate Factor or K' Factor, which reflects the effect of watershed storage on the hydrograph shape and directly impacts the peak discharge value. As such, K' must be based on the true watershed storage of runoff, and not on the slope of the landscape, which is more accurately accounted for in the time of concentration. More details can be found in the permitting guidelines (SFWMD, 2014).

Surface storage, including that available in wetlands and low-lying areas, must be considered as depression storage, which shall be analyzed for its effect on peak discharge and the time of concentration. Depression storage can also be considered in post-development storage routing, which requires development of stage-storage relationships. If depression storage is considered, then both pre-development and post-development storage routing must be considered.

The rules require that building floors must be at or above the 100-year flood elevation level, as determined from the most appropriate information, including Federal Flood Insurance Rate Maps (FIRMs). Both tidal flooding and the 1-day, 100-year storm event are considered in determining elevations. In cases where criteria are not specified by the local government with jurisdiction, the design criteria for drainage and flood protection, the 1-day, 5-year return frequency is used for roadways.

With respect to floodplains, no net encroachment into the floodplain, between the average wet season water table and that encompassed by the 100-year event, which will adversely affect the existing rights of others, is permitted. Treatment is required for offsite discharge to many categories of waters. Treatment that is part of retention/detention must provide for: 1) the first inch of runoff from the developed project, or the total runoff of 2.5 inches times the percentage of imperviousness, whichever is greater; or 2) dry detention volume must be provided equal to 75% of the above amounts computed for wet detention; or 3) retention volume shall be provided equal to 50% of the above amounts computed for wet detention. Projects having greater than 40% impervious area, and which discharge directly into receiving waters, are required to provide at least one-half inch of dry detention or retention pretreatment as part of the required retention/detention. The major point is that added volumetric loadings are not permitted in most circumstances.

3.1.4 Local Regulations/Comprehensive Plans

In 1985, the Florida legislature approved the Growth Management Act, which guided community development in the state until 2010. However, many communities still conduct planning activities as if the Growth Management Act were still in place. As a result, comprehensive plans are still available in most communities (some may be dated, but the information is still useful).

Comprehensive plans are official public documents that have been adopted by a local government as a policy to guide decisions regarding development in the community. These plans are generally how local leaders communicate how they view community growth over the next 20-30 years. Many communities still update these plans. Broward County and most of the communities within the study area have such plans. While the modeling of future floodway conditions will largely depend on the analytical approaches used (see Section 4.0), projected future land use and land cover will have a direct relationship to future runoff. All plans have a stormwater element.

Local governments in the watershed have local land development regulations. Stormwater issues are addressed via reference to SFWMD standards. The 2016 stormwater utility report indicates the following status for local stormwater utilities created for funding local improvements. That report (2016 FSA Stormwater Utility Report) goes over the utility fee that Dania Beach, Hollywood, and Cooper City rely on for their stormwater utilities and assessments for funding. The Town of Davie relies on its general fund.

The following HUC 030902061205 Davie/Dania Beach subwatershed communities have stormwater or watershed plans:

- Town of Davie (https://www.dropbox.com/home/Frederick%20Bloetscher/davie%20deliverables)
- City of Hollywood (for coastal waterways only - https://www.hollywoodfl.org/DocumentCenter/View/3519/Hollywood-Waterways-Show-EDSA_140224?bidId=)
- Broward County (https://thrivingearthexchange.org/wp-content/uploads/2017/03/Broward-County-Enhanced-LMS-FINAL-November-2012-FINAL.pdf)

As of March 2021, the following communities have no local watershed or stormwater plans that are publicly available:

- City of Dania Beach
- City of Cooper City
- City of Hollywood (City-wide)
- Seminole Tribe of Florida, Hollywood Reservation

The following communities in the subwatershed have a comprehensive plan with associated land development regulations:

- Broward County
- Town of Davie
- City of Dania Beach
- City of Cooper City
- City of Hollywood

As a general statement, the local plans contain the policy framework necessary for environmental resource regulation. All local plans, though, defer to state and federal regulatory agencies for the technical expertise for environmental permitting. Broward County does have separate staff for review of development proposals for environmental impact. The plans are summarized as follows:

3.1.4.1 Broward County

Under Florida Statutes, Chapter 163, each local government is required to prepare a land use plan element for its jurisdiction, which will meet specific local needs; however, this local land use element must be consistent with the Broward County Land Use Plan under the Broward County Charter. To determine consistency, local governments must submit their land use plans, which have been prepared in conformance with the Florida Statute, to the Council for Certification Review. If the Council finds the local plan to be in substantial conformity to the Broward County Land Use Plan, the local land use plan will be certified by the Planning Council and become the land use guide for that jurisdiction with full force and effect of law under the Charter when adopted by the local governmental unit in conformance with the State Act. Unless otherwise noted, municipal plans may always be more restrictive than the County Plan.

The initial Broward County Land Use Plan (BCLUP) was adopted in 1977 when much of the County was undeveloped and unincorporated, and the subsequent BCLUP was instituted in 1989. Low-density, suburban development with a focus on auto-oriented design were the predominant premises of these plans. The 1989 BCLUP was amended piecemeal several times through the years to better reflect current planning strategies and address economic market forces. On April 22, 2014, the Broward County Commission initiated a comprehensive evaluation and update of the BCLUP, as a joint undertaking by the Broward County Planning Council and County Planning staff, in coordination with municipalities and affected and interested stakeholders. The effort was branded “BrowardNext.”

Much of the County is already developed, so the focus was on redevelopment. The goals for redevelopment included the following (https://www.broward.org/BrowardNext/):”

- Review redevelopment plan to ensure they match market trends.
- Examine the vacant land still available and provide incentives through “land use” for redevelopment.
- Consider slivers of surplus land that is available.
- Aging shopping centers are appropriate for redevelopment with mixed-uses and transit-oriented designs.
- Contemplate the impacts of gentrification upon the economy and neighborhood character when preparing redevelopment plans.
- Determine residential densities based upon the efficient use of resources and quality of life factors.
- Leverage of funding should be considered for the implementation of all comprehensive plan elements, such as the replacement of aging infrastructure, creation of affordable housing, and mitigation of sea level rise.
- Redevelopment is a local issue. County should look at intensity of development regionally.
- Look at redevelopment along the FEC Corridor and explore a Transit Oriented TIF (tax increment financing).
- Streamline land uses and have one mixed use designation.
- Leverage Land Use Plan for adaptive reuse.
- Use innovation zones for more flexibility.
- Redevelopment plans should include post-disaster development scenarios. Whether or not to replace damaged infrastructure should be examined in areas subject to repeated damages.
- Assignment of flexibility should be analyzed in terms of market potential.
- The Florida East Coast rail corridor should be seriously analyzed in terms of its redevelopment potential, including the consideration of a transit corridor tax increment financing district.
- Health impacts assessments, place-making, and food systems planning should be incorporated into the planning process.
- Aging shopping centers are well-situated for transit-oriented redevelopment. Mixed-use redevelopment incentives should be offered.

- Redevelopment plans should consider gentrification and generational displacement.
- Plan should provide direction for the establishment of funding mechanisms are needed to replace aging infrastructure and address climate change.
- Incentives are needed to preserve historic structures.
- Densities and intensities allowed by adopted mixed-use categories may not align with changing economic conditions. A stream-lined land use plan amendment process should be developed for these circumstances.
- Impacts associated with redevelopment projects are generally local issues. Broward County's focus should be on regional issues and developments with regional impacts.
- Financial institutions and developers need to collaborate to alleviate financing restrictions on mixed-use redevelopment projects.
- Leadership in Energy and Environmental Design (LEED) principles should be applied on a site-specific basis."

Along with these redevelopment goals, the plan suggested better intergovernmental cooperation to:

- "Create added flexibility.
- Rethink the flexibility unit rules.
- There is a need to update flexibility zone boundaries.
- Flexibility zones are not relevant and should be eliminated.
- Provide municipalities the flexibility to allocated flexibility units how they see fit.
- Use thresholds to allow smaller scale projects to go through the municipality approval process but not the County's.
- Create a range of development density/intensity limits to allow for development activities to respond to market conditions.
- Higher development densities/intensities should be permitted where infrastructure capacity is demonstrated, shifting from a parcel-by-parcel approach.
- Shift to a form-based code and coordinate between the County development review processes and what the municipalities would use in a form-based approach.
- Move the urban infill line to the western edge of the developed area of Broward County.
- Allow staff to approve minor project changes and plat notes so all these types of changes do not need to go through the formal approval process."

The future land use plan is shown previously in Section 2.5 (Figure 32).

The county plan also included specific climate and sea level rise goals and identified areas of priority concern (Figure 46):

- Plan for more than 30 years into the future.
- Allow smaller parcel sizes.
- Provide live-work zoning categories.
- Allow on-site infrastructure.
- Built resilient communities and allocate funding for appropriate infrastructure.
- Fort Lauderdale Innovation Zone should allow two (2) units per acre.
- Zoning should provide infrastructure impact allowances for land uses that provide on-site infrastructure.
- Climate change needs a regional approach and large-scale capital projects should be examined.
- Consider renewable energy criteria when reviewing land use plan amendments.
- Community redevelopment agencies are not represented at the focus area meeting.
- Climate change should be considered in Community Redevelopment Plans due to its potential to have a blighting influence.
- Consider sea level rise which has been proven in court in Miami-Dade County
- Examine planning processes in other states post information on the Broward Next website.
- Build houses that can adapt as sea levels rise. For example, consider floating houses.
- Sea level rise cannot be reversed in the foreseeable future.

Post disaster plans include examining post-disaster redevelopment needs and identifying appropriate areas to replace damaged infrastructure.

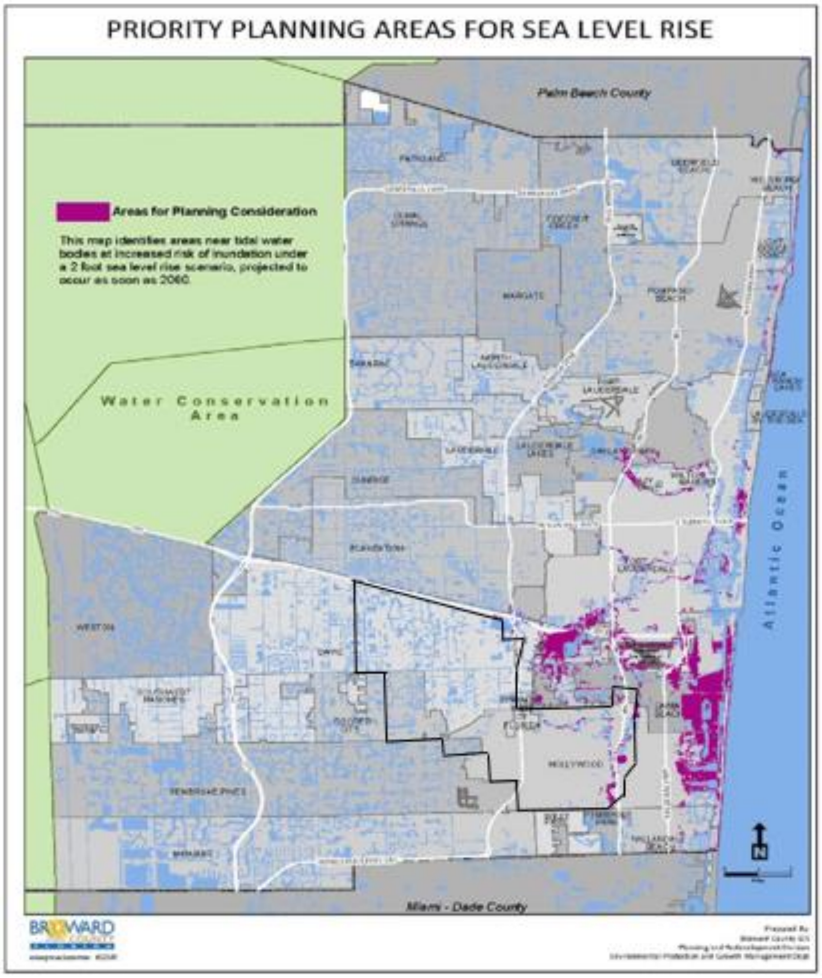

Figure 46. Priority areas for sea level rise (Broward County – BrowardNext plan - https://www.broward.org/Climate/PublishingImages/ppawithaaa_05112016.jpg)

3.1.4.2 Town of Davie

The Town of Davie's plan is available at https://www.davie-fl.gov/DocumentCenter/View/3380/Comprehensive-Plan---Goals-Objectives--Policy. Its land use objectives are:

OBJECTIVE 1: SMART GROWTH & GREEN PLANNING PRINCIPLES
The Town is committed to achieving future growth that is sustainable while carefully maintaining the rural atmosphere that makes Davie unique. This will be done by building capacity within the Town, by conserving energy and natural resources within municipal operations, and by providing sustainability related education outreach and support to the community. Incorporate the following smart growth and green planning

principles into future land use planning, capital improvement decisions, and the development review process.

Policy 1-1 Continue to provide a wide range of housing opportunities for Town residents of all income levels.

Policy 1-2 Create more walkable neighborhoods by requiring developers to incorporate pedestrian friendly features within the design of all development and redevelopment projects within the Town. By way of example, pedestrian-friendly features may include sidewalks, compact site design, interconnected pathways, and other infrastructure and design features that contribute to the comfort, safety, and convenience of pedestrians.

Policy 1-3 Encourage community and stakeholder collaboration on all public and private projects during all phases of the development approval process.

Policy 1-4 Protect existing residential and nonresidential areas from any adverse impacts of future development to the maximum extent practicable.

Policy 1-5 Within Davie foster distinctive communities with a strong sense of place and/or history.

Policy 1-6 Ensure all development review process decisions are fair, predictable, and cost effective.

Policy 1-7 Encourage the mixing of land uses within the infill and redevelopment areas of eastern Davie, particularly projects within the RAC and the Transit Oriented Corridor areas.

Policy 1-8 Continue to protect open space, farmlands, natural vistas, and critical environmental areas.

Policy 1-9 Continue to ensure a wide variety of transportation choices are available to Town residents and visitors through visionary road and transit projects and developer contributions and fees.

Policy 1-10 Direct new development toward existing developed areas consistent with the FLUM and the Land Development Regulations, and work to constantly improve submitted plans for private development.

Policy 1-11 Encourage compact building design and take advantage of any resulting opportunities for the mixing of uses, enhanced landscaping, open space, and community improvements.

Policy 1-12 Encourage the use of sustainable building practices throughout the Town on new building construction and renovations.

Policy 1-13 Direct growth to identified Urban Development areas within Davie in order to discourage urban sprawl, reduce development pressures on rural lands, maximize the use of existing public facilities and centralize commercial, governmental, retail, residential and cultural activities.

Policy 1-14 New public buildings constructed by the Town shall include energy efficient design features and green building standards.

The Town of Davie notes that with respect to the Basis of Review for Surface Water Management Permit Applications, SFWMD standards will be used (design storm will be the 3-day, 25-year event). The County issues these permits. The future land use plan for the Town of Davie is shown in Figure 47.

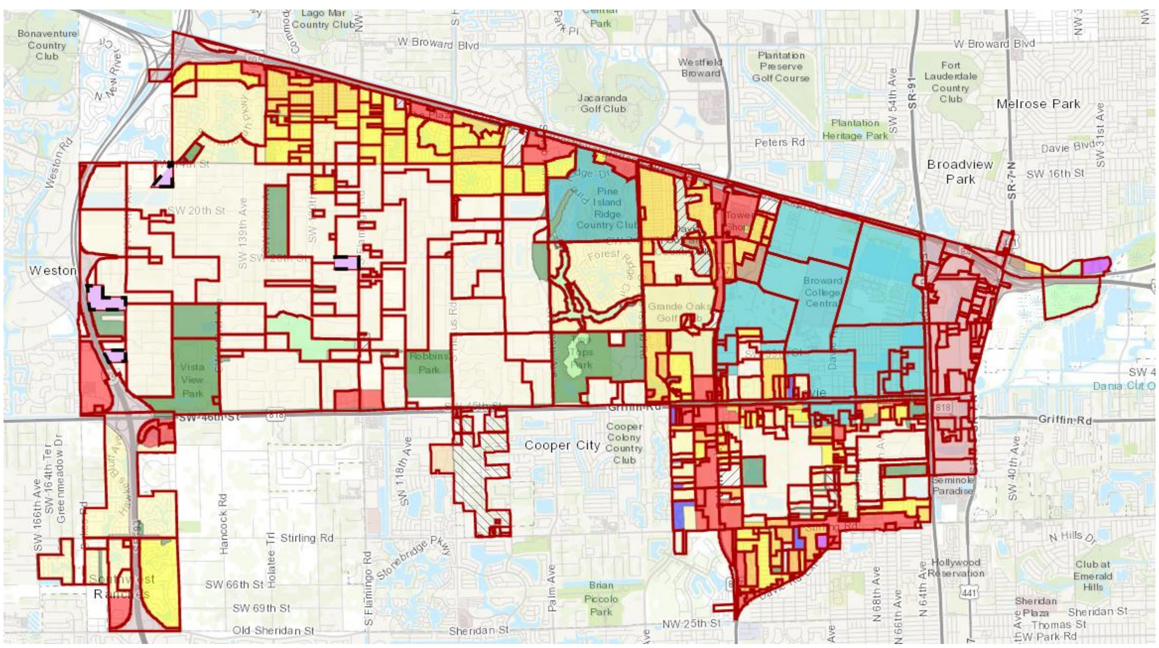

Figure 47. Future land use plan – Town of Davie 2021, (https://daviefl.maps.arcgis.com/apps/Viewer/index.html?appid=3077ff17560b45968ccdb167f31bb37e)

Originally the Town was located only in the eastern basin of the Central Broward Water Control District, which consists of a major network of drainage canals with positive outlets into the South Florida Water Management District C-11 canal. The canal network is a gravity feed system of good deep and wide channels. A western section was connected at SW 100 Avenue. The west basin is controlled by a SFWMD pump station (S-9) located at approximately US-27 and Griffin Road. The eastern basin is controlled by a pump station (S-13) on the C-11 canal. The SW 100 Avenue divide is an equalizer known as S-13A. This structure can be opened to control local storms or equalize west to east only.

The Town of Davie's stormwater master plan was developed by FAU. The result of this plan subdivided the Town into 10 subsections. Figure 48 and Figure 49 show a typical output based on different storm events and different sea level rise scenarios. The plan estimated approximately $300 million in current dollars by 2100 to address flood risks (

Table 8). The costs accelerate in future years. Note that at about 2.5 ft of sea level rise, the limiting factor is the pumping station weir on the C-11 canal at US 441.

Table 8. Cost estimate of current and future needs in millions of dollars (Bloetscher, 2018)

Scenario	**Cost in $ millions**
0 ft SLR	
Min Need	$ 38
Max Need	$ 148
1 ft SLR	
Min Need	$ 78
Max Need	$ 159
2 ft SLR	
Min Need	$ 123
Max Need	$ 255
3 ft SLR	
Min Need	$ 178
Max Need	$ 335

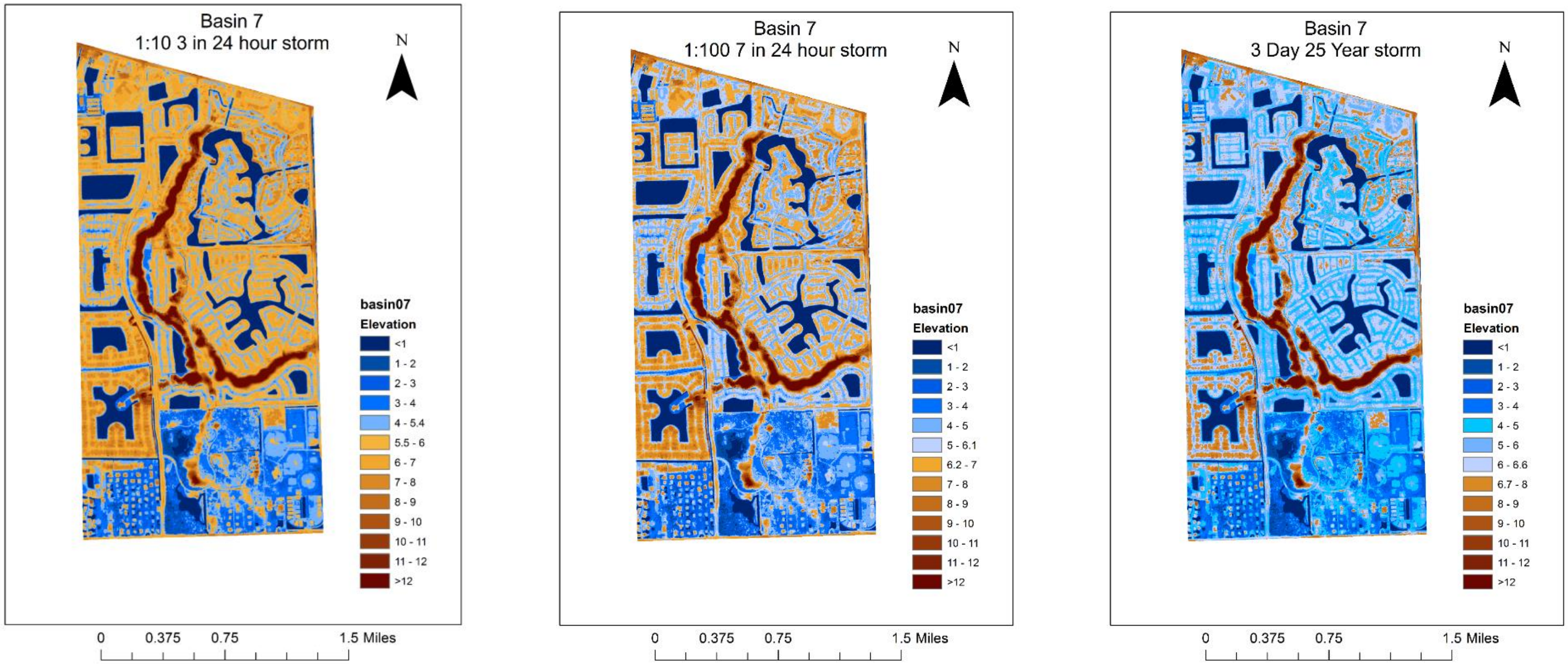

Figure 48. Area 7 under the 1 ft sea level rise condition, given the 1-day/10-year (left), 1-day/100-year (middle), and 3-day/25-year (right) storm events

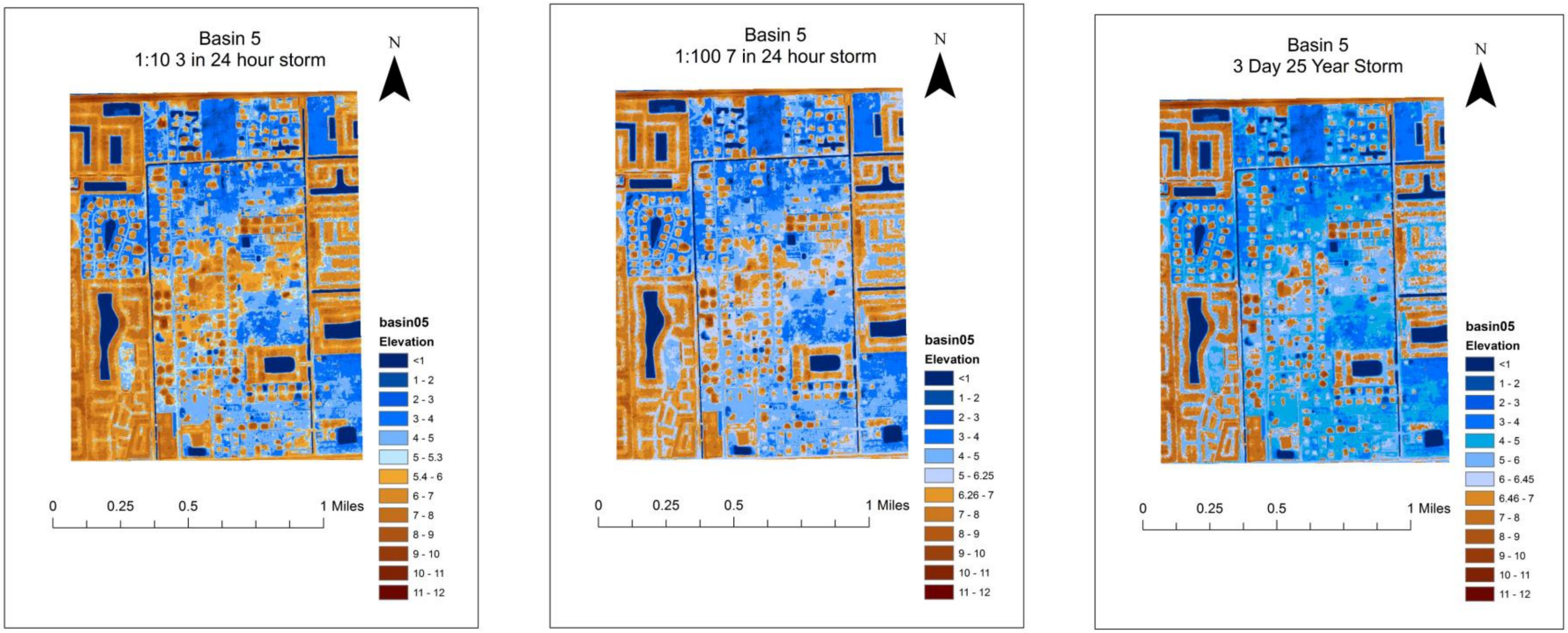

Figure 49. Area 5 under the 2 ft sea level rise condition, given the 1-day/10-year (left), 1-day/100-year (middle), and 3-day/25-year (right) storm events

In June 2017, the Town reported an 11-inch, 24-hour storm event concentrated in the northwestern area. Figure 50 shows the areas that reported flooding. Note that Shenandoah is a private development with private stormwater management, and they must maintain this system, not the Town. The roads in their neighborhood flooded during the June 2017 rain event. Some roads had over a foot of water. This is likely due to two issues – the rainfall overwhelming the stormwater system and/or maintenance issue that prevented water draining to the on-site lakes. It should be noted that the modeling indicated the streets would be flooded with the 3-day, 25-year event, which is only 9 inches of rain in 3 days, not 11 inches in only one day. Hence the capacity of the system was exceeded. The modeling also indicated challenges south of Shenandoah in SW 145 Ave, SW 20 Ave, and SW 21 Ave. In fact, the mapping indicates much of the area will experience some degree of flooding, which it did. This was a dry season event – in the wet season, the groundwater is higher, soil storage is lower, and chances of flooding would likely be greater.

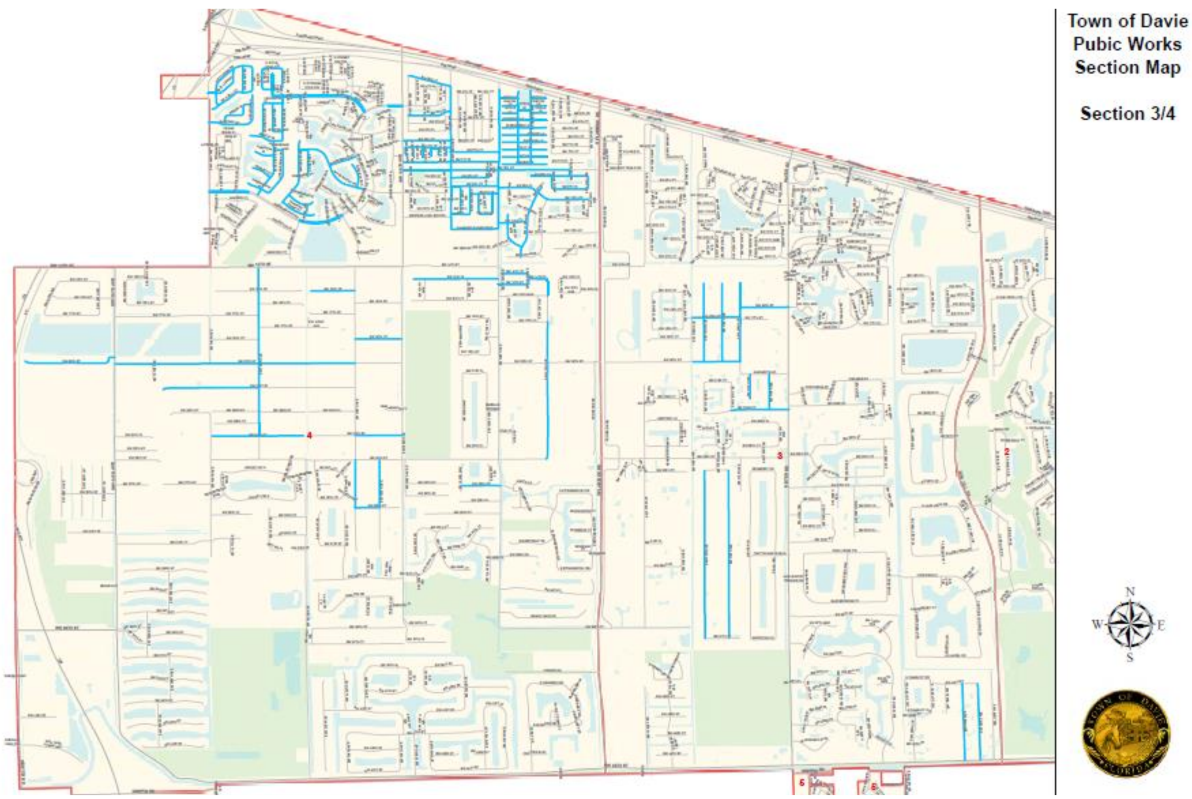

Figure 50. Flooded areas after the 11-inch, 24-hour June 2017 rainfall event (Town files, provided to FAU)

3.1.4.3 Dania Beach

The Comprehensive Plan for Dania Beach (https://daniabeachfl.gov/1273/Comprehensive-Plan) notes that the City of Dania Beach has areas that are flood prone. Any new development or redevelopment within these flood prone areas on the FEMA flood map must conform to the finished floor elevation requirements plus one foot as shown on the flood insurance rate maps. The plan adopts a series of land redevelopment policies:

> Objective I. Land development regulations shall be maintained that promote orderly growth, development, and placement of land uses, which will encourage a mix of residential types and provide good quality of life for the residents of the City of Dania Beach.
>
>> Policy 1.1 Provide for a mix of residential communities that will promote a diverse population and a healthy environment.
>>
>> Policy 1.2 Commercialized activities will be provided to serve the residents of the community.
>>
>> Policy 1.3 Clean, light, industrial development will be encouraged to support the tax base for the community and to provide a wide range of employment for residents of the community.
>>
>> Policy 1.4 Future industrial land uses shall be located with access to major transportation facilities including highways, airports, railroads, and seaports. (B.C.P. #03.01.02)
>>
>> Policy 1.5 In order to ensure sufficient amounts of industrial land are available to meet Dania Beach's future needs, those lands enjoying a future land use industrial designation on the Future Dania Beach Land Use Plan Map shall not be utilized for nonindustrial purposes, except where in conformance with the Industrial Permitted Use subsection of the Plan Implementation Requirements section of the Dania Beach Land Use Plan. (B.C.P. #03.01.04).
>>
>> Policy 1.6 Significant industrial land is currently available. The City will encourage light/marine oriented industrial uses as an alternative to traditional industrial uses.
>>
>>> Policy 1.61 Heavy Industrial Uses. The City shall not encourage additional Heavy Industrial Development. After January 1, 1999, Heavy Industrial Uses will be allowed only when they offer significant gains and opportunities to the City (in terms of employment opportunity, increased tax base, an enhancement to the City's growing reputation as a significant commerce location for the Marine Industry, or the provision of services and goods deemed necessary and desirable for Dania Beach's citizenry as distinguished from the citizens of Broward County or Southeast Florida), and when industrial facilities are planned, designed, and built to minimize adverse

secondary impacts of noise, outdoor activities, environmental pollution, vibration, dust, odors, traffic generation, or other physical activity. In evaluating heavy Industrial Use development, the City may require more than the minimum setback, landscaping, open space, and pervious area requirements, and less than the otherwise maximum allowable building height and lot coverage requirements to minimize or offset negative secondary impacts.

Policy 1.62 Marine Industrial Uses. The City shall encourage additional Marine Industrial development. In doing so, Marine Industrial development shall be planned, designed, and built to be as fully enclosed in buildings as is reasonably possible and to minimize adverse secondary impacts of noise, outdoor activities, environmental pollution, vibration, dust, odors, is generation, or other physical activity. In evaluating Marine Industrial development, the City may require more than the minimum setback, landscaping, open space, and pervious area requirements, and less than the otherwise maximum allowable building height and lot coverage requirements to minimize or offset negative secondary impacts.

Policy 1.63 Landfills and resource recovery facilities shall be planned to minimize impacts on adjacent existing or planned land uses. (B.C.P. #08.01.15)

Policy 1.7 Minimum floor elevation standards for building sites promulgated and administered by the Federal Emergency Management Administration shall be applied citywide for new construction. (B.C.P. #08.01.18)

Policy 1.8 Areas surrounding existing and proposed airports/heliports shall be planned to promote compatible land uses consistent with the affected elements of the Dania Beach Comprehensive Plan. (B.C.P. 15.03.01)

Policy 1.9 Within areas surrounding existing or committed airports/heliports, Dania Beach shall not issue Future Land Use Element City of Dania Beach Page 46 development orders for land uses or structures that are incompatible with airport/heliport uses, pursuant to the Development Review Requirements subsection of the Plan Implementation Requirements section of the Dania Beach Land Use Plan. (B.C.P. #15.03.02)

Policy 1.10 The recommendations of adopted Part 150 Study Technical Reports shall be taken under consideration during land use decisions affecting airports/heliports and their adjacent areas. (B.C.P. #15.03.03)

Policy 1.11 Dania Beach shall protect from obstruction Federal Aviation Administration approved and locally adopted aircraft air corridors. (B.C.P. #15.03.05)

Policy 1.12 The City shall establish development review procedures to ensure that Crime Prevention Through Environmental Design (CPTED) principles are addressed during the review process. (B.C.P. #14.04.00)

Policy 1.13 The City's land development regulations shall enable a variety of housing types to accommodate the housing for all income levels in the City of Dania Beach. The City shall encourage the inclusion of low and moderate housing opportunities in large-scale residential developments. (B.C.P. #1.07.03)

Objective VII Land development regulations will be maintained which will ensure the future residential densities for land uses within the coastal hazard zone will be limited by the hurricane evacuation standards identified within the Broward County Hurricane Evacuation Plan.

Policy 7.1 Land use plan amendments to residential categories east of the Intracoastal Waterway will be limited by the hurricane evacuation standards identified within the Broward County Hurricane Evacuation Plan.

Objective VIII New growth and development will only be permitted where services are available and meet the level of service standards of the Comprehensive Plan thereby eliminating urban sprawl.

Policy 8.1 Adequate drainage and stormwater management shall be provided for all development.

Objective XI Coordinate future land uses with topography and soil conditions to protect Dania Beach's water supply and minimize flooding problems. (B.C.O. #09.10.00)

Policy 11.1 Regulate development on flood prone soils, as defined by the United States Soil Conservation Service, consistent with the criteria and mapping of the Federal Emergency Management Administration and the policies included under Objectives XIX and XX. (B.C.P. #09.10.02)

Objective XIX Protect identified floodplains and areas subject to seasonal or periodic flooding. (B.C.O. #09.07.00)

Policy 19.1 Dania Beach land development codes shall contain floodplain protection provisions consistent with the criteria and mapping of the Federal Emergency Management Administration. (B.C.P. #09.07.01)

Policy 19.2 Dania Beach shall require redevelopment within identified floodplains to address existing flooding problems. (B.C.P. # 09.07.01)

Policy 19.3 Through provisions in Dania Beach development regulations, public roads and parking lots shall be designed consistent with the criteria of the South Florida Water Management District. (B.C.P. # 09.07.03)

Policy 19.4 Dania Beach Land Development regulations shall include the requirement that the minimum floor elevations standards for building sites promulgated and administered by the Federal Emergency Management Administration shall apply to all new construction. (B.C.P. #8.01.18)

Objective XX Estimate flooding problems while preserving groundwater quality through planned growth, the provision of drainage and stormwater management systems and the adoption of appropriate development codes and regulations. (B.C.P. # 09.09.00)

Policy 20.1 New development shall provide water storage capacity equal to that which existed under predevelopment conditions consistent with the water management regulations and plans of the South Florida Water Management District, Broward County Department of Planning and Environmental Protection, Broward County and independent drainage districts. (B.C. P. # 09.09.01)

Figure 51 is the future land use map contemplated by the comprehensive plan for Dania Beach.

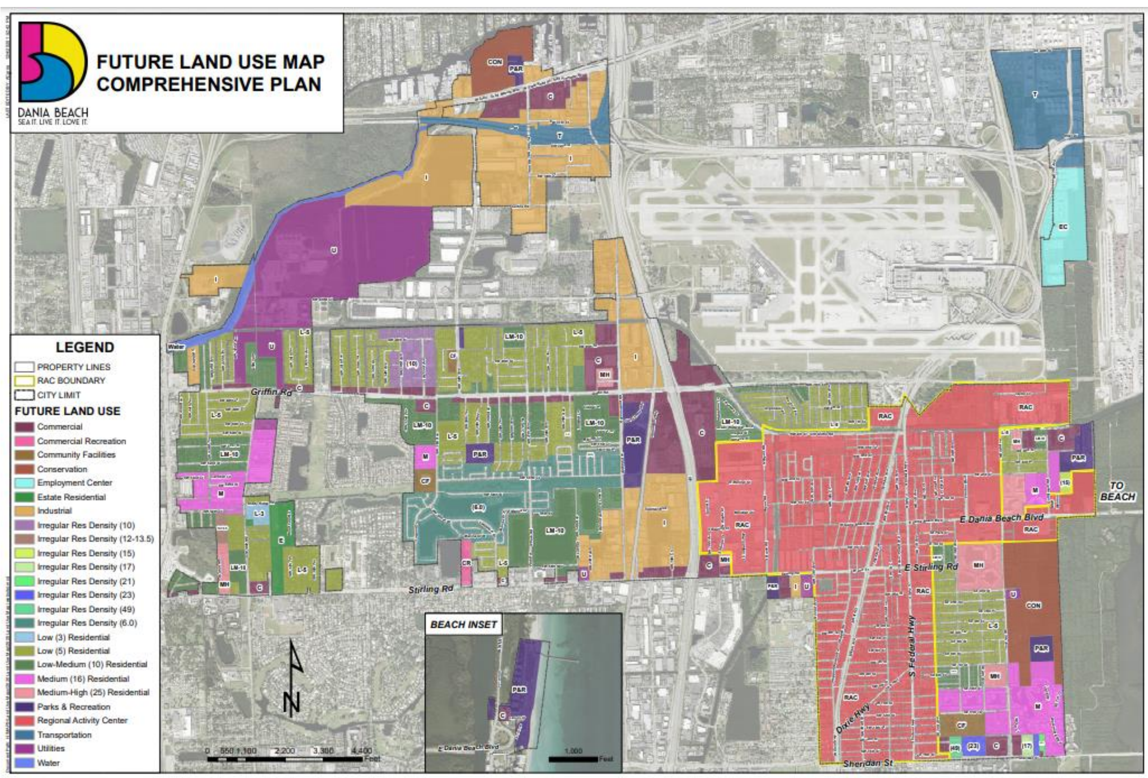

Figure 51. Dania Beach future land use map accessed 03/10/2021)
(https://daniabeachfl.gov/DocumentCenter/View/563/Comprehensive-Landuse-Map?bidId=)

The drainage system within the City of Dania Beach is composed of canals and lakes that discharge to the Dania Cut-off Canal and the C-10 Canal. These canals ultimately discharge into the Atlantic Ocean. The drainage system is managed by SFWMD, the Broward County Water Resources Management Division, and the City Engineer. The drainage system has adequately protected the existing community. The City is wholly downstream of the pump station (S-13) on the C-11 canal. This structure can be opened to control local storms or equalize west to east only. Pumping to reduce flooding in Dania Beach and Cooper City can inundate Dania Beach based on modeling performed by FAU in 2018.

The primary drainage system of the City of Dania Beach, as well as Broward County, is controlled by the canal and pump system of the SFWMD. Drainage primarily consists of storm sewers, exfiltration trench systems, and onsite retention/detention systems. Retention/detention systems consists of wet, which retains or detains storm water in lakes and dry, which retains or detains storm water in areas that are normally dry. Both of these methods provide for stormwater storage and aquifer recharge; however, dry retention systems provide the added benefit of improving water quality due to the filtration action of the soils.

The southeast area of the City located east of U.S. 1 and south of Dania Beach Boulevard perhaps has the most severe drainage problems. The area is quite low with typical elevations around +3.0 ft NGVD, and the soils have poor percolation. The existing system consists of storm sewers and swale drainage being collected and discharged into a three-acre lake. When the stage of the lake reaches elevation +4.0 ft, the 151,000 gallon per minute pump is started that discharges through a series of ditches to the Dania Cut Off Canal. The City has installed nearly $2,000,000 worth of drainage improvements to the southeastern portion of the City and is planning another $14 million in the next 3 years. This includes upgrading the pumping systems.

The review process of new developments ensures that SFWMD, Broward County and City drainage and recharge criteria are met. This review is conducted based on the following criteria:

- Floor elevation: 1-day, 100-year storm event (see Figure 44)
- Public road elevation: 1-day, 10-year storm event (see Figure 45).

The following level of service standards are utilized by the City:

<u>Road Protection</u>

- Residential and primary streets crown elevation meet the minimum elevations as published on the Broward County 10-year Flood Criteria Map (based on Figure 45).

Buildings

- The lowest floor elevation shall not be lower than the elevation published on the Broward County 100-year flood elevation map (based on Figure 44) or 18 inches above the adjacent crown of road for residential and 6 inches above the adjacent crown of road for commercial/industrial.

Storm Sewers

- Shall be designed using the Florida Department of Transportation Zone 10 rainfall curves.

Flood Plain Routing

- Modified SCS routing method as established by the SFWMD "Basis of Review."

Best Management Practice

- Efforts shall be utilized to use best management practice to reduce pollutants entering the groundwater.

The City of Dania Beach notes that with respect to the Basis of Review for surface water management permit applications, SFWMD standards will be used. The design storm will be the 3-day, 25-year event. The County issues these permits. Any new development will meet the criteria of SFWMD, Broward County, and the City as far as attaining the specified level of service.

3.1.4.4 Cooper City

Cooper City's land development code was updated in 2009 with the following objectives:

- Regulate the subdivision of land;
- Regulate the use of land and water consistent with the Comprehensive Plan (2015) and ensure the compatibility of adjacent land uses and provide for open space;
- Protect environmentally sensitive lands designated on the Future Land Use Map (Figure 52) and in the Conservation Element;
- Regulate areas subject to seasonal and periodic flooding and provide for drainage and stormwater management;
- Protect potable water wellfields and aquifer recharge areas (Not Brian Piccolo Park that contains the County's regional wellfield);
- Regulate signage;
- Ensure safe and convenient on-site traffic flow access restrictions and vehicle parking needs consistent with the Broward County and Cooper City Comprehensive Plans;

- Provide that development orders and permits shall not be issued that result in a reduction of the level of services for the affected public facilities below the level of service standards established in the 2015 Comprehensive Plan and shall be consistent with Broward County's Land Use Plan Implementation Requirements, Development Review Requirements Subsection (BCP 8.01.02);
- Platting requirements of land for all new principal buildings shall be in accordance with Broward County's Land Use Plan implementation requirements (BCP 8.02.01);
- Monitor and enforce the provisions consistent with the Broward County Land Use Plan implementation requirements (BCO 1.04.00);
- Protect, whenever possible, existing and planned residential areas from disruptive land uses and nuisances (BCP 1.04.04);
- Permit planned unit developments and other innovative development techniques, that help facilitate the establishment and maintenance of landscaped open space and residential buffers (BCP 1.06.01);
- Promote developments that are well planned, orderly, attractive, and well maintained and contribute to the health, safety, and welfare of the residents (BCP 1.04.00, BCP 1.06.00);
- Promote development that is consistent with the City of Cooper City Capital Improvements Elements and the Goals, Objectives, and Policies Cooper City Land Use Plans (BCO 1.04.00) (https://www.coopercityfl.org/vertical/sites/%7B6B555694-E6ED-4811-95F9-68AA3BD0A2FF%7D/uploads/Chapter_8_-_Capital_Improvements(1).pdf).

Cooper City's future land use plan is shown in Figure 52.

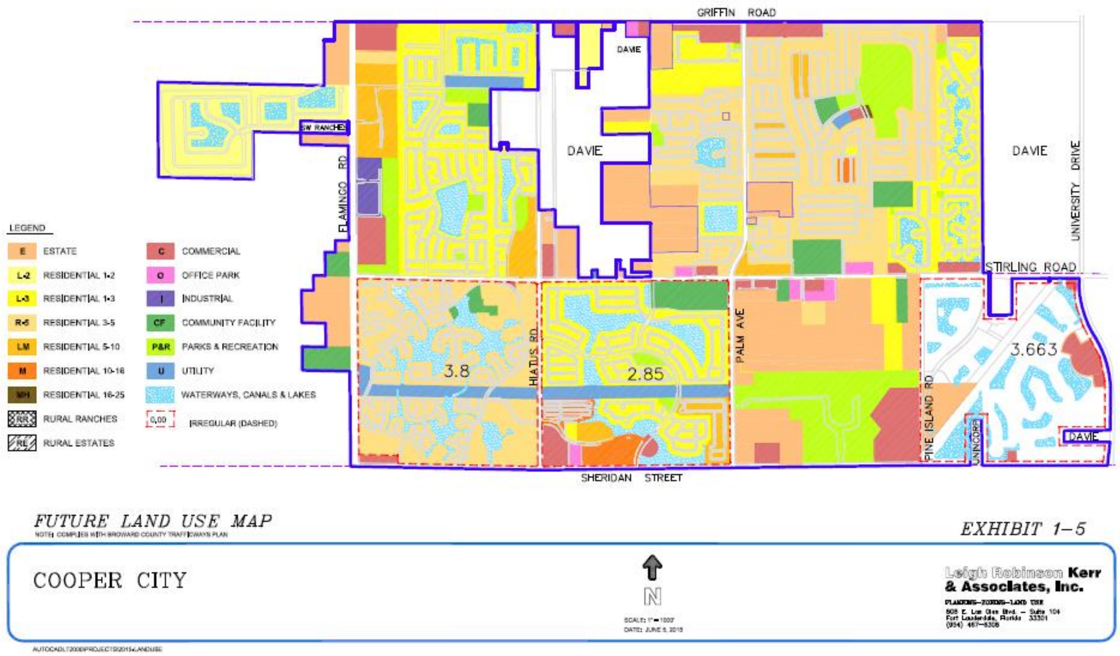

Figure 52. Cooper City future land use map (https://www.coopercityfl.org/vertical/sites/%7B6B555694-E6ED-4811-95F9-68AA3BD0A2FF%7D/uploads/FUTURE_LAND_USE_MAP_PDF_(06_05_15)(1).pdf)

The City's drainage is currently handled through a system of swales, ditches, catch basins, and storm sewers. The system drains into secondary canals, which overflow rainwater directly into the C-11 canal that runs along its northern municipal boundary. The C-11 primary canal is under the jurisdiction of the SFWMD. The Central Broward Water Control District (CBWCD) regulates, under State Law, drainage permits and construction standards for the prevention of flooding and the maintenance of secondary and tertiary drainage facilities. The current system meets the City's drainage requirements and adopted level of service [5.005(2)(a) 4]. The stormwater system is split into two zones, so water can flow west if needed. The subwatershed is controlled by a pump station (S-13) on the C-11 canal to the equalizer structure S-13A. This structure can be opened to control local storms or equalize west to east only.

The 2015 comprehensive plan has a drainage element (Chapter 4, section 39) that notes two basic factors involved in establishing a successful stormwater management program: 1) establishing and applying uniform design standards and procedures; and 2) ensuring adequate maintenance of system components once they are constructed. The design standard is the design storm event that specifies the intensity (rate of rainfall) and duration of the rainfall event per Broward County regulations is to be used in the design of facilities. Typically this is the 3-day, 25-year storm event for land development. Note the County has delegation from SFWMD to permit stormwater facilities under 50 acres.

Cooper City requires compliance with the Water Quality Act of 1987, and Chapter 62-40 Florida Administrative Code contains the State's water policies related to water quality, surface water protection and management and minimum flows and levels There have been only two instances of repetitive losses due to flooding in Cooper City. The City participates with FEMA and the Insurance Services Office (ISO) in the CRS program to reduce the threat of flood damage. The drainage system requires constant maintenance of debris and silt management and aquatic weed control. Implementation of the stormwater rule is achieved through a permitting process. FDEP has delegated permitting responsibility to the SFWMD with jurisdiction over the Cooper City Area. The City of Cooper City has delegated its stormwater management to the CDWCD.

Cooper City has a stormwater utility like Dania Beach. Their code of ordinance Section 19-159 states that there shall be established a stormwater management utility fund (the "fund") for the deposit of all fees collected pursuant to this article. The fund shall be used exclusively to pay for costs associated with the stormwater management system, including but not limited to: (a) Operation and maintenance of stormwater management facilities under the jurisdiction of the city; (b) Costs for the expansion of stormwater management facilities under the jurisdiction of the city; (c) Administrative costs related to the management of the stormwater management system; (d) Management services such as permit review and planning and development review related to the stormwater management system; and (e) Debt service financing of capital improvements related to the stormwater management system. (Ord. No. 04-10-01, 10-12-04).

3.1.4.5 City of Hollywood

The City of Hollywood created a comprehensive master planning document in 2001 and has updated it periodically. The 2008 version is found at:

https://www.hollywoodfl.org/DocumentCenter/View/93/comprehensiveplan?bidId=

It characterized the City of Hollywood as a mature built-out city. Over 95% of the land in the City is developed, with the remaining 5% consisting mainly of small infill lots. With a limited amount of vacant land and an aging housing stock and infrastructure system, Hollywood is faced with the challenge of finding ways to stimulate new development.

The City-Wide Master Plan envisions the proactive role of the public sector in creating conditions necessary to turn the City-Wide Master Plan recommendations into reality. To ensure the common good, a number of general principles were utilized in the development of plan. These are:

- Emphasizing the qualities of the City of Hollywood's historic urban plan and built environment.
- Maintaining and improving the natural environment.
- Preserving and enhancing single-family residential areas.
- Improving and promoting mobility, both within the City of Hollywood and the surrounding region.
- Providing for continued growth potential directed to specific and adequate areas.
- Identifying areas where to channel public investments and actions to accomplish the City's sustainability and development goals.

City wide goals of the plan included:

- Policy CW.4: Provide information on the City's website regarding neighborhoods; code compliance, associations, Capital Improvement Plan, citizen participation, and Neighborhood Master Plans.
- Policy CW.5: In conformance with the City of Hollywood Comprehensive Plan, preserve and maintain historically significant structures located within the City.
- Policy CW.6: Define, options and develop recommendations for the land use/zoning issues on major transportation corridors, i.e.: Dixie Highway, US 1, Stirling Road, Griffin Road, Pembroke Road, US 441/SR 7 and Hollywood Boulevard.
- Policy CW.7: Revise procedures allowing code enforcement officers to react quickly and efficiently to issues.
- Policy CW.8: Address the cumulative effect of years of nonconforming and grandfathered properties through future land use map amendments and official zoning map amendments.
- Policy CW.9: Eliminate significant inconsistencies between zoning districts and land use designations City-wide.
- Policy CW.10: Coordinate design and expansion of infrastructure, including telecommunication, electric, local cable, natural gas, drainage, water, and sewer. Replace existing utility infrastructure concurrent with road construction to save on costs.
- Policy CW.11: Revise zoning code to incorporate new overlay district recommendations consistent with adjacent neighborhoods.
- Policy CW.12: Continue to update neighborhood plans and provide funding mechanisms for implementation.
- Policy CW.13: Ensure consistency between neighborhood plans and the City-Wide Master Plan's recommendations.
- Policy CW.14: Implement development regulations that would require increased pedestrian access between neighborhoods and commercial uses.

- Policy CW.15: Place a priority on protecting, preserving, and enhancing residential neighborhoods. Geographic, Zoning and Land Use Geographic, Zoning and Land Use
- Policy CW.16: Improve visual qualities when undertaking new construction and building rehabilitation and place utility lines underground, when feasible.
- Policy CW.17: Encourage the creation of mixed-use and/or special-use districts to address areas of special concern.
- Policy CW.18: Work with adjacent communities and the South Florida Regional Planning Council (SFRPC) on corridor studies and roadway plans.
- Policy CW.19: Protect residential areas from encroaching non-residential uses into residential areas.
- Policy CW.20: Review zoning district standards as they relate to buffering and uses between single-family and more intense uses along the trafficway corridors, to create adequate separations and to allow a deepening, where possible, of the commercial or industrial zone.
- Policy CW.21 Create and expand where appropriate commercial and industrial zones to increase tax dollars.

Other goals specifically addressing flood protection include:

- Policy CW.35: Identify streets and roads with flooding as a result of a significant rainfall and prioritize the method and time frame for addressing flooding problems.
- Policy CW.38: Investigate programs to restore and maintain swales.
- Policy CW.39: Identify road improvement projects that can incorporate local drainage into construction plans.
- Policy CW.40: Explore working with appropriate companies, as well as, state and federal agencies to determine the feasibility of dredging water bodies in the City of Hollywood (i.e., Northlake, C-10 and others) while minimizing environmental impacts to the immediate and surrounding areas.
- Policy CW.131: Identify areas that frequently flood and determine preventative methods.
- Policy CW.132: Determine sources of funding to eliminate flooding or ensure timely drainage of flood areas.

The City's land development code includes language on flood protection as follows:

FLOOD RESISTANT DEVELOPMENT

§ 154.50 BUILDINGS AND STRUCTURES.

(A) Design and construction of buildings, structures and facilities exempt from the Florida Building Code. Pursuant to § 154.04(B), buildings, structures, and facilities that are exempt from the Florida Building Code, including substantial improvement or repair of substantial damage of such buildings, structures, and facilities, shall be designed and constructed in accordance with the flood load and flood resistant construction requirements of ASCE 24. Structures exempt from the Florida Building Code that are not walled and roofed buildings shall comply with the requirements of § 154.56.

(B) Buildings and structures seaward of the coastal construction control line. If extending, in whole or in part, seaward of the coastal construction control line and also located, in whole or in part, in a flood hazard area:

(1) Buildings and structures shall be designed and constructed to comply with the more restrictive applicable requirements of the Florida Building Code, Building Section 3109 and Section 1612 or Florida Building Code, Residential Section R322.

(2) Minor structures and non-habitable major structures as defined in F.S. § 161.54, shall be designed and constructed to comply with the intent and applicable provisions of this chapter and ASCE 24.

(C) Specific methods of construction and requirements. Pursuant to Broward County Administrative Provisions for the Florida Building Code, the following specific methods of construction and requirements apply:

(1) Minimum building elevations.

(a) Residential buildings. New construction and substantial improvement of residential buildings shall have the lowest floor, including basement, elevated to or above the elevation required in the Florida Building Code, Residential or Florida Building Code, Building, as applicable, or at least 18 inches above the highest point of the crown of all streets adjacent to the plot upon which such buildings are located or in accordance with a system or method of design admitting of rational analysis in accordance with well-established principles of mechanics and sound engineering practices as determined by the Director, Public Utilities.

(b) Nonresidential buildings. New construction and substantial improvement of nonresidential buildings shall have the lowest floor, including basement, elevated or dry floodproofed to or above the elevation required in the Florida Building Code, Building or at least six inches above the highest point of the crown of all streets adjacent to the plot upon which such buildings are located or in accordance with a system or method of design admitting of rational analysis in accordance with well-established principles of mechanics and sound engineering practices as determined by the Director, Public Utilities.

(2) Minimum lot elevation - finished grade. The minimum lot elevation after finished grading shall not be less than the crown of the adjacent street or top of sidewalk, whichever is higher. Lots shall be provided with drainage facilities as required by the Florida Building Code, to avoid drainage onto adjoining properties. The finished grade at the perimeter of residential buildings shall be a minimum of six inches below the minimum building elevation as specified in this section.

(3) Limitations on enclosed areas below elevated buildings. For buildings in special flood hazard areas, the following limitations apply to enclosed areas below elevated buildings:

(a) Access shall be the minimum necessary to allow for only parking of vehicles (garage door), limited storage of maintenance equipment in connection with the premises (standard exterior door), or entry to the living area (stairway or elevator).

(b) The interior portion shall not be temperature controlled, partitioned, or finished into separate rooms.

(4) Cumulative substantial improvement. In the Florida Building Code, Building and the Florida Building Code, Existing Building, definitions for the term "Substantial Improvement" shall be as follows: Any combination of repair, reconstruction, rehabilitation, addition or improvement of a building or structure taking place during a five-year period, the cumulative cost of which equals or exceeds 50% of the market value of the structure before the improvement or repair is started. For each building or structure, the five-year period begins on the date of the first improvement or repair of that building or structure. If the structure has sustained substantial damage, any repairs are considered substantial improvement regardless of the actual repair work performed. The term does not, however, include any project for improvement of a building required to correct existing health, sanitary or safety code violations identified by the building official and that are the minimum necessary to assure safe living conditions.

(Ord. O-2014-13, passed 7-16-14; Am. Ord. O-2020-04, passed 2-19-20)

§ 154.51 SUBDIVISIONS.

(A) Minimum requirements. Subdivision proposals, including proposals for manufactured home parks and subdivisions, shall be reviewed to determine that:

(1) Such proposals are consistent with the need to minimize flood damage and will be reasonably safe from flooding;

(2) All public utilities and facilities such as sewer, gas, electric, communications, and water systems are located and constructed to minimize or eliminate flood damage; and

(3) Adequate drainage is provided to reduce exposure to flood hazards; in Zones AH and AO, adequate drainage paths shall be provided to guide floodwaters around and away from proposed structures.

(B) Subdivision plats. Where any portion of proposed subdivisions, including manufactured home parks and subdivisions, lies within a flood hazard area, the following shall be required:

(1) Delineation of flood hazard areas, flood zones, and design flood elevations, as appropriate, shall be shown on preliminary plats; and

(2) Compliance with the site improvement and utilities requirements of § 154.52.

(Ord. O-2014-13, passed 7-16-14)

§ 154.52 SITE IMPROVEMENTS, UTILITIES AND LIMITATIONS.

(A) Minimum requirements. All proposed new development shall be reviewed to determine that:

(1) Such proposals are consistent with the need to minimize flood damage and will be reasonably safe from flooding;

(2) All public utilities and facilities such as sewer, gas, electric, communications, and water systems are located and constructed to minimize or eliminate flood damage; and

(3) Adequate drainage is provided to reduce exposure to flood hazards; in Zones AH and AO, adequate drainage paths shall be provided to guide floodwaters around and away from proposed structures.

(B) Sanitary sewage facilities. All new and replacement sanitary sewage facilities, private sewage treatment plants (including all pumping stations and collector systems), and on-site waste disposal systems shall be designed in accordance with the standards for onsite sewage treatment and disposal systems in Chapter 64E-6, F.A.C. and ASCE 24 Chapter 7 to minimize or eliminate infiltration of floodwaters into the facilities and discharge from the facilities into flood waters, and impairment of the facilities and systems.

(C) Water supply facilities. All new and replacement water supply facilities shall be designed in accordance with the water well construction standards in Chapter

62-532.500, F.A.C. and ASCE 24 Chapter 7 to minimize or eliminate infiltration of floodwaters into the systems.

(D) Limitations on placement of fill. Subject to the limitations of this chapter, fill shall be designed to be stable under conditions of flooding including rapid rise and rapid drawdown of floodwaters, prolonged inundation, and protection against flood-related erosion and scour. In addition to these requirements, if intended to support buildings and structures (Zone A only), fill shall comply with the requirements of the Florida Building Code.

(E) Limitations on sites in coastal high hazard areas (Zone V). In coastal high hazard areas, alteration of sand dunes and mangrove stands shall be permitted only if such alteration is approved by the Florida Department of Environmental Protection and only if the engineering analysis required by § 154.05(C)(2) demonstrates that the proposed alteration will not increase the potential for flood damage. Construction or restoration of dunes under or around elevated buildings and structures shall comply with § 154.56(E)(3).

(Ord. O-2014-13, passed 7-16-14)

§ 154.56 OTHER DEVELOPMENT.

(A) General requirements for other development. All development, including man-made changes to improved or unimproved real estate for which specific provisions are not specified in this chapter or the Florida Building Code, shall:

(1) Be located and constructed to minimize flood damage;

(2) Be anchored to prevent flotation, collapse or lateral movement resulting from hydrostatic loads, including the effects of buoyancy, during conditions of the design flood;

(3) Be constructed of flood damage-resistant materials; and

(4) Have mechanical, plumbing, and electrical systems above the design flood elevation or meet the requirements of ASCE 24, except that minimum electric service required to address life safety and electric code requirements is permitted below the design flood elevation provided it conforms to the provisions of the electrical part of building code for wet locations.

(B) Concrete slabs used as parking pads, enclosure floors, landings, decks, walkways, patios, and similar nonstructural uses in coastal high hazard areas (Zone V). In coastal high hazard areas, concrete slabs used as parking pads, enclosure floors, landings, decks, walkways, patios and similar nonstructural uses are permitted beneath or adjacent to buildings and structures provided the concrete slabs are designed and constructed to be:

(1) Structurally independent of the foundation system of the building or structure;

(2) Frangible and not reinforced, so as to minimize debris during flooding that is capable of causing significant damage to any structure; and

(3) Have a maximum slab thickness of not more than four inches.

(C) Decks and patios in coastal high hazard areas (Zone V). In addition to the requirements of the Florida Building Code, in coastal high hazard areas decks and patios shall be located, designed, and constructed in compliance with the following:

(1) A deck that is structurally attached to a building or structure shall have the bottom of the lowest horizontal structural member at or above the design flood elevation and any supporting members that extend below the design flood elevation shall comply with the foundation requirements that apply to the building or structure, which shall be designed to accommodate any increased loads resulting from the attached deck.

(2) A deck or patio that is located below the design flood elevation shall be structurally independent from buildings or structures and their foundation systems, and shall be designed and constructed either to remain intact and in place during design flood conditions or to break apart into small pieces to minimize debris during flooding that is capable of causing structural damage to the building or structure or to adjacent buildings and structures.

(3) A deck or patio that has a vertical thickness of more than 12 inches or that is constructed with more than the minimum amount of fill necessary for site drainage shall not be approved unless an analysis prepared by a qualified registered design professional demonstrates no harmful diversion of floodwaters or wave runup and wave reflection that would increase damage to the building or structure or to adjacent buildings and structures.

(4) A deck or patio that has a vertical thickness of 12 inches or less and that is at natural grade or on nonstructural fill material that is similar to and compatible with local soils and is the minimum amount necessary for site drainage may be approved without requiring analysis of the impact on diversion of floodwaters or wave runup and wave reflection.

(D) Other development in coastal high hazard areas (Zone V). In coastal high hazard areas, development activities other than buildings and structures shall be permitted only if also authorized by the appropriate federal, state or local authority; if located outside the footprint of, and not structurally attached to, buildings and structures; and if analyses prepared by qualified registered design professionals demonstrate no harmful diversion of floodwaters or wave runup and wave reflection that would increase damage to adjacent buildings and structures. Such other development activities include but are not limited to:

(1) Bulkheads, seawalls, retaining walls, revetments, and similar erosion control structures;

(2) Solid fences and privacy walls, and fences prone to trapping debris, unless designed and constructed to fail under flood conditions less than the design flood or otherwise function to avoid obstruction of floodwaters; and

(3) On-site sewage treatment and disposal systems defined in 64E-6.002, F.A.C., as filled systems or mound systems.

(E) *Nonstructural fill in coastal high hazard areas (Zone V).* In coastal high hazard areas:

(1) Minor grading and the placement of minor quantities of nonstructural fill shall be permitted for landscaping and for drainage purposes under and around buildings.

(2) Nonstructural fill with finished slopes that are steeper than one unit vertical to five units horizontal shall be permitted only if an analysis prepared by a qualified registered design professional demonstrates no harmful diversion of floodwaters or wave runup and wave reflection that would increase damage to adjacent buildings and structures.

(3) Where authorized by the Florida Department of Environmental Protection or applicable local approval, sand dune construction and restoration of sand dunes under or around elevated buildings are permitted without additional engineering analysis or certification of the diversion of floodwater or wave runup and wave reflection if the scale and location of the dune work is consistent with local beach-dune morphology and the vertical clearance is maintained between the top of the sand dune and the lowest horizontal structural member of the building.

(Ord. O-2014-13, passed 7-16-14; Am. Ord. O-2020-04, passed 2-19-20)

§ 155.10 DRAINAGE.

(A) This chapter provides that the Engineering Department prepare a contour map for the entire city and assign a grade to each and every street in a general master drainage plan showing the elevation and slope of every street in the city.

(B) No building permits shall be issued for houses on streets which are not now paved or developed until the Engineering Department can check the proposed elevation of that house, to see how it will conform with the proposed elevation of the street on the master contour drainage map. If the floor elevations of the houses are low, the developer will be required to build up the streets in that area or the house floor elevation until such time as the street is built up to its proper drainage grade.

(C) When a building permit is issued, the applicant shall have the following options of providing for the necessary drainage facilities:

(1) Making a contribution to the city of $.10 per square foot of the impervious portion of the property involved for the privilege of draining water from his property onto public property.

(2) Constructing on his property, at his expense, drainage facilities to accommodate a rainfall rate, selected at his discretion, and making a contribution to the city for the privilege of draining the overflow water from his property onto public property. The contribution shall be the greater of either:

(a) The estimated expense to the city to provide for the overflow, not to exceed $.10 per square foot of the impervious portion of the property; or

(b) One cent per square foot of the impervious portion of the property involved. This option is available only if approved by the City Engineer, and only if city facilities for handling the expected overflow are readily available. If the applicant chooses to proceed under this option, the City Engineer shall make his determination of estimated expense within 60 days of the applicants request.

(3) Constructing on his property, at his own expense, all drainage facilities required by the city, in accordance with city engineering specifications.

(D) A special drainage fund is hereby created and all contributions for storm drainage onto public property, as set forth in division (C)(3) hereof, shall be deposited into said fund, to be used for storm drainage projects throughout the city. Said projects shall be designated by the Engineering Department, subject to the approval of the City Commission.

The City of Hollywood's future land use map is included in Figure 53.

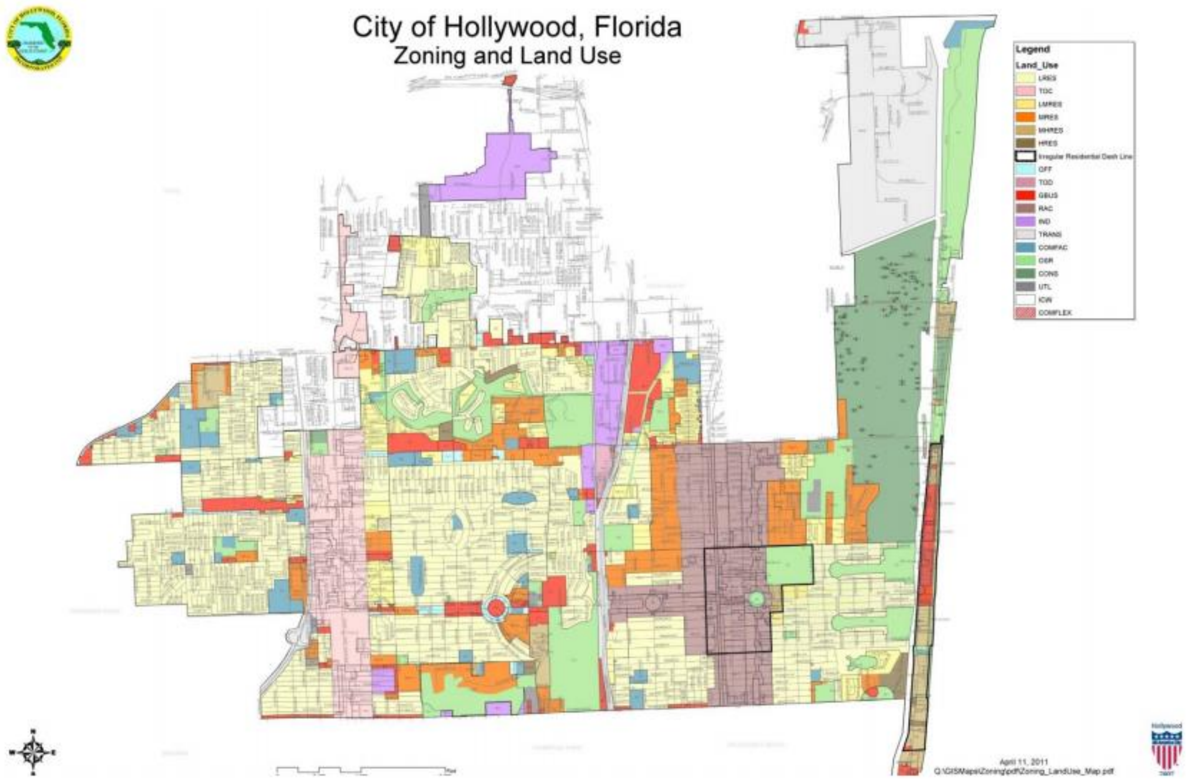

Figure 53. City of Hollywood future land use map

Hollywood established a special drainage fund by ordinance and all contributions for storm drainage onto public property (CH 154.56)

3.1.4.6 Central Broward Water Control District

The Central Broward Water Control District is a political subdivision of the State of Florida with ad valorem taxing privileges, created by a special act of the legislature. As a special district, Central Broward Water Control District is charged with the responsibility of not only maintaining the canal network, but also with the duty to regulate the drainage within its geographic area.

Recent studies, by both SFWMD and the Central Broward Water Control District, reflect a desire to maintain the standards of criteria for limited discharge by developments into the canal network. The Central Broward Water Control District is currently performing these tasks. All plans, rules and programs of the Central Broward Water Control District must be consistent with the goals and policies of this Chapter. Treatment is generally accomplished through retention or through detention with filtration. Retention requires the diversion of the required volume of runoff to an impoundment area with no subsequent direct discharge to surface waters. Pollutant removal by settling and by percolation of the stormwater through the soil is almost total. Detention facilities are typically within the line of flow of the drainage system. Stormwater from a site passes through the detention facility and is filtered prior to discharge to remove pollutants.

Both the SFWMD and the CBWCD require all new development to utilize best management practices to reduce pollutant levels in stormwater runoff. Current standards require that the maximum allowable discharge from any project in the West Basin of the District is limited to 0.75 inch per acre per day and to 1.5 inches per acre per day within the East Basin. These systems are confined to self-maintenance and overflow discharge only. The overflow is directed into a network of canals provided by the Central Broward Water Control District, which is responsible for maintenance and the regulation thereof.

The Broward County Water Management Division is responsible for implementing grading and drainage criteria for county rights-of-way. These standards are adopted by the Central Broward Water Control District and the City of Cooper City.

3.2 Design Storm Events (1 day, 10 year; 3-day, 25-year; 1-day, 100-yr)

As discussed in Section 3.1.3, Figure 43 shows the 3-day, 25-year storm event, and Figure 44 shows the 1-day, 100-year events to comply with. Figure 45 shows the 1-day, 10-year storm. Other events are not part of SFWMD guidance. However, FAU can provide screening model runs for alternate storms if needed. Note that FAU has compared the 3-day, 25-year event and the 1-day, 100-year events, and found that in general the difference was within the vertical accuracy of the LiDAR (see Section 4.2.2 for more detail). In the coastal area, flooding from king tides and storms is a greater consideration than rainfall.

3.3 Peak Flows and Volumes

Figure 15 in Section 1.1.3 shows the flow volumes for the Dania Cutoff canal, which averaged 143 cfs over an 11-year period from 2010-2020. Additional SFWMD regulations were discussed in Section 3.1.3.

3.4 Minimum Flows and Levels (MFLs)

Minimum flows and levels (MFLs) are established to identify where further withdrawals would cause significant harm to the water resources or to the ecology of the area. Significant harm is defined in Subsection 40E-8.021(31), F.A.C., as the temporary loss of water resource functions, which results from a change in surface water or groundwater hydrology, that takes more than 2 years to recover, but is considered less severe than serious harm. Per Subsection 40E-8.021(17), F.A.C., an MFL exceedance means “to fall below a minimum flow or level, which is established in Parts II and III of Chapter 40E-8, F.A.C., for a duration greater than specified for the MFL water body.”

There are no MFLs established for the C-10, C-11, or Dania Cutoff canals.

3.5 Available Policy Documents

Note that WMPs are distinctly different than a variety of other plans developed for different purposes including water quality and TMDL plans, local mitigation strategy plans, flood insurance studies, floodplain management plans, stormwater master plans, local ordinances, and CRS plans. For example, a County’s Local Mitigation Strategy (LMS) details all of the possible hazards that the incorporated and unincorporated areas need to be concerned about. These possible hazards are identified and rated on the potential for damage based on previous hazards of similar type. LMS plans follow the FEMA hazard mitigation definitions in an attempt to address issues that will reduce or eliminate exposure to hazard impacts, including flooding.

3.5.1 Water Quality Management Reports (TMDL/BMAP/SWIM Plans)

See section 3.1.2.

3.5.2 Flood Insurance Study

“A Flood Insurance Study (FIS) is a compilation and presentation of flood risk data for specific watercourses, lakes, and coastal flood hazard areas within a community. The FIS report contains detailed flood elevation data in flood profiles and data tables” (FEMA, 2020). FIS are encouraged by FEMA and commonly used to present flood risk data for specific waterbodies, lakes, and coastal flood hazard areas within a community. All counties that take part in the NFIP should have access to a FIS for their respective county. It is important to remember that flood elevations shown on the FIRMs are primarily intended for flood insurance rating purposes, developed from historical data.

Broward County is making steady progress toward updating its Community 100-year flood map to account for conditions predicted in 2060-2069. The flood maps assume two feet of sea level rise, accounting for impacts to drainage systems, stormwater discharge, reductions in soil storage, and intensification of rainfall events. The study is expected to permit the County to work with FEMA to develop a revised map to update requirements for finished floor elevations for new construction and major redevelopment, while also informing the siting and design of critical infrastructure. The project will help maintain the affordability of flood insurance by keeping properties above the FEMA flood zone and establishing stricter standards that account for sea level rise, activities that deliver flood insurance discounts through the NFIP. This effort has been funded through cost share provided by the County, nine municipalities, and the local drainage district. The project completion date was December 2019, and the map was presented for adoption by the county commission as the 2nd map in the county's future conditions map series. The prior FIS map for the County was not available.

3.5.3 Floodplain Management Plan

Floodplain Management Plans (FMP) contain information on floodplains as they relate to community boundaries in all Florida Counties. FMPs are found at both the municipal and county level, making them varied in format and content. In the study area, only Broward County has such a plan, and it is the same as the surface water management plan.

Residents and businesses in Broward County are encouraged to view the current flood zones map and FEMA's preliminary flood zones map to better understand their potential flood risk (Table 9) and to help identify steps they may need to take to protect against property damage and loss. The maps are used by insurance companies for flood insurance purposes, and the base flood elevations are used for all new construction and substantial improvements to existing construction.

Table 9. Flood zone definitions

Designation	**Definition**
Zone AO	Flood insurance rate zone that corresponds to areas of shallow flooding (usually sheet flow on sloping terrain) with average depths between 1 and 3 feet. Mandatory flood insurance purchase requirements apply.
Zone AE	Flood insurance rate zone that corresponds with flood depths greater than 3 feet. Mandatory flood insurance purchase requirements apply.
Zone AH	Flood insurance rate zone that corresponds to areas of shallow flooding with average depths between 1 and 3 feet. Mandatory flood insurance purchase requirements apply.
Zone VE	Flood insurance rate zone that corresponds to coastal areas that have additional hazards associated with storm waves. Mandatory flood insurance requirements apply.
Zone X-Shaded (0.2 % Annual Chance Flood Hazard)	Flood insurance rate zones that are outside the flood plain or the average flood depths of less than 1 foot. Flood insurance purchase is not mandatory.

Property owners and renters should consider purchasing a flood insurance policy, even if it is not mandated for their location. All areas are susceptible to flooding, although to varying degrees.

Refer to Figure 12 and Figure 19, which show the FIRMs from 2020 from FEMA in Broward County.

3.5.4 Florida "Peril of Flood" Guidance

The 1000 Friends of Florida has a website for coastal resiliency (https://1000fof.org/) mainly focused on Tampa Bay. Southeast Florida has not been included in the effort.

3.5.5 Comprehensive Plans

Refer to Section 3.1.4.

3.5.6 Unified Land Development Regulations (ULDRs)

Land development codes/comprehensive planning was discussed in Section 3.1.4, which is tied directly to the land development codes.

3.5.7 Stormwater Management Policies

The following communities in the study area have stormwater management plans:

- Town of Davie (plan prepared by FAU in 2018) as discussed in 3.1.4.2.

3.5.8 Local Mitigation Strategies (LMS)

A county's LMS identifies potential hazards (including floods) and ranks them on a scale of potential for damage based on previous hazards of similar type. There is also a plan of action for responding to each potential event. FEMA requires these LMS reports and their resubmission every five years to stay eligible for funding (Section 322 of the Disaster Mitigation Act of 2000), which means that they are widely available. LMS follows FEMA hazard mitigation definitions in an attempt to address issues that will reduce or eliminate exposure to hazard impacts. While the flood hazard event section of LMS relate directly to CRS activity 510, there are still more aspects of LMS that can be used for WMPs. These reports are only produced at the county level but are adopted through resolutions into a municipal ordinance. The link for the Broward County report is as follows:

- Broward County (https://thrivingearthexchange.org/wp-content/uploads/2017/03/Broward-County-Enhanced-LMS-FINAL-November-2012-FINAL.pdf)

3.5.9 Intergovernmental Cooperative Agreements

Broward County does the MS4 permitting for most municipalities within its jurisdiction, including Davie, Dania Beach, and Cooper City. Hollywood has its own permit which has virtually identical requirements. Generally, MS4 permits in southeast Florida require the same information. Broward County's permit requirements are as follows:

FACILITY NAME: Broward County MS4

PERMIT NUMBER: FLS000016-004 - MAJOR Facility

ISSUANCE DATE: January 5, 2017

EXPIRATION DATE: January 4, 2022

This permit covers all areas located within the political boundary of Broward County that are served by the MS4s owned or operated by the permittees identified.

Permittee Responsibilities

Permittees are individually responsible for:

- Compliance with permit conditions relating to discharges from portions of the MS4 where they are the operator;
- Implementation of their SWMP on portions of the MS4 where they are the operator;
- Where permit conditions are established for specific portions of the MS4, the permittees need only comply with the permit conditions relating to those portions of the MS4 for which they are the operator;
- A plan of action to assume responsibility for implementation of stormwater management and monitoring programs on their portions of the MS4 should inter-jurisdictional agreements allocating responsibility between permittees be dissolved or in default (See Part II.G.3 of this permit also); and
- Submission of annual reports as specified in Part VI (Reporting Requirements)

Permittees are jointly responsible for:

- Collection of monitoring data as required by Part V.B; and
- Insuring implementation of system-wide management program elements, including any system-wide public education efforts.

3.4.10 Special Watershed Restoration Plans

One special regional plan directed from the federal government is the Comprehensive Everglades Restoration Plan (CERP), whose mission is to revert the altered south Florida watershed complex into a more natural state, thereby facilitating ecological restoration at a regional level while also maintaining drinking water resources. More information is available at https://evergladesrestoration.gov and https://www.sfwmd.gov/our-work/cerp-project-planning. This effort directly ties to any WMP effort within CERP's geography and mandates certain management criteria to various regulatory agencies accordingly.

The method by which the plan is enacted is succinctly detailed in the National Parks Service description of CERPs working order:

> "In recognition of the magnitude of the restoration effort and the critical importance of partnerships with state, tribal, and local governments, the intergovernmental South Florida Ecosystem Restoration Task Force (Task Force) was established by Congress in 1996. The Task Force uses a restoration framework to organize and assess this complex intergovernmental effort. It includes three strategic goals that address water (Goal 1), habitats and species (Goal 2), and the built environment (Goal 3). Efforts to achieve these goals include the Comprehensive Everglades Restoration Plan (CERP), a consensus plan approved by Congress specifically to reverse unintended consequences of the C&SF Project, and a host of additional projects to further restore the ecosystem's hydrology, improve water quality, restore natural habitats, and protect native species."

The major federal and regional effort for watershed protection involves the Comprehensive Everglades Restoration Program. The Office of Ecosystem Projects is the lead office responsible for implementation of the FDEP's responsibilities under the Comprehensive Everglades Restoration Plan (CERP), pursuant to Chapter 373.026(8)(b) of the Florida Water Resources Act, Florida Statutes (F.S.). This function involves close coordination with the lead agencies implementing the CERP, USACE, and SFWMD, as well as with staff from FDEP's South and Southeast district offices. Responsibilities of the Office of Ecosystem Projects include:

- Evaluation of comprehensive plan project components pursuant to Section 373.1501, F.S.
- Regulation of comprehensive plan project components pursuant to Section 373.1502, F.S.
- Serving as a member of the CERP Design Coordination Team
- Providing program level guidance and assistance to USACE and water management district staff:
    - Water Quality Guidance Memorandum

- Programmatic Regulations
  - Independent Technical Review
  - Toxic Substances Screening Process - Mercury and Pesticides
- Serving as local sponsor for the Comprehensive Integrated Water Quality Feasibility Study (CIWQFS)
- Coordinating with DEP staff on CERP issues and activities
- Serving as members of REstoration, COordination and VERification (RECOVER) and Project Delivery Teams
- Investigating regional water quality issues
- South Florida Water Quality Protection Program
- C-43 Pollutant Loading and Abatement Analysis
- North Palm Beach Pollutant Loading and Abatement Analysis
- Reviewing land acquisitions purchased with Save Our Everglades Trust Fund dollars

USACE is the lead federal agency responsible for undertaking implementation of CERP in partnership with the SFWMD (lead non-federal sponsor). The implementation of the CERP strongly depends on partnerships with the U.S. Department of Interior (USDOI), the State of Florida, and other local sponsors (U.S. Congress, 2000). Approximately $1.3 billion in funding, in combined contributions from the federal and state partners, has been provided in support of the CERP and prospective CERP projects from 2014-2019. CERP cumulative expenditures through fiscal year 2019 total $3.23 billion. The updated cost estimate for CERP is $23.158 billion.

CERP identified 68 components that can contribute significantly to restoring the health of the ecosystem. Through a rigorous planning process, the components described in the CERP “Yellow Book” are combined into 50+ implementable projects that become part of the Integrated Delivery Schedule. The components include, among others, storage reservoirs, wetland restoration, stormwater treatment areas (STAs), seepage management, aquifer storage and recovery (ASR), wastewater reuse, removing barriers to sheetflow, and operational changes. Restoration activities, including operational components recommended in CERP, occur within the context of the larger, actively operated C&SF system. The current C&SF project includes 1,000 miles of canals, 720 miles of levees, and several hundred water control structures providing services to south Florida such as water supply, flood protection, water management, preservation of fish and wildlife, navigation, recreation, and prevention of saltwater intrusion. Figure 54 and Figure 55 shows the most recent CERP update from the SFWMD:

https://www.eenews.net/assets/2020/12/28/document_gw_03.pdf

WRDA 2000 introduced the concept of Interim Goals, further developed into the Programmatic Regulations of 2003 and defined as “a means by which the restoration success of the Plan may be evaluated throughout the implementation process.” The regulations also required the development of Interim Targets for “evaluating the progress towards other water-related needs of the region provided for in the Plan…” These goals and targets are based on selected native habitats and species called indicators that, through monitoring and forecasting, can tell us how the Everglades is expected to respond to restoration. For the current effort, which began in 2017 and concluded with a report in 2020, RECOVER generated forecasts for changes in the indicators by 2026 and 2032 due to the scheduled implementation of CERP projects. Overall, model forecasts show unsubstantial progress toward ecosystem goals while also meeting needs for water supply and flood protection. The hydrological and ecological needs of the Greater Everglades portion of the ecosystem are still not fully achieved by 2032. Water management operations (e.g. Lake Okeechobee; Combined Operational Plan) will play key roles in achieving CERP goals for ecosystem restoration, water supply, and flood protection. Agencies must continue to monitor the ecosystem and use adaptive management to respond to changing real world conditions.

The Lake Okeechobee System Operating Manual (LOSOM) study is underway with the goal of incorporating flexibility in Lake Okeechobee operations while balancing congressionally authorized purposes. As part of the evaluation, the LOSOM will test the timing and volume of water that can be sent south and ensure compliance and compatibility with the State’s Restoration Strategies, which treat the water before it reaches the Greater Everglades. The LOSOM will leverage the progress made by the new water control plan for Water Conservation Area 3, Everglades National Park, and the South Dade Conveyance System, known as the Combined Operational Plan, which moves more water south across the Tamiami Trail. When the Central Everglades and the EAA Reservoir Projects are complete, they will further connect from north to south and improve the resilience of the natural system.

Recent legislation by U.S. Congress has authorized two key components of CERP. The Water Infrastructure Improvements for the Nation (WIIN) Act of 2016 authorized the Central Everglades Planning Project, and America’s Water Infrastructure (AWI) Act of 2018 authorized the Central and Southern Florida, Everglades Agricultural Area (EAA), Florida Project. Together, these two projects provide necessary infrastructure to meet the CERP goals for clean water flow to the central Everglades and further the ongoing restoration of the Southern Everglades and Florida Bay. These projects will reduce the releases from Lake Okeechobee to the St. Lucie and Caloosahatchee estuaries by capturing, storing, and cleaning and re-directing that water to the Everglades where it is needed. Significant progress has also been made since 2015 on the planning of the next set of CERP projects (refer to Figure 54 and Figure 55).

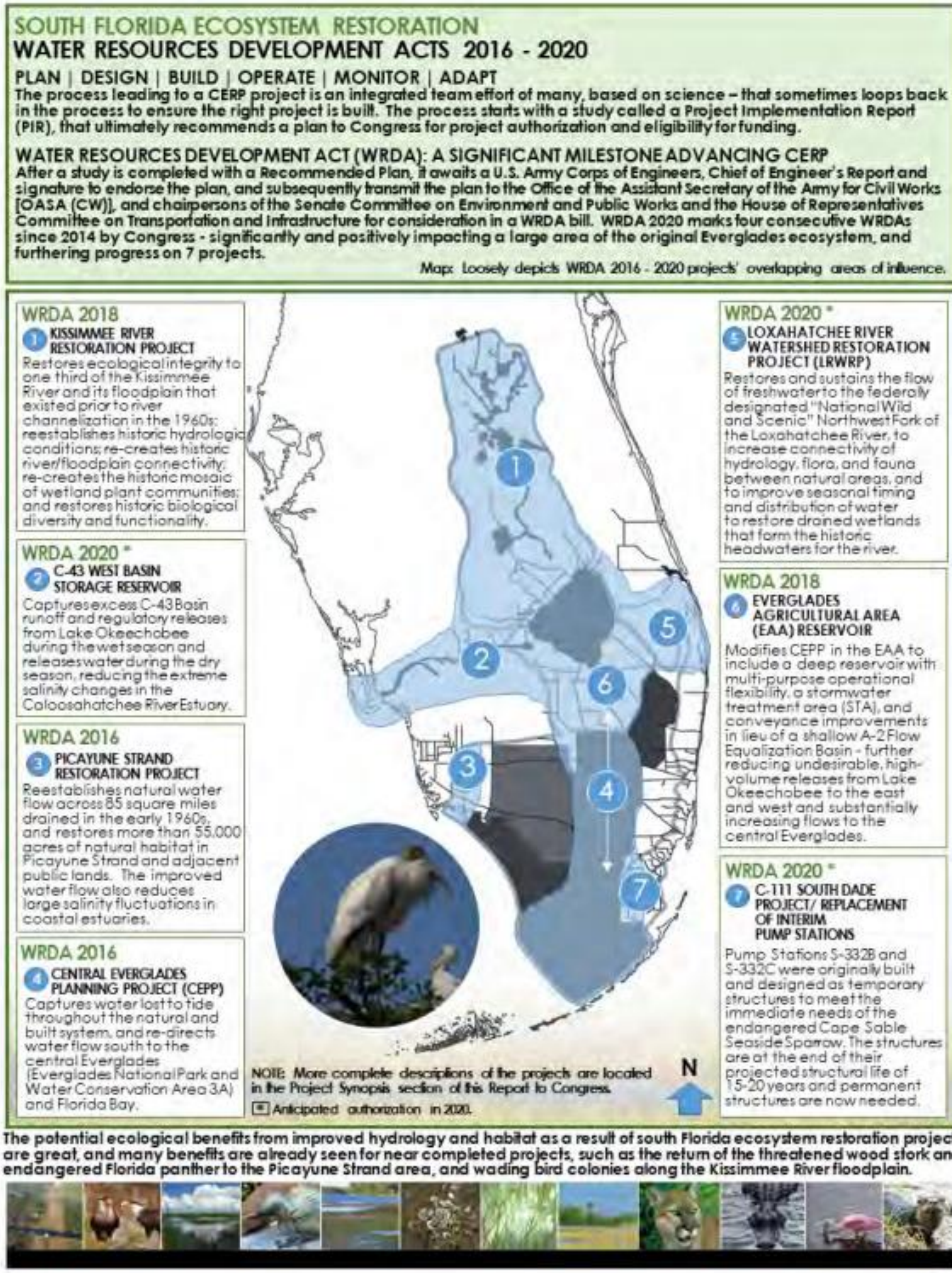

Figure 54. Update of 5 years' efforts toward CERP program, page 1 (SFWMD, 2020)

2015 – 2020

MOMENTUM AND THE MILESTONES

The array of efforts and coordination between federal, state and local partners and stakeholders to move Everglades restoration forward is immense – as is the range of expertise required across all phases of the project delivery process. Although "Plan – Design – Build – Operate – Monitor – Adapt" is a simple way to refer to a very integrated and complex process, these milestones do allow us to take a brief pause, whether informally in a status report or formally with a ceremony, to recognize those that have contributed to the current milestone and those who will contribute to the next. Records of these milestones are yet another way to tell a story of restoration coordination and dedication that is making the vision of a healthy Everglades a reality.

NON-CERP MILESTONES

C-111 SOUTH DADE (C-111 SD)
- All construction contracts completed
- Post-Authorization Change Report to replace the existing temporary S-332B and S-332C pump stations with permanent pumps stations and concrete outlets completed
- Combined Operations Plan (COP) for C-111 SD and Modified Water Deliveries to Everglades National Park (MWD) recommended plan and water control plan update completed

HERBERT HOOVER DIKE (HHD) MAJOR REHABILITATION PROJECT AND DAM SAFETY MODIFICATION STUDY
- Replacement of 17 water control structures (culverts)
- Construction contracts for the remaining 11 culvert replacements awarded
- Construction contracts for the remaining 35.2 miles of cutoff wall installation awarded
- Initiation, scoping and plan formulation of Lake Okeechobee System Operations Manual (LOSOM), a new Lake schedule/revised water control plan

KISSIMMEE RIVER RESTORATION PROJECT
- Construction completed for:
  - S-65EX1 Structure
  - River Acres Canal
  - MacArthur Ditch Backfill
  - Reach 3 Backfill
  - Reach 3 North Backfill Repairs
- Construction of Reach 2 Backfill awarded
- Construction of S-69 Weir and Reach 3 Backfill Repairs awarded

LAKESIDE RANCH STORMWATER TREATMENT AREA (STA)
- Operation of Phase II, southern Stormwater Treatment Area (STA)
- Construction of Phase III, S-191A pump station, initiated

MODIFIED WATER DELIVERIES TO EVERGLADES NATIONAL PARK (MWD)
- All construction contracts completed
- Operational field testing of S-356 and G-3273 relaxation while incrementally raising the L-29 Canal stage initiated under Increment 1
- Operational Increment 1.1/1.2 implemented
- Operational Increment 2 implemented
- Combined Operations Plan (COP) for C-111 SD and MWD recommended plan and water control plan update completed

RESTORATION STRATEGIES
- Construction and the Operational, Testing, and Monitoring Phase (OTMP) of A-1 Flow Equalization Basin (FEB) completed
- Construction and OTMP of L-8 FEB completed
- Modification/construction of three primary conveyance features (S-5AS, L-8 divide structure, and S-375) completed

TAMIAMI TRAIL NEXT STEPS PROJECT
- Construction of 2.6-mile bridge completed

TEN MILE CREEK WATER PRESERVE AREA
- Rehabilitation of reservoir to allow a 4-foot fill
- Operations of water preserve area and STA

WEST PALM BEACH CANAL STA-1 EAST/C-51 WEST
- Culvert repairs completed

CERP MILESTONES

BISCAYNE BAY COASTAL WETLANDS, PHASE 1
- Operation of L-31E Interim Pump for early benefits in coastal wetlands and Biscayne Bay
- Installation of all L-31E Flow-way culverts completed
- L-31E Contract 4 awarded for L-31E flow-way

BROWARD COUNTY WATER PRESERVE AREA
- Construction of Mitigation Area A Berm completed

C-111 SPREADER CANAL WESTERN PROJECT
- Installation and operation of additional pump capacity at S-199 and S-200 completed
- Connection of the C-222 Header Channel to the L-31W Canal (via the G-737 culvert) completed

CALOOSAHATCHEE RIVER (C 43) WESTERN BASIN STORAGE RESERVOIR PROJECT
- Award for S-470 Intake Pump Station Contract
- Award for final contract for Embankment and Civil Works
- Construction of the S-476 Irrigation Pumping Station completed

CERP EVERGLADES AGRICULTURAL AREA PROJECT
- Design and early construction of the A2 STA initiated
- Design of the EAA A-2 Reservoir

CENTRAL EVERGLADES PLANNING PROJECT
- Construction of S-333N spillway (1,150 cfs) completed
- Removal of Old Tamiami Trail Road and S-346 initiated
- Construction of Contract 1 (S-631, S-633 water control structures, L-67A Spoil Removal, and L-67C Levee Gap) initiated

DECOMPARTMENTALIZATION PHYSICAL MODEL (DPM)
- Years 3 and 4 of Phase I Testing during dry seasons (flow testing) completed
- Approval for Phase II year round testing
- Years 5, 6, and 7 of Phase II testing completed

INDIAN RIVER LAGOON SOUTH, PHASE 1
- Construction of C-44 STA discharge spillway completed
- C-44 STA initial fill initiated
- Construction of C-44 Reservoir Pump Station completed
- Design for C-23/24 North Reservoir, South Reservoir, and STA

PICAYUNE STRAND RESTORATION PROJECT
- Construction of Faka Union Pump Station completed
- Removal of 100 miles of roadways completed
- Construction of Miller Pump Station completed
- Removal of 65 miles of road and 26 miles of logging trams between Merritt and Faka Union Canals completed
- Construction of Manatee Mitigation Feature completed
- Construction of East-west canal plugging

Figure 55. Update of 5 years' efforts toward CERP program, page 2 (SFWMD, 2020)

The Loxahatchee River Watershed Restoration Project has a signed Chief's Report and was provided to U.S. Congress in early 2020 for consideration in future legislation. This project will restore and sustain the flow of freshwater to the federally designated "National Wild and Scenic" northwest fork of the Loxahatchee River and reconnect the wetlands of the historic headwaters of the river. The Lake Okeechobee Watershed Restoration Project is in the final phase of review of its Project Implementation Report and Environmental Impact Statement. This project will provide much needed storage north of Lake Okeechobee and restore wetlands within the watershed.

3.5.11 Stormwater Pollution Prevention Plans (SWPPPs)

Stormwater Pollution Prevention Plans (SWPPPs) identify primary sources of stormwater pollution at construction sites, best practices to reduce stormwater discharge from construction sites, and procedures to comply with construction permits. As part of the Clean Water Act, it is required that nearly all construction site operators engaged in clearing, grading, and excavating activities that disturb one acre or more, including smaller sites in a larger common plan of development or sale, must obtain a National Pollutant Discharge Elimination System (NPDES) permit for their stormwater discharges. Understanding the requirements of the SWPPP and the NPDES are helpful in addressing parts of a WMP with regards to stormwater and runoff management. No specific plan exists in the subwatershed. However, the County and FDEP have a variety of TMDL's that they enforce in the basin (see Section 3.1.2). The MS4 permitting process discussed in Section 3.5.9 replaces the NPDES permits for most of the communities in the study area.

3.5.12 Post-Disaster Redevelopment Plan

Some communities may decide to formalize a Post-Disaster Redevelopment Plan to facilitate long-term recovery following a disaster. A community's Post-Disaster Redevelopment Plan can address issues relating to the identification of key roles, personnel, and agencies for future land use and zoning of areas damaged by disasters. Key sections of Post-Disaster Redevelopment Plans that should be considered when developing a WMP are as follows:

- Mapping Hazard Risks. Aligns the need for geospatial hazard analysis and mapping efforts, which leads to more informed policy recommendations post-disaster.
- Protecting or Restoring Natural Areas. Focuses on the redevelopment process taking place in areas that are less sensitive to development, leaving areas more prone to disaster and allowing them to serve as a buffer or other mitigating effect.
- Funding through Capital Improvement Programs. The identification of funding can assist a community to implement well-managed growth and redevelopment.

No single local jurisdiction in Broward County has the capability and resources to address disasters or major emergency situations on its own except the County itself. Therefore, Broward County performs emergency management planning for the other local governments via an emergency management plan designed with the input and cooperation of all local entities (https://www.broward.org/BrowardEMD/Documents/CEMP.pdf). The plan creates the Broward Emergency Response Team (BERT) which was established to provide and address disaster related issues on a countywide basis via the Broward Countywide Recovery Process (CRP) guidance (https://www.broward.org/BrowardEMD/Documents/CRP%208-5-2011.pdf), which defines responsibilities, establishes recovery organizational structures, defines lines of communications, and is complies with the National Incident Management System (NIMS). This plan has six recovery phases, as described in the CRP. The plan includes elements that comply with the FDEM "*Post-Disaster Redevelopment Planning*" guide for Florida Communities (2010) and integrates a newly conceived idea of Just In Time Recovery Planning that enables the recovery organization to compile the Recovery Action Plan of direct actions to effectively manage the rapid recovery process for disasters as they occur.

3.5.13 Climate Adaptation Action Plan (CAAP)

The adaptation chapter of Florida's Climate Adaptation Action Plan (CAAP) is one that contains a series of 28 varying goals with strategies that work towards addressing the impacts of climate change as they relate to infrastructure, biodiversity, coastal areas, and oceans (Georgetown Climate Center, 2018). While all sections of the CAAP are significant, the topics of particular interest to the development of WMP are as follows:

- Coasts and Oceans. Recommends actions to improve overall coastal resilience to bolster both impact communities and ecosystems.
- Water. Identifies the impacts of climate change and how they relate to the water resources of the state. Recommends actions that would improve conservation measure and efforts to understand, quantify, and plan for uncertainties affecting water resources.
- Infrastructure. Identifies development strategies and engineering solutions that can reduce risks from tidal flooding, storm surge, stormwater-driven flooding, and related impacts of sea-level rise when updating coastal management elements of their comprehensive plans.
- Public Health and Emergency Preparedness. Recommends actions that would reduce public health threats from climate change and resilience against the impacts of climate change.

Climate action requires cooperation between entities. As a result, the Southeast Florida Regional Climate Compact (SEFRCC) was created by 4 counties of which Broward County is a charter member and organizer. SEFRCC is a partnership between Broward, Miami-Dade, Monroe, and Palm Beach Counties, to work collaboratively to reduce regional greenhouse gas emissions, implement adaptation strategies, and build climate resilience across the Southeast Florida region.

This group convened the Southeast Florida Resilient Redesign, an intensive four-day workshop to develop innovative design strategies for three archetypal southeast Florida land use scenarios that could serve as models of resilience throughout the region. Following the success of the 2014 exercise, a second Resilient Redesign workshop was held in 2015— this time organized with the assistance of the Florida Climate Institute members: Florida Atlantic University, Florida International University, University of Florida, and University of Miami —for three new communities. Compact partners intend to follow up on many of the ideas developed in these workshops and to hold additional Resilient Redesign events on an annual basis. The Resilient Redesign events generated creative community resilience strategies through engagement with stakeholders and experts. By following the Resilient Redesign model, other communities can capitalize on local and outside knowledge to address their specific sets of climate challenges. The unique format of these workshops and the focus on projects representative of the landscape of the Compact have made Resilient Redesign a success and place the Compact on the cutting edge of resilience work.

Successful implementation of the ideas generated throughout the Resilient Redesign workshop may face challenges, due to funding constraints, the inertia of business-as-usual approaches, and outdated public policies and private practices. However, the design concepts emerging from Resilient Redesign help to identify much more specifically the potential costs (and benefits) of adaptation and the barriers to implementation. With a greater understanding of these limits, policymakers and stakeholders can develop strategies to overcome them. Resilient Redesign organizers offer a number of lessons for communities which might be considering a similar resilient design initiative:

- Outside experts suggested 30 participants as the ideal number, though the southeast Florida Resilient Redesign events included about 50 each year.
- Outside expertise is critical, particularly experts who have already participated in or led similar efforts, such as Dutch Dialogues or Rebuild by Design.
- The workshop will be beneficial if the team and design leads have dynamic and engaging personalities.
- Maps, data, and other resources must be prepared in advance.
- External financial support for facilitators, travel and lodging for outside experts, tour buses, refreshments, etc., is helpful. Nonprofit organizations, local foundations, or universities could fill this role.

Community partners must be engaged and willing.

The Compact is a focused collaborative, providing the vision and framework for regional resilience. The Compact calls for partners to work cooperatively to:

- Develop annual Legislative Programs and jointly advocate for state and federal policies and funding
- Dedicate staff time and resources to create a Southeast Florida Regional Climate Action Plan to include mitigation and adaptation strategies
- Meet annually in Regional Climate Summits to mark progress and identify emerging issues.

With the support of a variety of stakeholders, and local, regional, state, and federal agencies (NOAA, USACE, USGS, and USEPA), the Compact developed and drafted the Southeast Florida Regional Climate Action Plan. All four Compact counties formally adopted the Plan document in the spring of 2014. The Compact's Action Plan provides a regional framework for mitigation and adaptation measures to prepare for the impacts of climate change on Southeast Florida. The plan makes over 100 "actionable" recommendations in seven goal areas, to be accomplished over the next five years. The categories include: Sustainable Communities and Transportation Planning; Water Supply, Management, and Infrastructure; Risk Reduction and Emergency Management; Energy and Fuel; Natural Systems; Agriculture; and Outreach and Public Policy. For over a decade, the Compact counties have successfully collaborated on mitigation and adaptation strategies, built bipartisan support for climate action, and forged partnerships with key stakeholders, including federal, state, and municipal governments and agencies; economic development entities; community-based organizations; and the academic community, enabling the development of a regional voice and vision for future prosperity in Southeast Florida.

SEFRCC has also created a website (https://southeastfloridaclimatecompact.org/) so local communities can build their own climate plan. Both Davie and Dania Beach participate. Davie does not have a specific climate plan, but does incorporate pieces of the SEFRCC program:

<u>RISK REDUCTION AND EMERGENCY MANAGEMENT</u>

RR-08: Promote climate adaptation plans across sectors

Continue to adopt and update consistent plans at all levels of government in the region that address and integrate mitigation, sea level rise, and climate change adaptation.

Ensure consistency among:

a. Strategic plans
b. Disaster recovery and redevelopment plans
c. Comprehensive plans

d. Long-range transportation plans
e. Comprehensive emergency management plans
f. Capital improvement plans
g. Economic development plans
h. Local mitigation strategies
i. Climate change action plans or resilience strategies
j. Future land use plans
k. Threat and hazard identification and risk assessments

Dania Beach has a climate action plan – the first in the County to do so. They also adopt certain portions of the SEFRCC program:

RR-01 Identify at-risk populations and infrastructure

Perform local vulnerability analyses to identify and quantify infrastructure and populations at risk under various sea level rise scenarios and other climate change scenarios.

Use the best available data, models, and resources, including the Compact's Unified Sea Level Rise Projection, to inform planning, prioritizing, and annual funding.

RR-09 Review the Florida Building Code

Using the lens of climate vulnerability, convene a panel of regional representatives from local government and the planning and construction sectors to review the Florida Building Code and assess its current standards that include climate projections.

Develop and adopt recommendations specific to Southeast Florida counties to strengthen the code and the built environment, particularly in regard to flooding hazards.

Develop resilience guidelines and create municipal pilot projects.

RR-13 Use social media to communicate

Use effective social media for emergency messaging, public health updates, and tidal flooding updates.

Determine the most locally relevant social media platforms and what audiences receive information from them.

Utilize relevant social media to regularly disseminate public emergency messages, such as updates on public health or tidal flooding.

Align all social media messages with existing government notification systems, such as Code Red.

Consider non-internet public communication alternatives due to power outages, such as community boards at public spaces.

RR-17 Define "communities at risk"

Ensure the emergency management definition of "communities at risk" includes economically vulnerable people.

Develop a "communities-at-risk" map of limited-income and socially vulnerable populations, such as the elderly, using census data as well as local knowledge.

Create programs for vulnerable populations—those unable to easily prepare for or recover from an emergency, and those without access to personal transportation—to prepare for and prevent additional impacts and prepare for and mitigate the need for additional recovery efforts.

Dania Beach's climate action plan notes that the City of Dania Beach must prepare its residents, businesses, and governmental operations for the unavoidable impacts of climate change. The City should reach out to other agencies and potential partners to access the resources it needs to do the kind of in-depth scientific research and program development necessary to handle a problem of this scale. Staff and budgetary constraints should not be used to delay action. While each city must access its own vulnerability (and ability to overcome these vulnerabilities), collaboration can make the most of limited resources, inform local planners on lessons learned and best practices available, and even be used for implementation of some actions within a municipal climate change program.

Ongoing program evaluation is key for the successful implementation of any plan, but even more critical for programs relying on the coordination of multiple players along multiple planning horizons. Intergovernmental coordination and other implementation challenges should be addressed regularly. The example Implementation Work Plan in Appendix A of the City's climate action plan is a guideline for this type of flexible tracking tool. Laid out as more of a brainstorming document rather than one used for formal reporting, the Work Plan highlights some of the major partnerships and programmatic components the City already has established which can be used to help jump start a climate program. It is important to note that Dania Beach is not starting from scratch; many climate change related actions are already being addressed in the CRP. While a more thorough climate program needs to be established, the Work Plan helps the City begin to implement its first steps to reaching these agreed upon targets and discover what other resources and partnerships are easily within their reach. Examples of steps under consideration are listed in Table 10, and Table 11 shows examples from the Work Plan used for internal discussion purposes only during quarterly staff meetings. Resources and contacts are embedded in the document, as is a gleaning of commitments the City has already made (but without a plan to work towards). As the City uses the Work Plan increasingly, more categories will need to be added to add value to the document and accountability to the process, such as the delegation of responsibility for each action item, measures for evaluation, and timelines for reassessment.

Table 10. Tools for Protection Transportation Infrastructure from Climate Change Impacts (from Dania Beach Climate Action Plan)

Transportation Resource Adaptation Alternatives
Protect Roadway Base • Increase stormwater drainage systems • Increase roadway pumping stations • Identify offsite stormwater retention areas • Eliminate exfiltration trenches as a solution • Install dewatering technology for permanent use • Raise roadway elevation
Protection of Roadway Surfaces • Increase roadway stormwater activity • Elevate FDOT roadways surfaces 5 ft above mean high tide • Increase local roads to average lowest finished floor elevation • Relocation of critical roadways
Abandon Roadways • Abandon roadways too low and with neighboring areas too low to elevate without private property impacts • Abandon state roads to local governments
Stormwater Management • Reengineering canal systems, control structures and pumping
Increase Other Modes of Transportation • Increase bus and train traffic • Increase commuter/community bus systems

Table 11. Implementation Program (from Dania Beach Climate Action Plan)

Trigger*	***Implementation Strategy***	***Barriers to Implementation***	***Point of Abandonment***	***Dania Beach, FL Cost***
Immediate 0-1 ft Sea Level Rise by 2030	Install stormwater pumping stations in low lying areas to reduce storm water flooding (requires study to identify appropriate areas, sites, and priority	NPDES permits, cost, land acquisition	When full area served is inundated (>3-5 ft SLR)	Start at $1.5 to 5 million each, 5-10 needs more study
1 – 2 ft Sea Level Rise 2030-2078	Well Point certain roads	NPDES permits, cost, land acquisition	When full area served is inundated (>3-5 ft SLR)	Start at $1.5 to 5 million each, 5-10 needs more study
	Install stormwater pumping stations in low lying areas to reduce storm water flooding	NPDES permits, cost, land acquisition	When full area served is inundated (>3-5 ft SLR)	Start at $1.5 to 5 million each, 5-10 needs more study
1 – 2 ft Sea Level Rise 2030-2078, timing depends	Raise elevation of local roadways to 6 ft NGVD	Public acceptance, permits, land acquisition for storage	Sea level rise to finished floor elevation	>300 million
Before 3 ft Sea Level Rise 2070- 2100	Raise elevation of Certain roadways to 10 ft NGVD	Public acceptance, permits, land acquisition for storage	Sea level rise to 10 ft	$60-100 million for roads, $10 million for utilities
	Install major stormwater pumping stations in fishbowls to reduce storm water flooding	NPDES permits, cost, land acquisition	When full area served is inundated	Start at $2 to 5 million each, needs more study
3 – 4 ft Sea Level Rise 2085 - 2100	Massive groundwater dewatering, send to Everglades	Regulations for redirection of stormwater that likely has high phosphorous levels, public perception, cost	n/a – solution to retard sea encroachment	$ billions
Beyond 4 ft Sea Level Rise After 2100	Large areas of the city must be abandoned	Public perception - worst case scenario, likely greater than 100 years out	n/a	>$ billions

In the comprehensive plan amendments to the Dania Beach Climate Action Plan, climate change planning has still not been addressed in the city's planning documents or ordinances. The only place that identifies future goals is the CRA plan. The city has an opportunity to update its Comprehensive Plan though the Evaluation and Appraisal Report (EAR) Process to incorporate climate change planning into the city's planning framework. While a more ambitious research and planning program around the issues of climate change will need to be developed in the long term, updating the city's comprehensive plan with current information is a positive first step.

State law requires municipalities to include mitigation strategies as part of the EAR process, such as greenhouse gas reduction strategies, support of alternative energy production and the increasing of energy efficiency standards. Therefore, many communities are voluntarily including protection and adaptation strategies for climate change, as a means to reduce their community's vulnerability. It is recommended that the City of Dania Beach use the EAR process as an opportunity to take the same leadership role on this issue.

Policies recommended are consistent with the political framework provided by Broward County and the State of Florida and have been vetted through key agency staff to ensure feasibility and support. Following the recommendations is a template for ongoing goal assessment and program evaluation. The template is an important tool for successfully planning and implementing a program in phases, through an adaptive management approach. The take-home message of this tool is that program designers and managers should establish a process by which goals are kept in focus, responsibility is clearly delegated, measures are established, and progress is reported on within agreed-upon timeframes. The following is an example of climate change policies to be considered:

Goal 1: Lessen the City's contribution to global climate change, by creating policies that support greenhouse gas emissions reduction strategies and the better management of high energy consuming resource use and development.

Objective 1.1: Reduce the impact of Transportation on the city's carbon footprint by supporting the development of alternative models of transit.

- Action 1.1.1: Support the creation of a regional mass transportation system to reduce vehicle miles traveled (VMT), thus reducing a significant portion of the carbon emissions associated with travel.
- Action 1.1.2: Continue to coordinate with Broward County Transit to provide highly visible, creative, and eye-catching structures that promote the city's green programs, use the latest technologies to provide

passengers with real time information on routes and schedules, and enhance the shade, safety and comfort of riders.

- Action 1.1.3: Coordinate land-use and zoning regulations so that building activities are consistent with the City's Comprehensive Mobility Strategy.
- Action 1.1.4: Create a system of bicycle paths, nature trails and waterways that connects with and/or is supportive of the Broward County Greenway Plan.
- Action 1.1.5: Consider the creation of a community lead mobility advisory team to survey the pedestrian/bicycle infrastructure, identify gaps and high-risk intersections, and suggest low-cost improvement strategies to the City.
- Action 1.1.6: Create a miles per gallon standard for the procurement of all new city vehicles. This strategy is economically sustainable because the city's fleet is upgraded to be more efficient, but on an "as needed" basis.
- Action 1.1.7. Consider community transportation to connect the anchors of downtown, Jia Alai and the beach for use by residents and visitors to the City.

Objective 1.2: Research, establish, and fund programs that promote green energy practices in the City of Dania Beach.

- Action 1.2.1: Establish a citywide goal of 20% renewable energy by 2020, as consistent with the 2008 Florida Energy and Climate Change Action Plan.
- Action 1.2.2: Promote solar power production on residential, commercial and municipal properties by creating installation incentives and removing permitting and other regulatory barriers.
- Action 1.2.3: Support the growth of hi-tech manufacturing, alternative energy production, and renewable resource businesses through incentives and cooperative agreements, as recommended in the 2010 Targeted Industries Priority Ranking Report.
- Action 1.2.4: Through the use of intergovernmental coordination, partner with other agencies and entities that advocate for state and federal legislation that would support alternative energy production and the City's energy efficiency and conservation goals.
- Action 1.2.5: Support the county's waste-to-energy goal of 90% biomass conversion of municipal solid waste by 2012, by redirecting all non-recyclable MSW from landfills to the southern waste-to-energy plant.

Objective 1.3: Create a collaborative management environment to increase the efficiency of water use in the city.

- Action 1.3.1: Continue to collaborate with county staff and experts in the field to devise a strategy and set of policies that uses best practices and innovative technologies to further reduce the city's water induced "carbon footprint".
- Action 1.3.2: Seek public-private partnerships to promote water conservation strategies and sponsor educational events (example: to distribute high efficiency faucets, shower heads and appliances at a discounted cost to residents).
- Action 1.3.3: Implement the city's water conservation planning goals, including the restructuring water rates and charges to more dramatically incentivize conservation and discourage wastefulness.

Objective 1.4: Promote green building techniques and other resource sensitive development strategies.

- Action 1.4.1: Require Leadership in Energy and Environmental Design™ (LEED) or acceptable green design standards on construction of all new and renovated public buildings and commercial space.
- Action 1.4.2: Require that the city's building department have at least one LEED accredited official on staff and provide incentives for all other licensed personnel in the department to achieve at least 8 continuing education units (CEUs) of training in emerging energy efficiency and renewable energy technologies.

Goal 2: Protect the City's social, natural and economic assets from the unavoidable impacts of climate change.

Objective 2.1: Planning, siting, construction, replacement, and maintenance of public infrastructure shall be required to consider the impacts of climate change to ensure that these long-term public investments are cost-effective and have a lasting positive impact on the community.

- Action 2.1.1: Determine vulnerability of all currently sited public infrastructure. This includes, but is not limited to: streets and bridges, water treatment plants, schools, city buildings, police / fire stations, and power generation facilities.

- Action 2.1.2: Factor sea-level rise and other climate change impacts into the assessment of need, placement, cost-benefit, design, and lifespan for all new infrastructure projects and retrofit plans of existing infrastructure.
- Action 2.1.3: Develop a planning framework to evaluate vulnerable infrastructure and identify solutions to protect this infrastructure or replace it by 2020.
- Action 2.1.4: Support the on-going and quantifiable communication program ensuring public services are planned for and available concurrent with sea level impacts.
- Action 2.1.5: Ensure and identify the consistency of local level of service standards by annually contacting all service providers to obtain current information, including: populations, level of services, service areas, and water supply facilities, and evaluate if future modification to either the service agreement or level of service standards should be include in subsequent Comprehensive Plan Amendments.

Objective 2.2: Conduct research to assess human vulnerability, develop tools and timeframes for appropriate response, and communicate with residents about the impacts of climate change and the City's strategic climate plan.

- Action 2.2.1: Determine human vulnerability by assessing the size and distribution of the City's current and future populations in regard to projections for expected impacts of climate change, using census data, asymmetric mapping, sea-level rise modeling, and other appropriate means of analysis.
- Action 2.2.2: Take sea-level rise projections and other climate impacts into consideration when using Flood Insurance Rate Maps (FIRM) from the Federal Emergency Management Agency (FEMA) which are useful in defining base flood elevations, flood zones and flood plain boundaries, if not already accounted for.
- Action 2.2.3: Take sea-level rise projections and other climate impacts into consideration when using 100-year flood maps and high hazard area designations for land-use decisions, if not already accounted for by the map modernization project coordinated through FEMA, SFWMD and DCA.
- Action 2.2.4: Create a Climate Change Preparedness Plan that includes analysis of various protection and abandonment strategies, specific policy recommendations and actionable steps, and timelines and measures for program assessment.

- Action 2.2.5: Educate the public about the community's vulnerability to the impacts of climate change, and the city's strategies for reducing these impacts, by hosting forums and events, and through print (Dania Press) and online (City's website) media resources.

Objective 2.3: Protect the health and vitality of natural systems for drinking water, storm water defense, and any interesting and biologically diverse environment. Protection of water quality and efforts to minimize potential flood damage and water shortages are crucial in this effort.

- Action 2.3.1: Ensure that the existing water supply resources and water infrastructure are protected, and adequate supplies of water remain available for drinking, agriculture, and natural resources in the future, by implemented efficiency standards in direct proportion to development growth.
- Action 2.3.2: Continue to protect well fields from pollution and saltwater intrusion by reducing supply demand (Action 2.3.1), promoting alternative sources of new water, and determining the feasibility of the increased reuse of water.
- Action 2.3.3: Protect the well fields by promoting strategies that help to recharge the Biscayne aquifer, such as requiring all new development, redevelopment, additions, retrofits, or modifications of property to increase pervious surface areas by a certain percent.
- Action 2.3.4: Seek ways to protect the city's natural storm surge defense systems, through the enhancement of the salt marsh and mangrove swamps in the northeastern sections of the city.
- Action 2.3.5: Promote sustainable urban forest landscape practices that will increase the city's carbon sequestration capacity, reduce the heat island effect, and improve the energy efficiency of nearby structures.
- Action 2.3.6: Increase habitat and species diversity by connecting parks, natural areas and green urban areas, and by promoting native and drought resistant landscaping on all private and public property.
- Action 2.3.7: The City will utilize its existing agreement with Broward County to provide traditional water sources that will be required within the 10-year planning horizon.
- Action 2.3.8: Investigate additional well locations in the City's current wellfield. This will require drilling of test wells, additional monitoring wells (completed 2007) and modeling of proposed locations to determine if additional raw water is available in Dania Beach.

- Action 2.3.9: Investigate Ranney well. The City shall continue the process to evaluate the ability of horizontal wells to skim water off of the sands above the Biscayne aquifer, while creating minimal drawdown that will prevent saltwater intrusion and upconing, and shallow enough that the Biscayne aquifer/Everglades is not affected. While this solution may be tantamount to a surface system with regard to treatment, but the extensive loss of water to tide would be only partially curtained as a result of the proposed horizontal well project. A protocol for development for this type of supply will result from ongoing modeling and investigations funded in 2008-2011.
- Action 2.3.10: Participate with the County of efforts to recharge the County wellfield on a utilization basis. This may include additional wells, storm water recharge or reuse recharge.
- Action 2.3.11: Develop a preliminary model of Ranney collector/horizontal well and test the well for production to identify a water source and infrastructure to meet water demands beyond 2030.
- Action 2.3.12: Continue to participate in the Southeast Broward County Regional Groundwater Model.
- Action 2.3.13: Continue to coordinate with the SFWMD's Regional Water Supply Plan.

Objective 2.4: Protect the economic vitality of the city by managing the placement and timing of public and private investments in accordance to climate change model predictions.

- Action 2.4.1: Focus development on high ground, such as along the FEC line and State Road 7/U.S. 441 corridor, using Transit Oriented Development strategies.
- Action 2.4.2: Support efforts to create a passenger rail on the FEC line, increase marine access, and promote other climate compatible alternative forms of transit.
- Action 2.4.3: Implement the Community Redevelopment Plan and other City programs and plans that direct development according to smart growth principles, encourage green building, incentivize energy and water efficiency, and support the general goals of the City's Climate Change Preparedness Plan.

Goal 3: Adapt current policies and regulatory frameworks in accordance to the changing environmental and social-political conditions that result from a changing climate.

Objective 3.1: Identify vulnerability hotspots and create policies that increase the adaptive capacity and/or resiliency of the City.

- Action 3.1.1: Use data on current climate trends and future impact scenarios, such as sea-level rise models, to spatially analyze vulnerability for the City and surrounding area.
- Action 3.1.2: Develop an adaptation strategy that focuses on highly vulnerable areas and offers a range of adaptation actions. Prioritize adaptation actions using tools such as multi-criteria analysis (MCA), cost-benefit analysis (CBA) and/or social accounting matrices (SAM).
- Action 3.1.3: Monitor the system's ability to cope with change over time, making any adjustments to policies and increasing or redirecting programmatic support tools as necessary.

Objective 3.2: Identify and remove additional stressors and external change agents with the potential of negatively impacting the local system, by making the city, its businesses and residents, self-sufficient.

- Action 3.2.1: Adopt a city transit plan that decreases fossil fuel dependence and increases access and mobility for all members of society.
- Action 3.2.2: Increase food security by establishing a weekly farmer's market, incentivizing composting and home gardening, and utilizing vacant sites for community garden projects.
- Action 3.2.3: Consider the creation of a special energy district over the city, by which solar power installations and other energy producing infrastructure could be funded through a bonding mechanism, ultimately transitioning the city into its own energy provider within one generation.
- Action 3.2.4: Develop a "Rainy Day" campaign to educate citizens about on-site water retention and provide rain barrels and other low-tech structures at no cost. (Lowering water supply demand reduces pressure on the aquifer, keeps the water table higher and decreases the likelihood of saltwater intrusion into our drinking water. Also, increasing independent storage capacity lessens the vulnerability of residents to seasonal water supply shortages.)

Objective 3.3: Develop and implement adaptive planning and zoning policies, regulations and programs to ensure that land use, construction and redevelopment activities consider the range of likely impacts of climate change.

- Action 3.3.1: Coordinate with Broward County, the South Florida Regional Planning Council, and other coastal municipalities in the state to develop standardized legal frameworks for land use regulations for limiting development in highly vulnerable areas.
- Action 3.3.2: Expand the building design and site placement review process for projects within the coastal high hazard zone to ensure their incorporation of climate change protection and adaptation strategies. Staff shall define new base finish floor elevation standards using projected sea level rise scenarios and flooding potential, consider lifespan exit strategies and cradle-to-cradle requirements for all new buildings, and determine the feasibility of alternative building foundations, such as floating, and other innovative strategies for adaption of the built environment.

Objective 3.4: Use adaptive management to administer the Climate Change Program in order to ensure program efficiency and effectiveness, and to reduce response time to any changes in the environmental, social or political conditions.

- Action 3.4.1: Survey current strategic plans and development priorities to understand institutional capacity, reduce redundancy, and identify areas of mutual support.
- Action 3.4.2: Develop and implement a local adaptation plan that is based on the City's research efforts regarding climate change vulnerability and response opportunities.
- Action 3.4.3: Establish a process and schedule for program evaluation. Staff will define measures of success for each response strategy, and regularly review and modify interventions accordingly.
- Action 3.4.4: Reassess vulnerability, survey best practices in the field, and update baseline scientific data every ten years to ensure that planning documents and activities are based on current conditions and needs.

Regarding the City of Hollywood, in June 2017, the City Commission voted on Resolution R-2017-168 to reaffirm its commitment to climate action. The resolution R-2017-168 states that "the City Commission of the City of Hollywood, FL, To Reaffirm Commitment To Climate Action And The Climate Goals Set Out In The City's Sustainability Action Plan, To Support The Principles And Goals Of The Paris Agreement, And To Continue To Implement Actions To Meet Established Climate Mitigation Goals."

The following are the parameters of the City's plan related to climate change that specifically address flooding issues:

"Goal #1: Reduce the City's contribution to the driving causes of sea level rise and climate change.

Actions to reduce GHG emissions:

1 Include sustainability criteria in all City plans and guidelines.
8 Improve energy efficiency at City properties.
9 Adopt green procurement policies.
12 Increase the renewable energy generated and used by the City.
14 Retrofit street lights to LED.
21 Track community scale greenhouse gas emissions and set reduction targets.
35 Create zoning regulations to encourage multi-modal transit.
37 Enhance green building program.
46 Mitigate urban heat island.
56 Develop energy efficiency programs.
59 Increase renewable energy generation city wide.
65 Decrease emissions related to solid waste.
72 Reduce air pollution related to vehicles.
75 Increase air quality by planting trees.
86 Increase the transit options available in the City.
87 Increase ridership on existing transit system.
88 Improve the City's bike infrastructure.
90 Enhance walkability in the City.
91 Create parking policies that will decrease vehicle miles traveled and congestion related to parking.
93 Increase the number of vehicles which are fuel efficient or use alternative fuels."

While most of these items are focused on climate change and reducing greenhouse gas emissions, the land development connection in Section 3.1.4.5 addresses the need to build for resiliency.

3.6 Dedicated Funding Sources

Funding for stormwater improvement projects can come from various sources. Some can come from accumulating funds from stormwater fees. Borrowing of funds for implementation projects can be accomplished at low interest rates from the State Revolving Fund (SRF) loan program that finances the cost of construction of publicly owned water, wastewater and stormwater facilities. Authority for the program is found in Chapters 62-622, 62-503 and 62-504 of the Florida Administrative Code. FDEP is charged with implementing the program. Generally, any local government entity is eligible to apply for SRF loans.

Dania Beach and Cooper City have made use of stormwater utility fees or assessments as a dedicated funding source, as has Hollywood. Davie has undergone two attempts but abandoned both based on political disinterest. However, Davie should consider establishing some form of stormwater utility assessment to help funding their specific flood control needs.

USACE relies on ongoing federal funding from U.S. Congress to meets its obligations. The SFWMD has the ability to enact property taxes to meet its mission. As a result, there appears to be funding to meet the obligations for the study area.

4.0 ASSESSMENT OF VULNERABLE AREAS

Defining flood risk due to compounding hydrographic influences is the central concern of this WMP. Modeling and assessment of vulnerability focused on the combination of a high water table elevation, heavy rains, and impervious conditions that can lead to localized nuisance flooding events. Through previous survey with local officials, the number of days of continuous nuisance flooding that the public will tolerate before that flooding is considered destructive is about 4 days (E Science 2014).

For a large study area, small portions may actually be at risk. The point is to identify where further study might be needed. A screening tool accomplishes this goal applied to the subwatershed scale to designate areas that are susceptible to periodic flooding events during key design storms. Utilizing the information collected and analyzed in Chapters 1 and 2, and comparing to data in Chapter 3, vulnerability can be identified using this process.

4.1 Historical and Existing Challenges

There are a series of historical challenges along the east coast of Florida that impact the HUC 030902061205 Davie/Dania Beach subwatershed including the following:

1. Control of discharges to the Atlantic Ocean from Lake Okeechobee, which cause ecosystem damage, harmful algal blooms, and other water quality issues for the coastal ocean
2. Flooding near Lake Okeechobee and the coastal ocean
3. Development adjacent to the floodplain
4. Use of C-51 reservoir (SFWMD, 2009) to prevent the major flushing event by holding water back
5. Water supply and flood protection are intertwined, opposing issues throughout the basin
6. Reconciliation of local and regional planning efforts
7. Water quality concerns with nutrient-laden Lake Okeechobee water and runoff from agriculture impacting southeast Florida canals

Pressure for development in the eastern portion of the basin exacerbates effort to protect open space for land percolation of water. While regulations are in place to reduce the influx of stormwater, challenges will continue with development. In the eastern portion of the regional watershed, the major water quality issues are associated with nutrient runoff and discharges from Lake Okeechobee that are regulated by USACE and SFWMD. CERP is supposed to address these regional issues. Localized flooding is the responsibility of the underlying local governments and their dedicated funding sources or general fund revenues.

4.1.1 Existing Management Efforts in the Subwatershed

The entire basin is controlled by the SFMWD and USACE with the intent of reducing flooding. Local governments have local stormwater utility infrastructure and planning/policy tools to reduce future flood potential, as discussed in Chapter 3. Most of the major projects to date have been driven by the SFWMD.

Hollywood has installed three major stormwater pumping stations since 1995 and has retrofit coastal outfalls with tideflex valves. Dania Beach has been planning a southeast drainage project for 15 years, but design has only recently been started. Davie addresses flooding as directed by the Town Council but has limited funding for capital construction. Cooper City is less impacted than the other three communities based on is location. Planned capital projects are presented in Section 6.4.

4.1.2 Critical Target Areas Identification

By modeling the Davie/Dania Beach subwatershed flood response to design storms outlined in Section 3.2, and further classifying flood risk as the probability of inundation, it was possible to identify critical target areas. These areas are particularly vulnerable to flooding and are subject to further study through a scaled-down modeling approach. The screening tool is first applied at the greater watershed level to provide an initial risk assessment focused on the hydrologic response to a rainfall event given the unique characteristics and features of the subwatershed or study area. The process is discussed later in Section 4.2, with results presented in Section 4.4.

4.1.3 Potential Preservation Areas

Broward County has a plan for limited land acquisition along the coast and in the sloughs throughout the County. Generally, these are incorporated in to parks as the two small areas that are wetlands in the subwatershed currently are. None of the other local governments within the HUC 030902061205 Davie/Dania Beach subwatershed have such plans. Protected lands are noted in the land use plans discussed in section 3.1.4.

4.2 Vulnerability Maps

4.2.1 Screening Tool

The screening tool utilizes topographic data from various sources (Section 2.1), water table elevations (Section 2.2) and surface water gauges (Section 2.3) downloaded from the SFWMD DBHYDRO website, tidal information for coastal areas obtained from the NOAA Current & Tides website (Section 2.3), soil maps obtained from the USDA (Section 2.4), and other key datasets, as described previously in Chapter 2. The design storms are discussed in Section 3.2. The reason this is critical is that to do any modeling (as required by the CRS program), a screening tool should be used to identify regions with a high risk of inundation based on multiple collected datasets and hydrological models. Figure 56 shows how the GIS layers interface in the tool and how they are combined for spatial analysis.

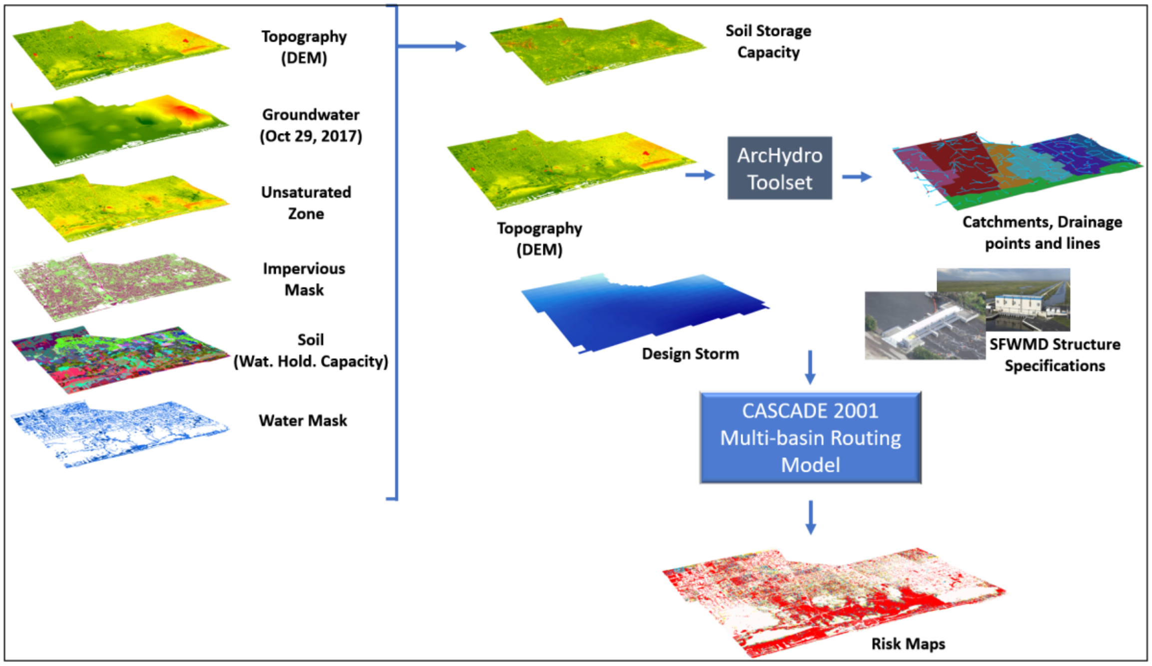

Figure 56. Screening tool methodology for creating flood risk maps

The model chosen for this screening tool is Cascade 2001, which is a multi-basin hydrologic/hydraulic routing model developed by the SFWMD to determine flooding scenarios for different storm events.

The software creates a glass box where water rises to a certain level and then decreases. Running the simulation requires defining the basin (HUC or sub-HUC) and input of the following data:

- Area
- Portion of area above a given elevation
- Initial ground water stage
- Longest travel time for the runoff to reach the most distance point of discharge
- Ground storage as estimated from the USDA gridded National Soil Survey Geographic Database (gNATSGO)

  Ground storage ≈ (Water holding capacity) × (Surface elevation – GW elevation)
  = 2 × (AWS for a soil layer of 0-150 cm) / 150cm × (Surface elevation – GW elevation)

- Available water storage (AWS) for a soil layer of 0-150 cm
- Average amount of precipitation that can be stored in the soil layer

The output from the model is an elevation surface that can be used to develop a flood map for the study area. An example that depicts the spatial distribution of probabilities of flooding for the 3-day, 25-year storm event is shown in Figure 57.

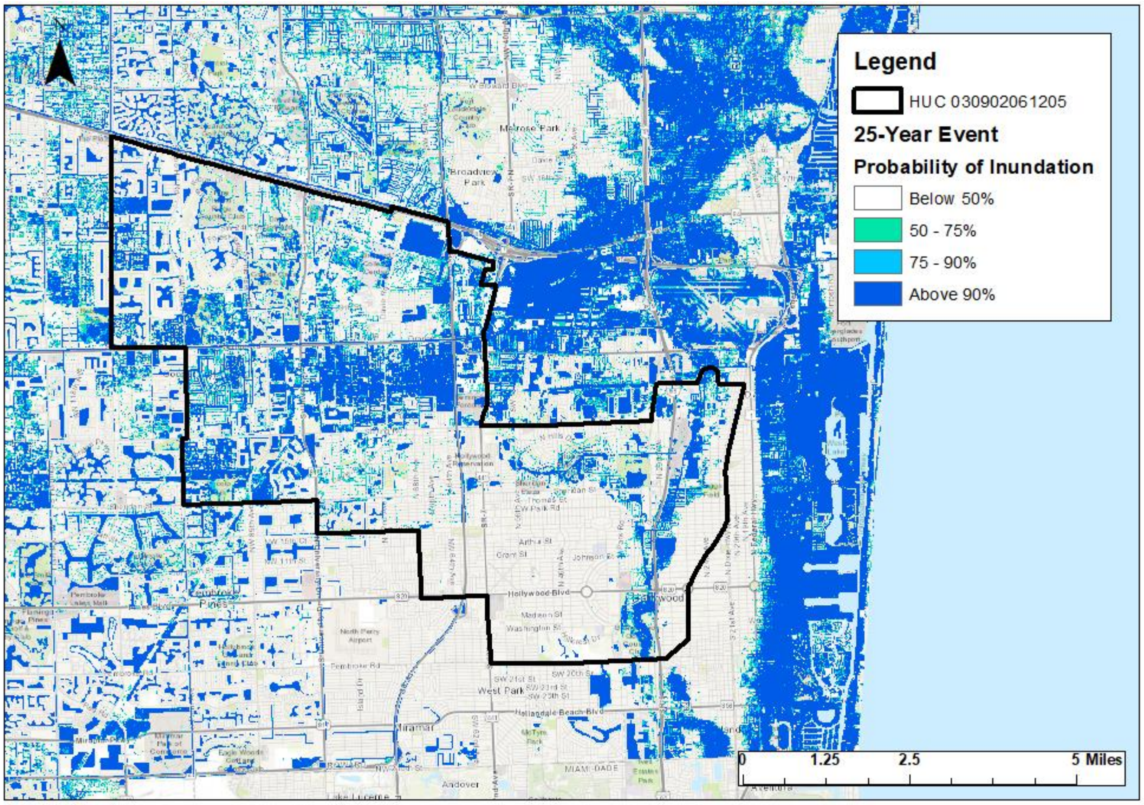

Figure 57. Probability of flood risk map for the 3-day, 25-year storm event in HUC 030902061205 Davie/Dania Beach subwatershed, as processed by FAU

Just because a property is shown to flood does not mean it always floods. The flood maps can be compared to the repetitive loss properties uploaded to the GIS platform as a separate layer, as shown in Figure 58.

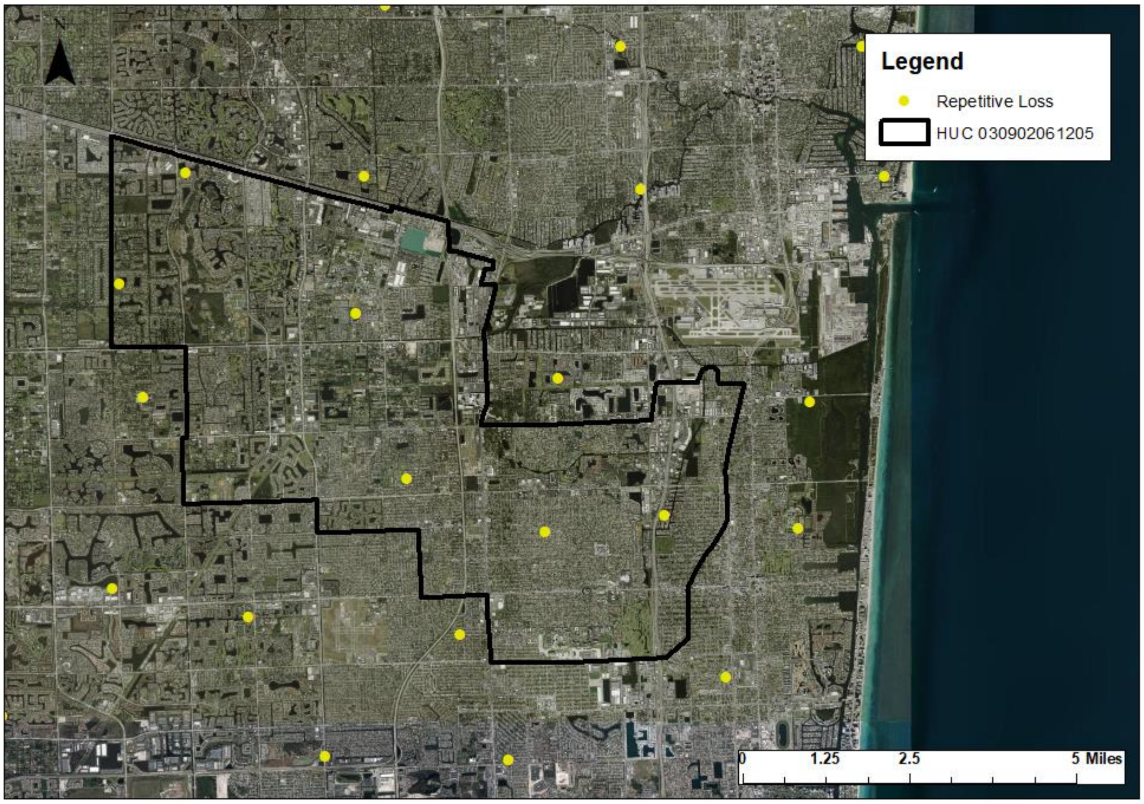

Figure 58. General locations of repetitive loss properties in the HUC 030902061205 Davie/Dania Beach subwatershed

4.2.2 Identification of Vulnerable Areas

Given the model assumptions and the Cascade 2001 outputs, the goal of this methodology is to produce a spatially-temporally quantified understanding of nuisance-destructive flood potential in the study area given observed values. Risk is a function of compounding geo-hydrological features, namely, surface water, groundwater, topography, build-out, and time of year. A GIS-based algorithm and spatial interpolation generated layers of the greatest observable hydrographic surfaces. These outputs were then compared with high resolution topographic LiDAR data to develop digital elevation models that reflect the observed risk landscape.

Figure 59 shows an example of the predicted flooding after the 3-day, 25-year storm event compared to the repetitive loss property maps superimposed to the GIS platform as a separate layer with the repetitive loss map. They compare favorably. The lighter blue areas represent land that floods, while the dark blue areas are classified as wetlands, lakes, rivers, streams, and other waterbodies.

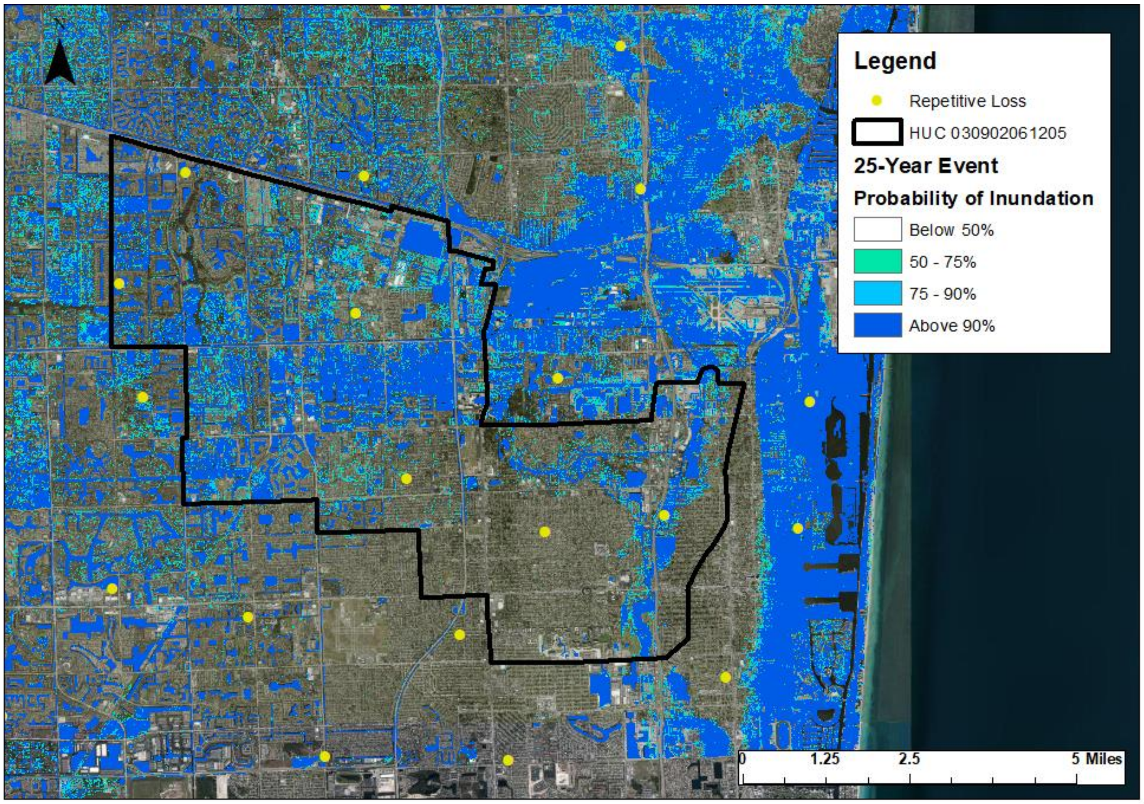

Figure 59. Flooded areas during a 3-day, 25-year storm in the HUC 030902061205 Davie/Dania Beach subwatershed as processed by FAU. The gold dots indicate repetitive loss properties from 2004 to 2014, from FEMA files.

To evaluate flood vulnerability at this scale, the analysis starts with a binary flooding surface (0 = below 50% chance of flooding; 1 = above 50% flooding) based on output from the screening tool for a specified design storm. Next, attributes of that raster based on "VALUE = 1" query are extracted using *Extract by Attributes* tool. Then the *Batch Project* tool was used to map critical facilities data to the common coordinate system (NAD83 UTM Zone 17N), unit = meters. Then a field was added using *Add Field* for [PriorityTier] = assigned Tier #1-4 value from the DOR codes and [Area_sqmeter]. The critical facilities layers were then merged into a single layer to calculate the polygon geometry for [Area_sqmeter] using the *Merge* tool. Next, *Zonal Statistics as Table* is used to calculate the SUM of flooded values ("VALUE = 1") within each critical parcel. Output table has fields for SUM (i.e., total # of flooded pixels per critical parcel) and AREA in map units of square meters (since each pixel in the flooding surface has a cell size of 3-meters by 3-meters, each area is equal to the SUM value multiplied by 9 m^2). Using the *Join Field* tool, the SUM and AREA fields are joined to the merged critical facilities layer based on a key attribute, first renaming these fields for clarity (e.g., AREA_FLOODED_3d25y). Once all field data is included, the next step involves using *Export Table* to export the dataset as a CSV file. Note that non-flooded parcels have zero flooded area, so they receive a <Null> value from the zonal statistics tool. To replace null values with zeros, we use *Calculate Field* in the attribute table along with the following Python expression (replacing the respective field name): "0 if !AREA_FLOODED_3d25y! is None else !AREA_FLOODED_3d25y!". Next, the CSV file is saved as an Excel Workbook (.xlsx). The Range is converted to an Excel Table, and the columns are rearranged in the desired order. Finally, the "percent-flooded" columns are calculated as follows:

- PCT_FLOODED_3d25y = ([@[AREA_FLOODED_3d25y]]/[@[TotalArea_sqmeter]])*100
- PCT_FLOODED_1d100y = ([@[AREA_FLOODED_1d100y]]/[@[TotalArea_sqmeter]])*100

After this calculation, the table is sorted to show the higher priority tiers and higher percent-flooded values first. To reduce the number of critical facilities shown in the final table, a filter was created to show only critical facilities with 10% or more flooded area in the parcel during both storm events. Records with duplicate parcel ID numbers were removed from the table. The results of this procedure are discussed in Section 5.2 of this document.

With respect to dams and levees, for purposes of the NFIP, FEMA only recognizes systems that meet, and continue to meet, minimum design, operation, and maintenance standards that are consistent with comprehensive floodplain management criteria. The Code of Federal Regulations,
Title 44, Section 65.10 (44 CFR 65.10) describes the information needed for FEMA to determine if a levee system reduces the risk from the 1% annual chance flood. FEMA has accredited levees and Provisionally Accredited Levees (that have a specified timeframe to obtain the necessary data to confirm the levee's certification status). If a levee system no longer meets Section 65.10, FEMA will de-accredit the levee system and issue an effective FIRM showing the levee-impacted area as a SFHA. FEMA coordinates its programs with USACE, who may inspect, maintain, and repair levee systems. USACE has authority under Public Law 84-99 to supplement local efforts to repair flood control projects that are damaged by floods. Like FEMA, USACE provides a program to allow public sponsors or operators to address levee system maintenance deficiencies. Failure to do so within the required timeframe results in the levee system being placed in an inactive status in the USACE Rehabilitation and Inspection Program. Levee systems in an inactive status are not eligible for rehabilitation assistance under Public Law 84-99. FEMA coordinated with USACE, the local communities, and other organizations to compile a list of levees that exist within Broward County for the FIS. There are no levees/dams listed in the subwatershed study area.

4.3 Future Challenges of Sea Level Rise and Climate Change

Climate change is likely to: 1) threaten the integrity and availability of fresh water supplies and 2) increase the risk of flooding, not only in the low-lying coastal areas, but also in the interior flood plains. Other issues include a) saltwater intrusion, which may be intensified by sea level rise, b) prolonged droughts that will contribute to water supply shortages and wildfires, and c) heavier rains during the rainy season and higher hurricane storm surge, which may increase the risk due to flooding. More frequent and damaging floods are likely to become an ever-increasing problem as sea level continues to rise because of: a) increasing groundwater table elevations and surface water gage heights, b) reduced groundwater seepage through the aquifer to the ocean, c) increasingly compromised stormwater drainage systems, and d) more frequent inundation of barrier islands and coastal areas.

NOAA and IPCC (2013) predictions suggest that by 2100, global temperatures will be on the order of 2-3°C (3-5°F) higher and sea levels will rise by up to 3 feet. Accompanying these drivers are potential changes in storm frequency and intensity, desertification, population migration, ocean acidification and coastal flooding (IPCC, 2007), exacerbated by the land cover and land use changes, which are substantially impacted by the fluxes, timing and quantity of precipitation (Adrians et al., 2003; Scanlon et al., 2005; Marshall et al., 2004; Salmun and Molod, 2006), and leading to changes in the timing of peak flows and volumes (Richey and Costa-Cabral, 2006).

An outcome of these climatic patterns is that during the past 140 years, an increase in sea levels has been observed (Bloetscher, 2012), a worrying pattern since sea level rise is a permanent phenomenon, that can be catastrophic to low lying areas in the long-term. The question is how much and how soon? Various studies (Bindoff et al., 2007; Domingues et al., 2008; Edwards, 2007; Gregory, 2008; Vermeer and Rahmstorf, 2009; Jevrejeva, Moore and Grinsted, 2010; Bloetscher, 2010, 2011; IPCC, 2007; Heimlich et al., 2009) indicate large uncertainty in projections of sea level rise by 2100. Gregory et al. (2012) note that during the last two decades, the global rate of sea level rise has been larger than the 20th-century time-mean, and Church et al. (2011) suggested that the cause was increased rates of thermal expansion, glacier mass loss, and ice discharge from icesheets. Gregory et al. (2012) suggested that there may also be increasing contributions to global sea level rise from the effects of groundwater depletion, reservoir impoundment, and loss of storage capacity in surface waters due to siltation. Measurements of Florida's east coast (Maul, 2008) show an average rate of sea level rise of 2.27 ± 0.04 mm per year from 1915 to 1992 based on tide gauge readings. Analyzing the tidal gauge readings for Florida shows that:

1. Florida average sea level rise is 2.10 ± 0.49 mm/yr

2. All but one location is within the 95% confidence limit range (the exception is Panama City where there is evidence of submergence and other land-based issues)
3. None of the Florida sea level rise rates differ statistically
4. Average global sea level rise for 1920-2000 was 2.0 mm/yr – within 95% confidence limit for Florida locations

From 1929 to 1992, over eight inches of sea levels have risen, with another 6 inches added since 1992, which is already having significant impacts on coastal communities where population growth has increased the need for improved flood management strategies (Bloetscher, 2008; Parkinson, 2010; Zhang et al., 2011, 2011a; NFIP, 2011; Schmidt et al., 2011; Warner et al., 2012). As a result, the SFRCCC (2015) adopted USACE's methodology to derive scenarios of sea level change intermediate to high rates of sea level rise for years 2030 (6" to 10") and 2060 (14" to 26") as the consensus projection to guide future planning in Southeast Florida.

4.3.1 NOAA intermediate High Scenario for the Study Area

NOAA (2017) outlines five scenarios for sea level rise. The NFIP proposes the use of the intermediate high projection for 2100, which is 61 inches from current sea level elevations (Figure 60), and the Southeast Florida Regional Climate Compact (SFRCC, 2015) projection recommended by its scientific working group for years 2030 (6" to 10") and 2060 (14" to 26"). The USACE high is equivalent to the NOAA intermediate high curve (61 inches by 2100). For this document, the NOAA intermediate high is modeled as 5 ft SLR in Section 4.4.

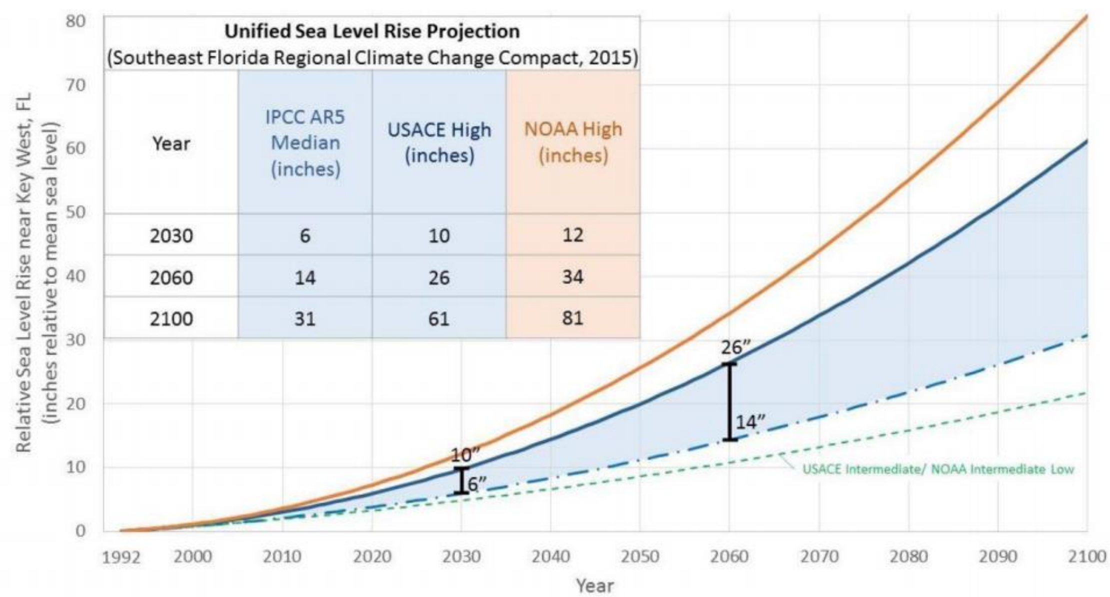

Figure 60. Graphic of sea level rise projections from NOAA (2017) (https://www.broward.org/BrowardNext/Documents/CompPlanDocs/archive/CCE%20Support%20Doc-Adoption%20March%202019.pdf)

4.3.2 Potential Sea Level Rise Impacts

As sea level rises, access to roads, bridges, rail, and transit could be at risk of flooding, causing the effects of sea level rise to spread indirectly throughout the entire transportation network, affecting the overall system performance. For example, the flooding of a critical road or facility access can cause a shifting of traffic flow causing congested conditions in other roadways that are not actually flooded. Since the roadway network would be unable to carry the traffic demand, the system would experience operational failure; as a result, causing travel times and delays. Moreover, the inundation of a critical access could cause transportation connectivity problems to essential infrastructure like ports or airports. Transportation infrastructure relies on the effectiveness of flood control and stormwater drainage systems for the transportation corridors. Road integrity relies on adequate drainage. The increased risk of severe flooding in Florida's low-lying terrain can adversely affect transportation infrastructure along the coastline; roads can be inundated, and roadway beds can be damaged. Sea level rise will cause increased water table levels (FDOT, 2012), as regional water tables cannot exist naturally below mean high tide (2 feet in Florida). Adding 3 feet of sea level rise on top of groundwater would compound the risk of flooding in low-lying areas. Road bases below 5 feet NVGD would become saturated under this scenario, likely causing premature base failure. As soil storage capacity is diminished due to rising groundwater elevations associated with sea level rise, the potential for more frequently flooded roadways would likely damage pavements (FDOT, 2012). Hence sea level rise must be accounted for in WMPs in coastal areas. To allow flexibility in the analysis due to the range of increases within the different time periods, an approach that uses incremental increases of 1, 2, and 3 feet of sea level rise is suggested for modeling. The increments can work as threshold values in planning considerations in terms of allowing planners the ability to know ahead of time where the next set of vulnerable areas will be, to allow for a proactive response approach that can be matched to the observed future rates. Sea level rise is a major concern since nearly half the US population lives within 50 miles of the coast, involving most major commercial, residential, and economic enterprises. The effects of sea level rise are shown in Figure 61 for Dania Beach, FL.

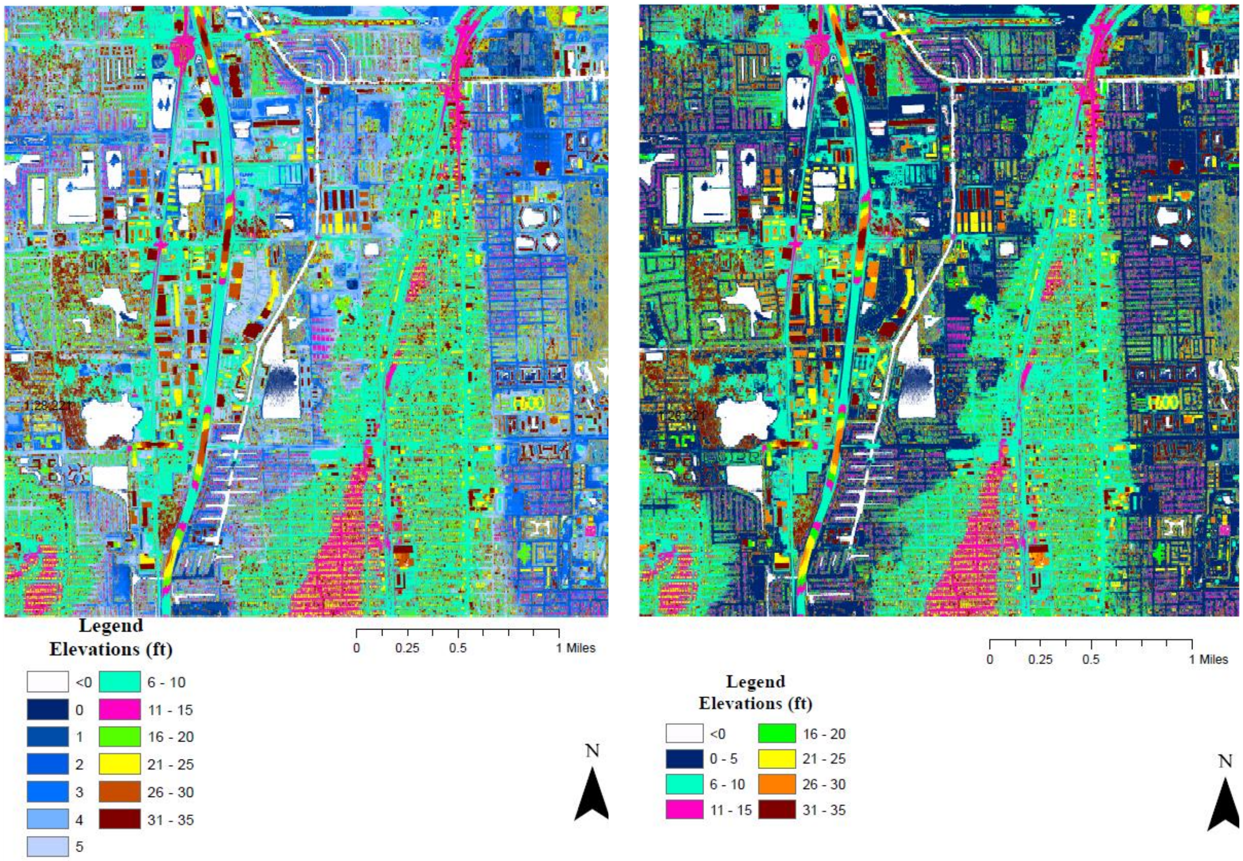

Figure 61. Current elevations of land under the 99th percentile tidal conditions for Dania Beach, FL (left) and projected conditions in the year 2100 (right) for Dania Beach, FL (Bloetscher, 2012), note that dark blue is land under 5 ft NAVD88 and potentially inundated at under the 99th percentile tidal conditions

4.4 Modeling Results

The following are a series of maps that depict risk of flooding in the study area based on the following scenarios:

1. 3-day, 25-year storm event (refer back to Figure 57)
2. 1-day, 100-year storm event (Figure 62)
3. 1-day, 10-year storm event (Figure 63)
4. For coastal areas – King tide at 2.6 ft (Figure 64)
5. King tide + 3-day, 25-year storm (Figure 65)
6. King tide + 1-day, 100-year storm (Figure 66)
7. King tide + 1-day, 10-year storm (Figure 67)

8. Sea level rise of 1 ft (only coastal area and GW affected – GW layer rises 1 ft) + 3-day, 25-year storm (Figure 68)
9. Sea level rise of 2 ft (only coastal area and GW affected – GW layer rises 2 ft) + 3-day, 25-year storm (Figure 69)
10. Sea level rise of 3 ft (only coastal area and GW affected – GW layer rises 3 ft) + 3-day, 25-year storm (Figure 70)
11. Sea level rise of 4 ft (only coastal area and GW affected – GW layer rises 4 ft) + 3-day, 25-year storm (Figure 71)
12. Sea level rise of 5 ft (only coastal area and GW affected – GW layer rises 5 ft) + 3-day, 25-year storm (Figure 72)
13. King tide at 2.6 ft + 1 ft sea level rise scenario above GW + 3-day, 25-year storm (Figure 73)
14. King tide at 2.6 ft + 2 ft sea level rise scenario above GW + 3-day, 25-year storm (Figure 74)
15. King tide at 2.6 ft + 3 ft sea level rise scenario above GW + 3-day, 25-year storm (Figure 75)
16. King tide at 2.6 ft + 4 ft sea level rise scenario above GW + 3-day, 25-year storm (Figure 76)
17. King tide at 2.6 ft + 5 ft sea level rise scenario above GW + 3-day, 25-year storm (Figure 77)
18. Sea level rise of 1 ft (only coastal area and GW affected – GW layer rises 1 ft) + 1-day, 100-year storm (Figure 78)
19. Sea level rise of 2 ft (only coastal area and GW affected – GW layer rises 2 ft) + 1-day, 100-year storm (Figure 79)
20. Sea level rise of 3 ft (only coastal area and GW affected – GW layer rises 3 ft) + 1-day, 100-year storm (Figure 80)
21. Sea level rise of 4 ft (only coastal area and GW affected – GW layer rises 4 ft) + 1-day, 100-year storm (Figure 81)
22. Sea level rise of 5 ft (only coastal area and GW affected – GW layer rises 4 ft) + 1-day, 100-year storm (Figure 82)
23. King tide at 2.6 ft + 1 ft sea level rise scenario above GW + 1-day, 100-year storm (Figure 83)
24. King tide at 2.6 ft + 2 ft sea level rise scenario above GW + 1-day, 100-year storm (Figure 84)
25. King tide at 2.6 ft + 3 ft sea level rise scenario above GW + 1-day, 100-year storm (Figure 85)
26. King tide at 2.6 ft + 4 ft sea level rise scenario above GW + 1-day, 100-year storm (Figure 86)
27. King tide at 2.6 ft + 5 ft sea level rise scenario above GW + 1-day, 100-year storm (Figure 87)

28. Sea level rise of 4 ft (only coastal area and GW affected – GW layer rises 4 ft) + 1-day, 10-year storm (Figure 88)
29. King tide at 2.6 ft + 4 ft sea level rise scenario above GW + 1-day, 10-year storm (Figure 89)
30. Sea level rise of 5 ft (only coastal area and GW affected – GW layer rises 5 ft) + 1-day, 10-year storm (Figure 90)
31. King tide at 2.6 ft + 5 ft sea level rise scenario above GW + 1-day, 10-year storm (Figure 91)

In all cases, flooding is noted along the coast, but also in many inland areas, especially to the far west. Of key importance is that once the sea level rises above 3 ft, the amount of flooding increases substantially. At 4 ft and higher sea level rise, with any storm, most of the area is inundated except the ridge along US 1. While 4-5 ft of sea level rise is expected from the 2100 NOAA intermediate high projection, for planning purposes, the state, SFWMD, Broward County, and local entities will need to develop significant efforts to protect property. The king tides in the fall exacerbate the situation, affecting large areas with only 2 ft of sea level rise which is likely to occur by 2100.

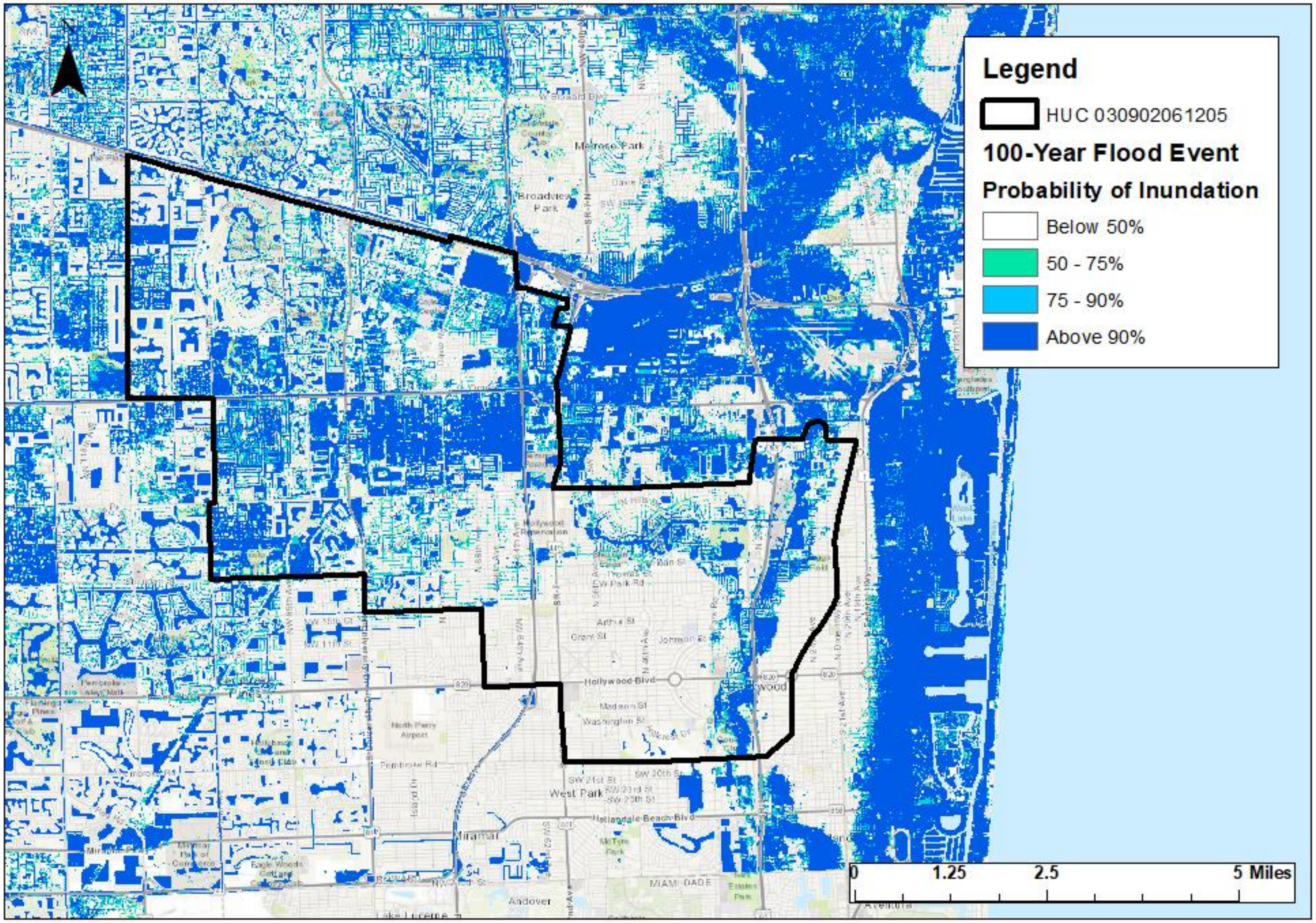

Figure 62. 1-day, 100-year storm event for the HUC 030902061205 Davie/Dania Beach subwatershed

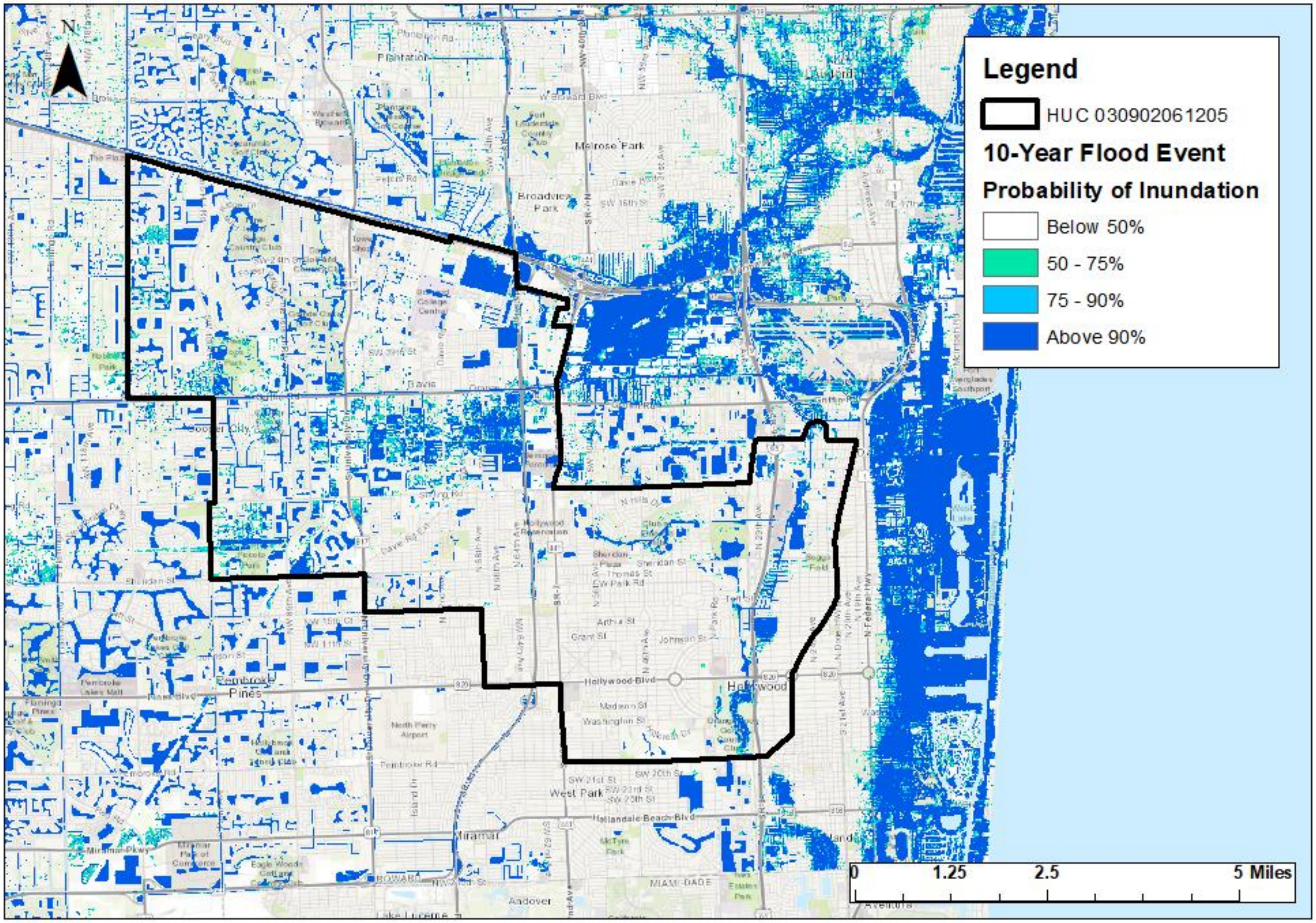

Figure 63. 1-day, 10-year storm event for the HUC 030902061205 Davie/Dania Beach subwatershed

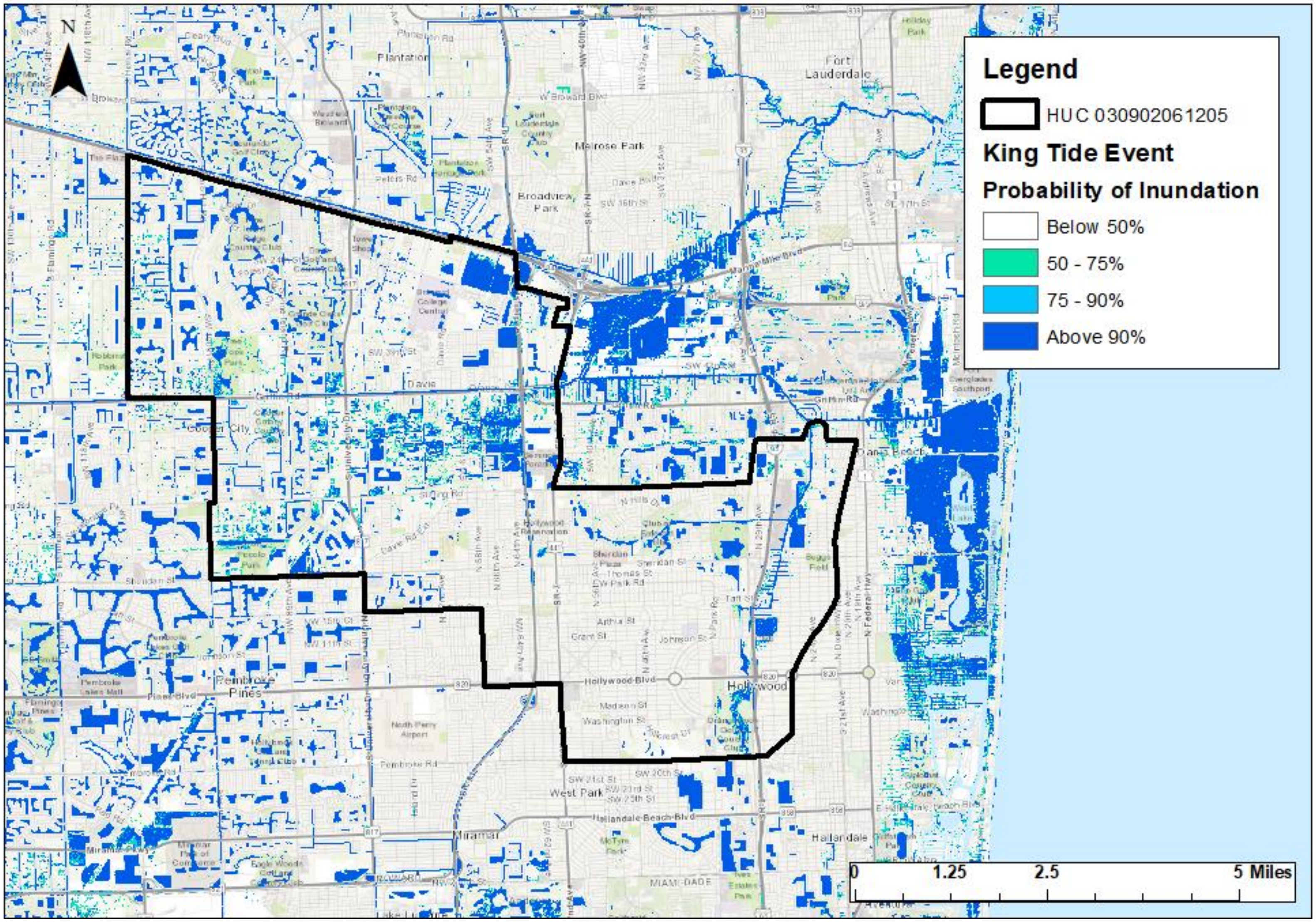

Figure 64. King tide at 2.6 ft for the HUC 030902061205 Davie/Dania Beach subwatershed

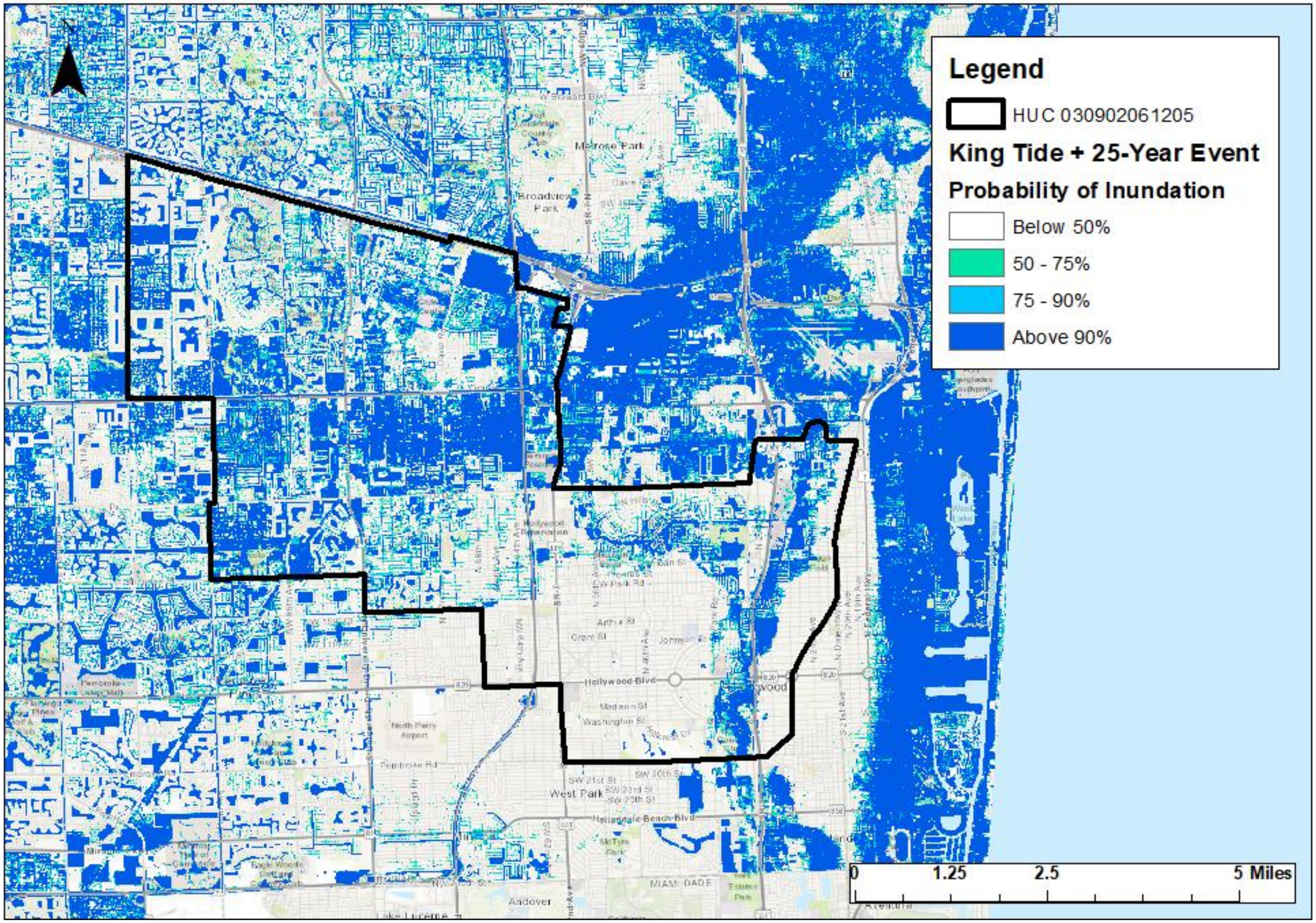

Figure 65. King tide at 2.6 ft + 3-day, 25-year storm for the HUC 030902061205 Davie/Dania Beach subwatershed

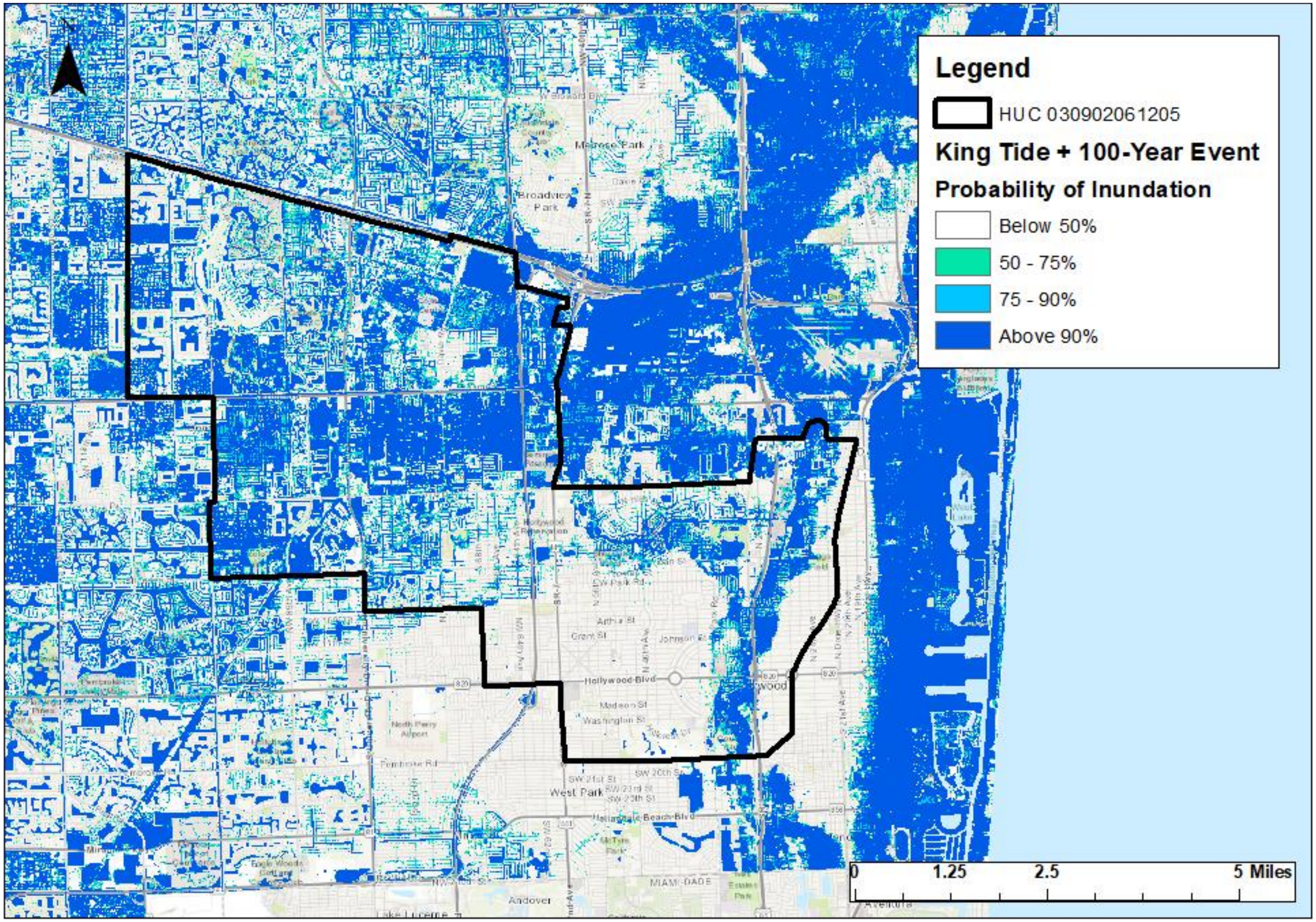

Figure 66. King tide at 2.6 ft + 1-day, 100-yr storm for the HUC 030902061205 Davie/Dania Beach subwatershed

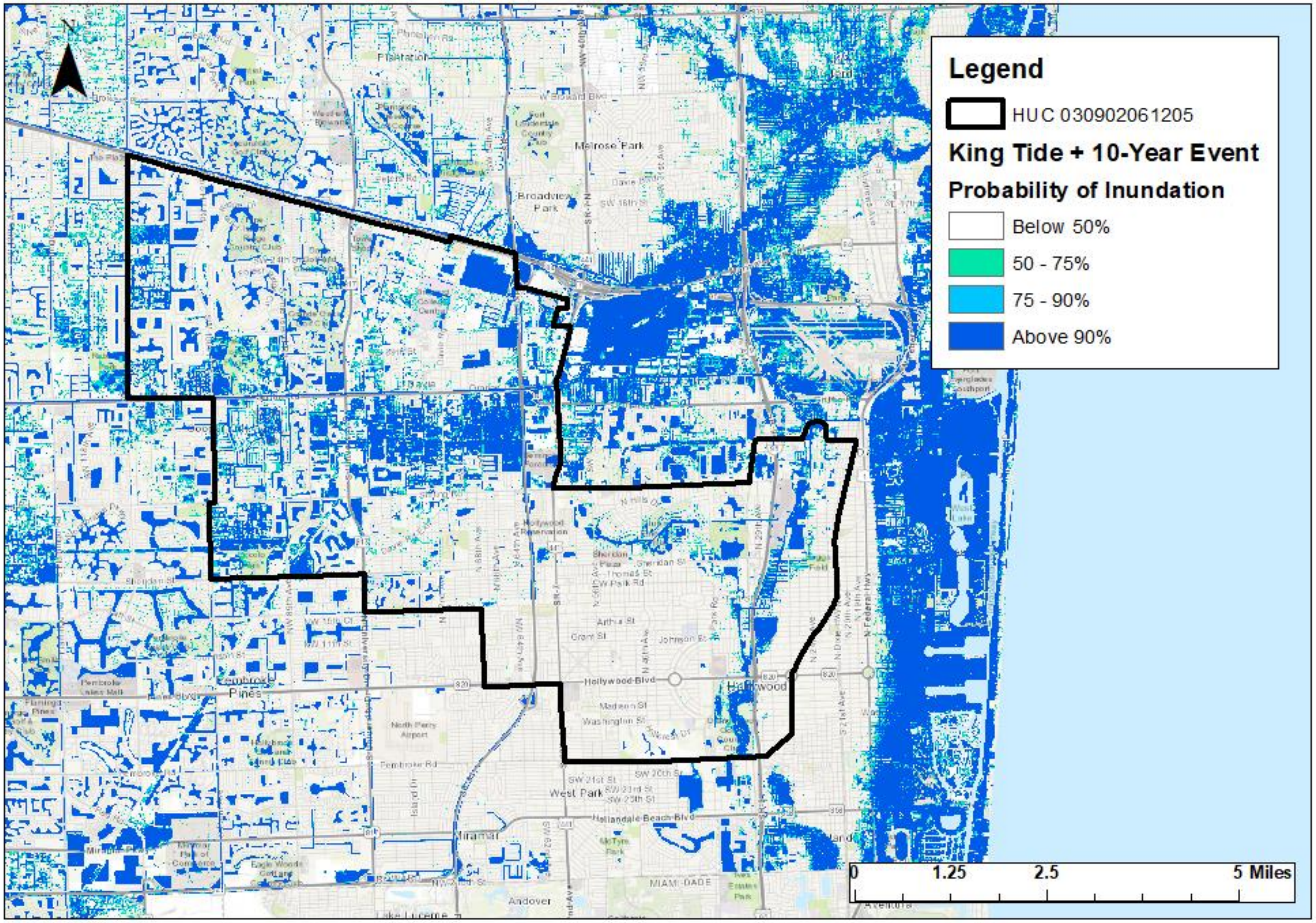

Figure 67. King tide at 2.6 ft + 1-day, 10-yr storm for the HUC 030902061205 Davie/Dania Beach subwatershed

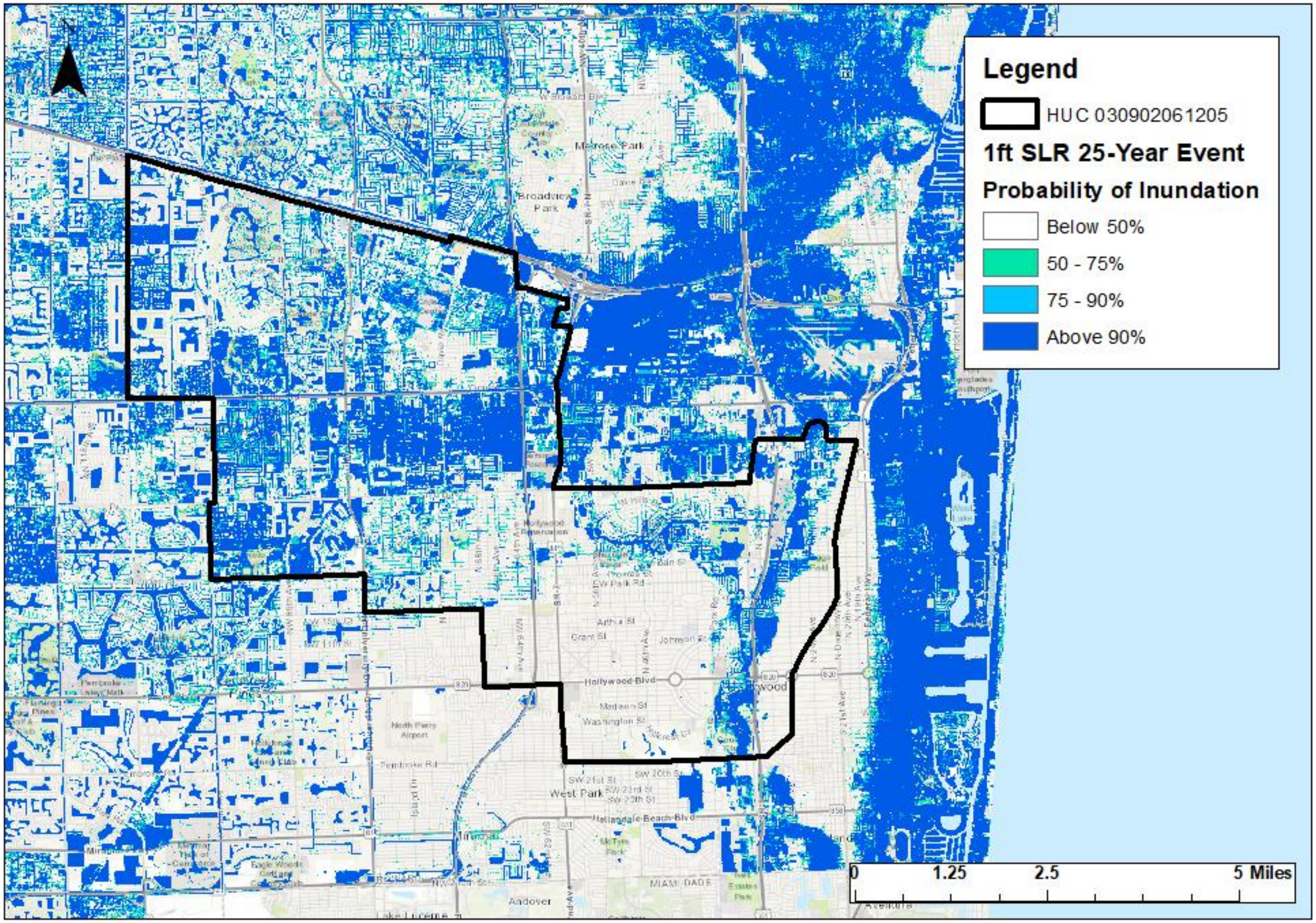

Figure 68. Sea level rise of 1 ft (only coastal area and GW affected – GW layer rises 1 ft) + 3-day, 25-year storm for the HUC 030902061205 Davie/Dania Beach subwatershed

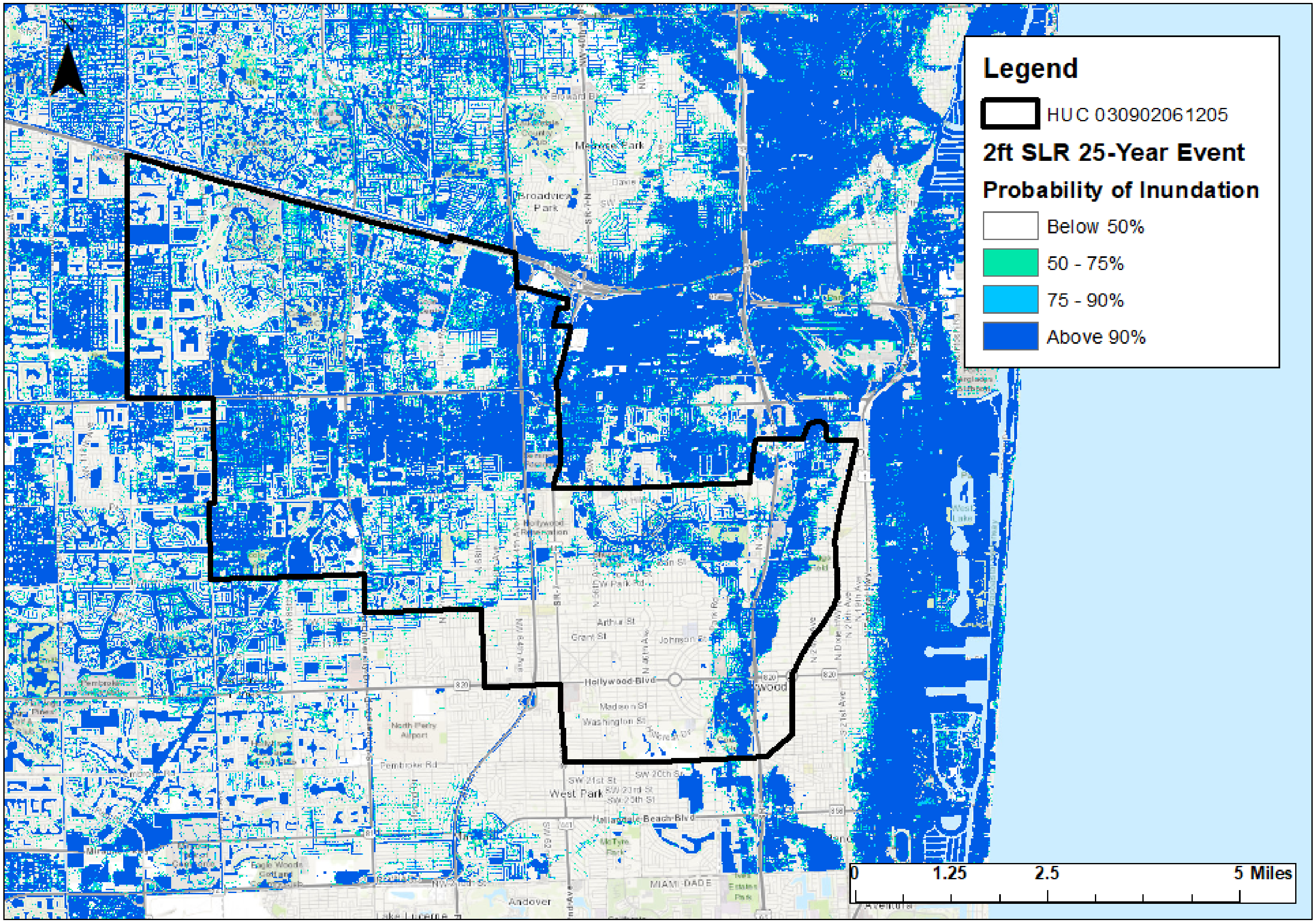

Figure 69. Sea level rise of 2 ft (only coastal area and GW affected – GW layer rises 2 ft) + 3-day, 25-year storm for the HUC 030902061205 Davie/Dania Beach subwatershed

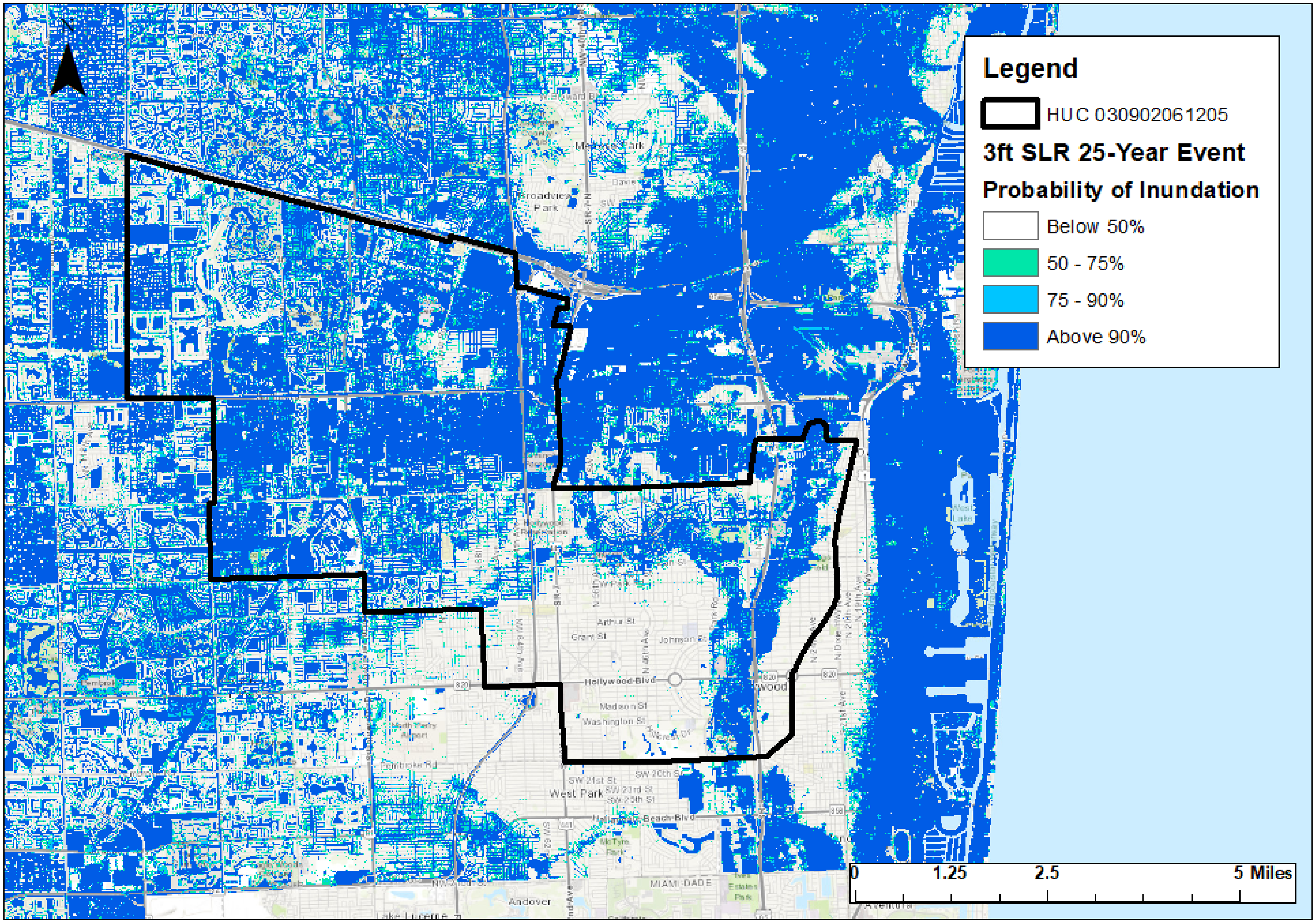

Figure 70. Sea level rise of 3 ft (only coastal area and GW affected – GW layer rises 3 ft) + 3-day, 25-year storm for the HUC 030902061205 Davie/Dania Beach subwatershed

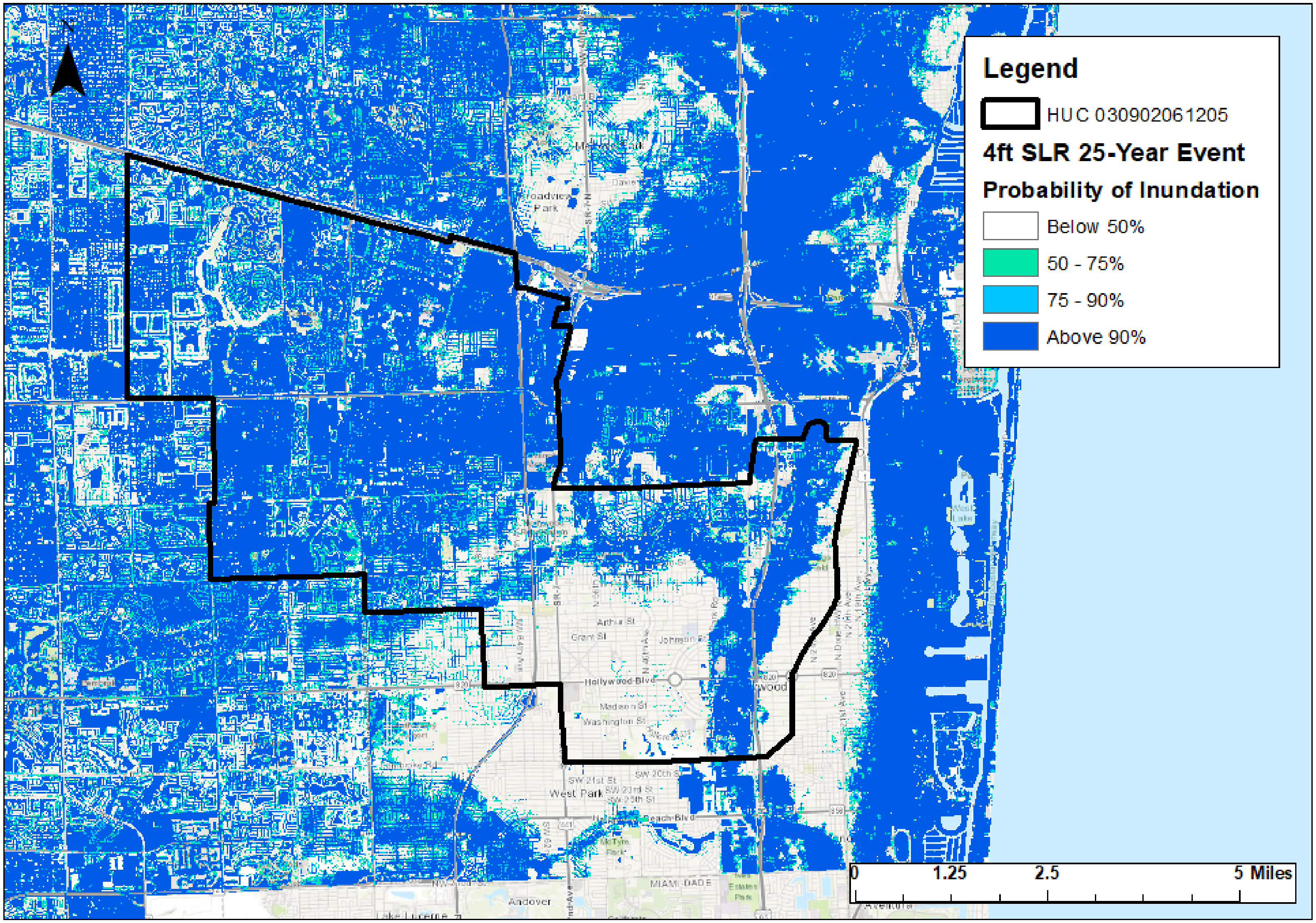

Figure 71. Sea level rise of 4 ft (only coastal area and GW affected – GW layer rises 4 ft) + 3-day, 25-year storm for the HUC 030902061205 Davie/Dania Beach subwatershed

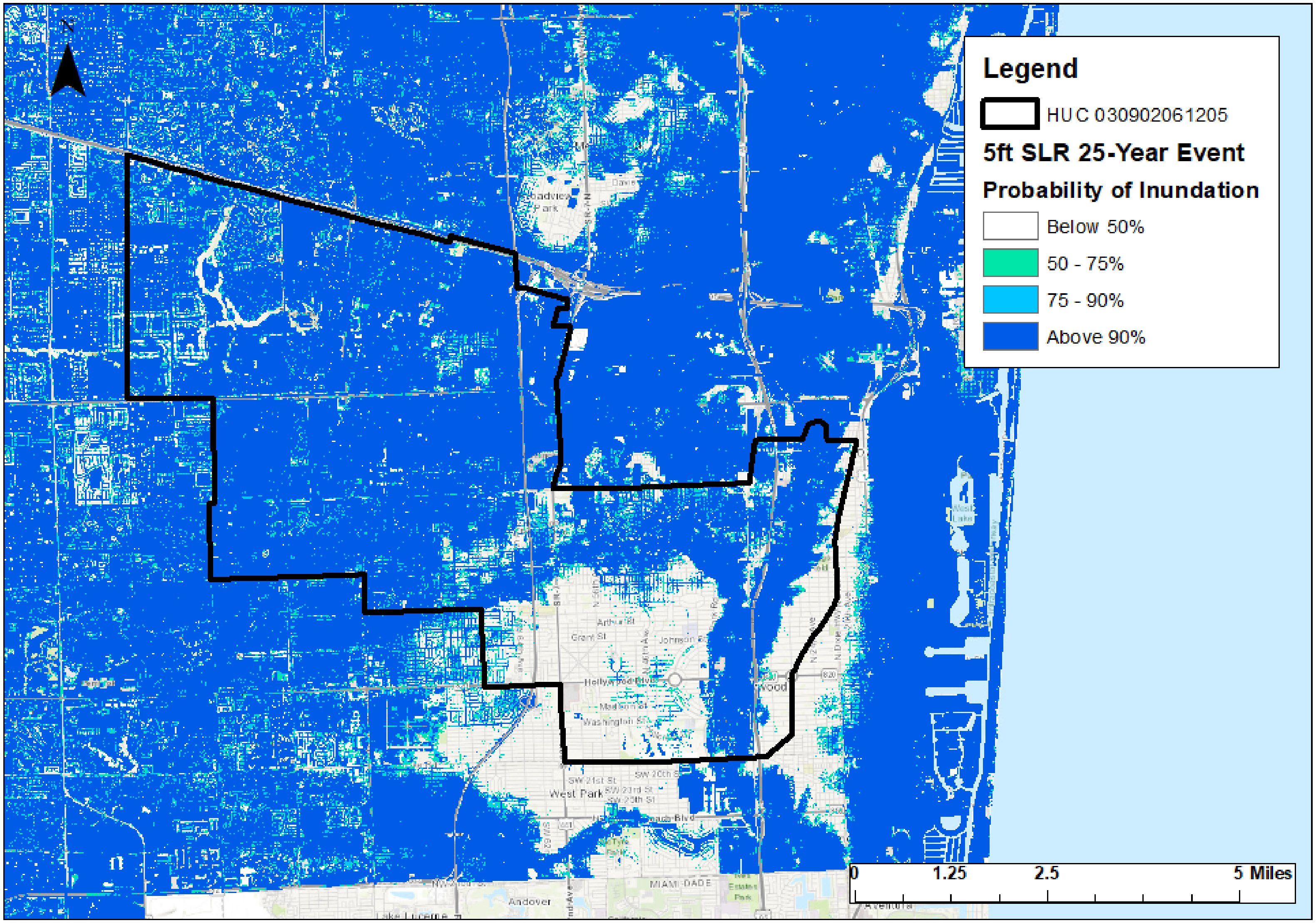

Figure 72. Sea level rise of 5 ft (only coastal area and GW affected – GW layer rises 5 ft) + 3-day, 25-year storm for the HUC 030902061205 Davie/Dania Beach subwatershed

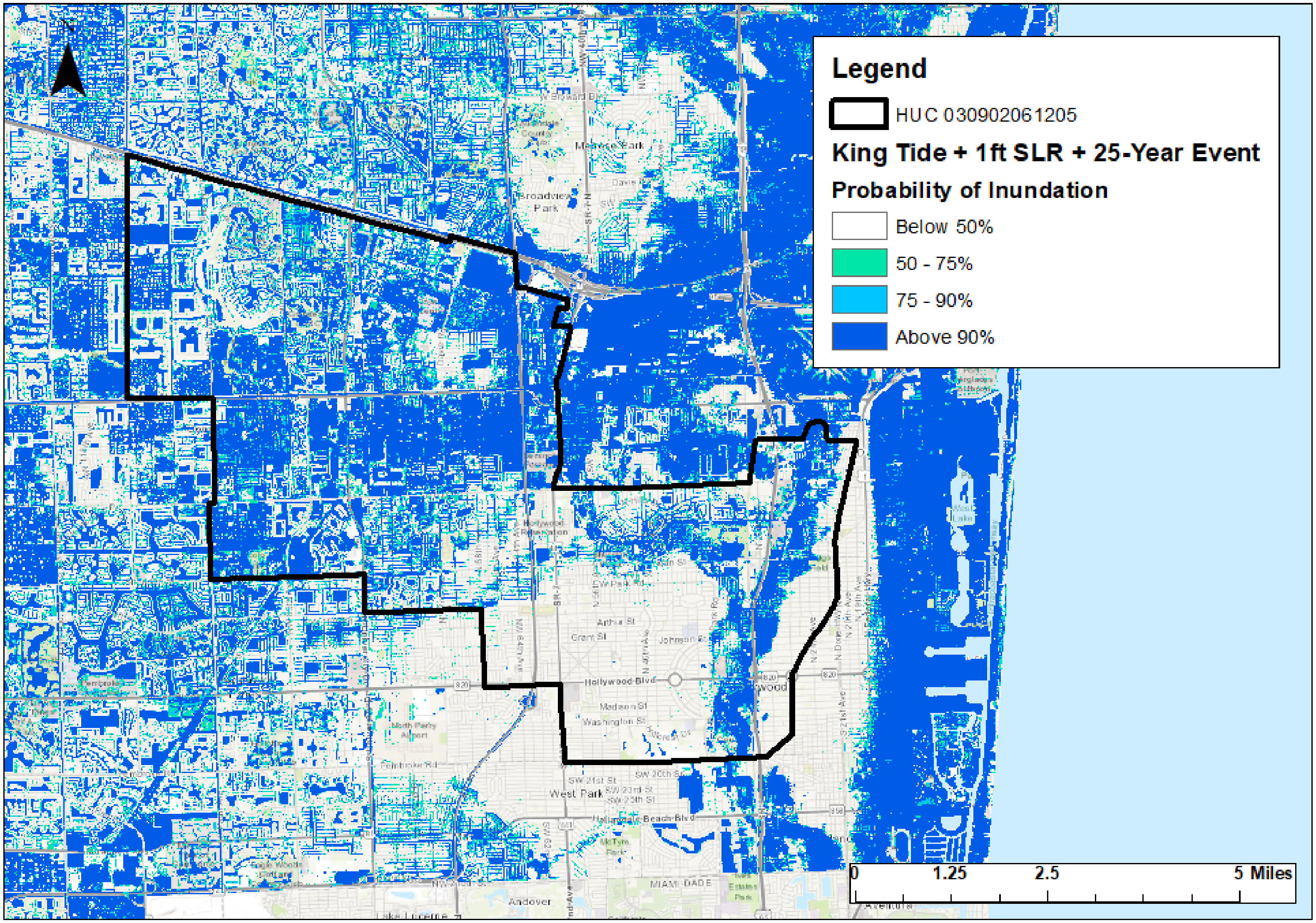

Figure 73. King tide at 2.6 ft + 1 ft sea level rise scenario above GW + 3-day, 25-year storm for the HUC 030902061205 Davie/Dania Beach subwatershed

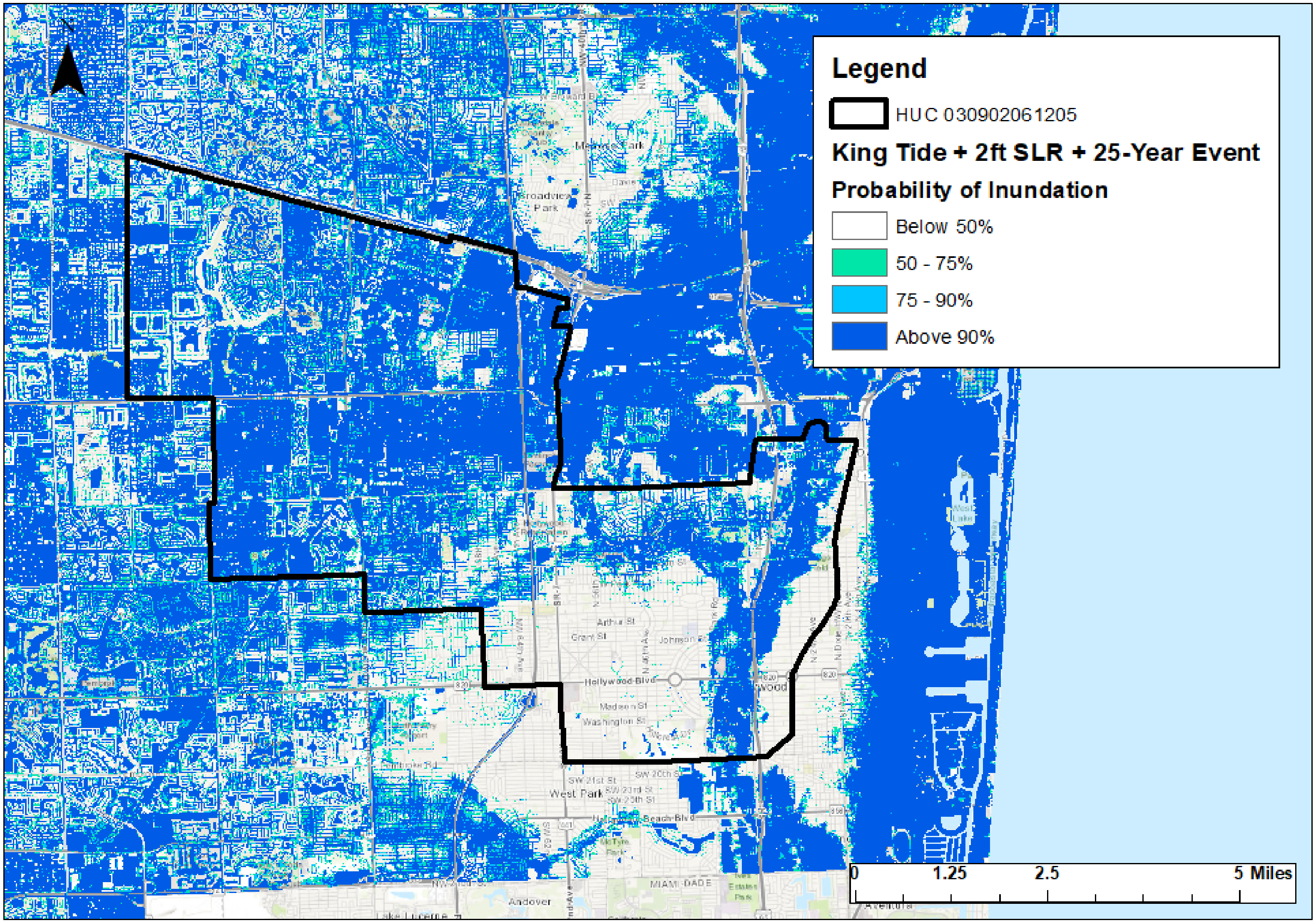

Figure 74. King tide at 2.6 ft + 2 ft sea level rise scenario above GW + 3-day, 25-year storm for the HUC 030902061205 Davie/Dania Beach subwatershed

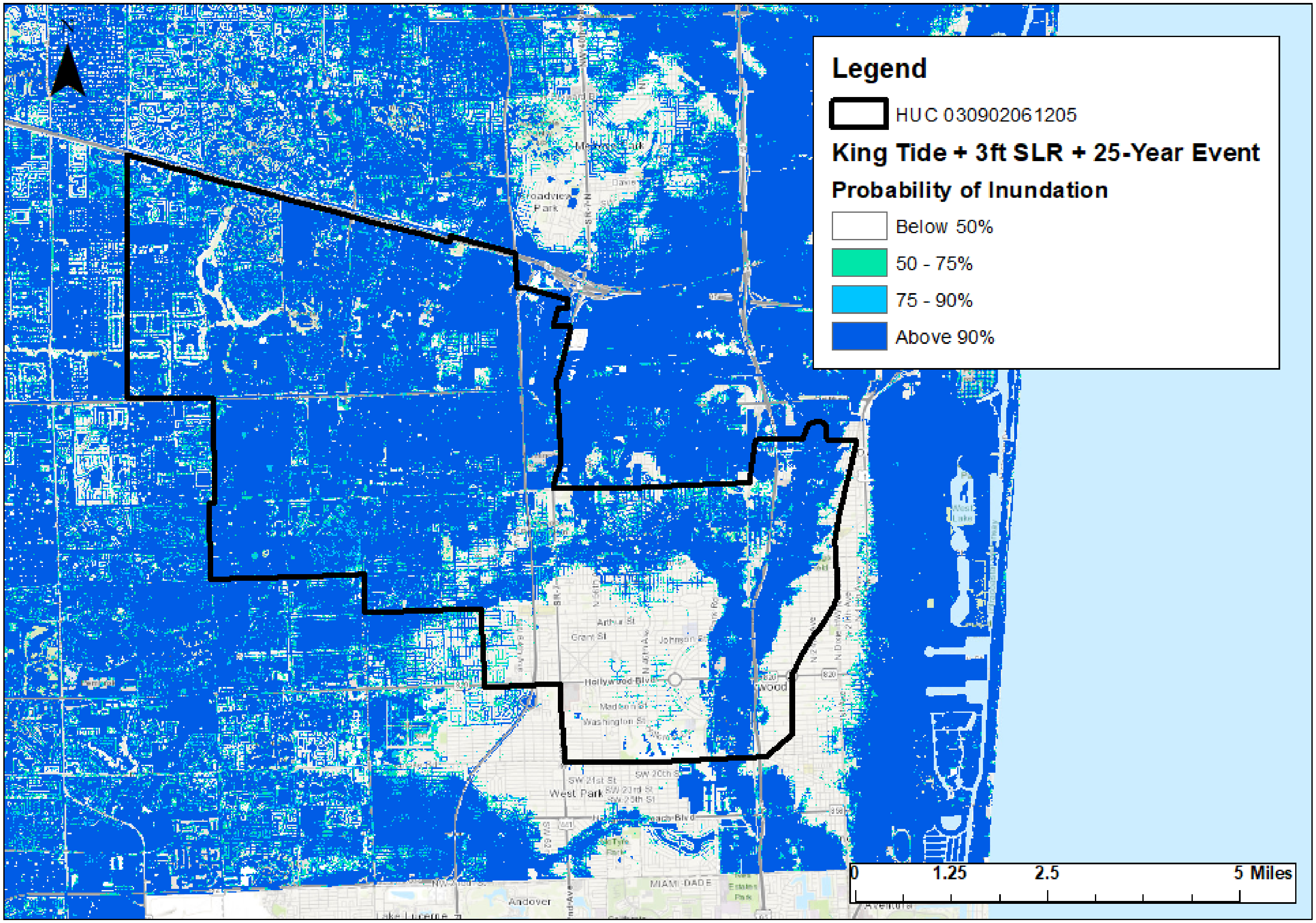

Figure 75. King tide at 2.6 ft + 3 ft sea level rise scenario above GW + 3-day, 25-year storm for the HUC 030902061205 Davie/Dania Beach subwatershed

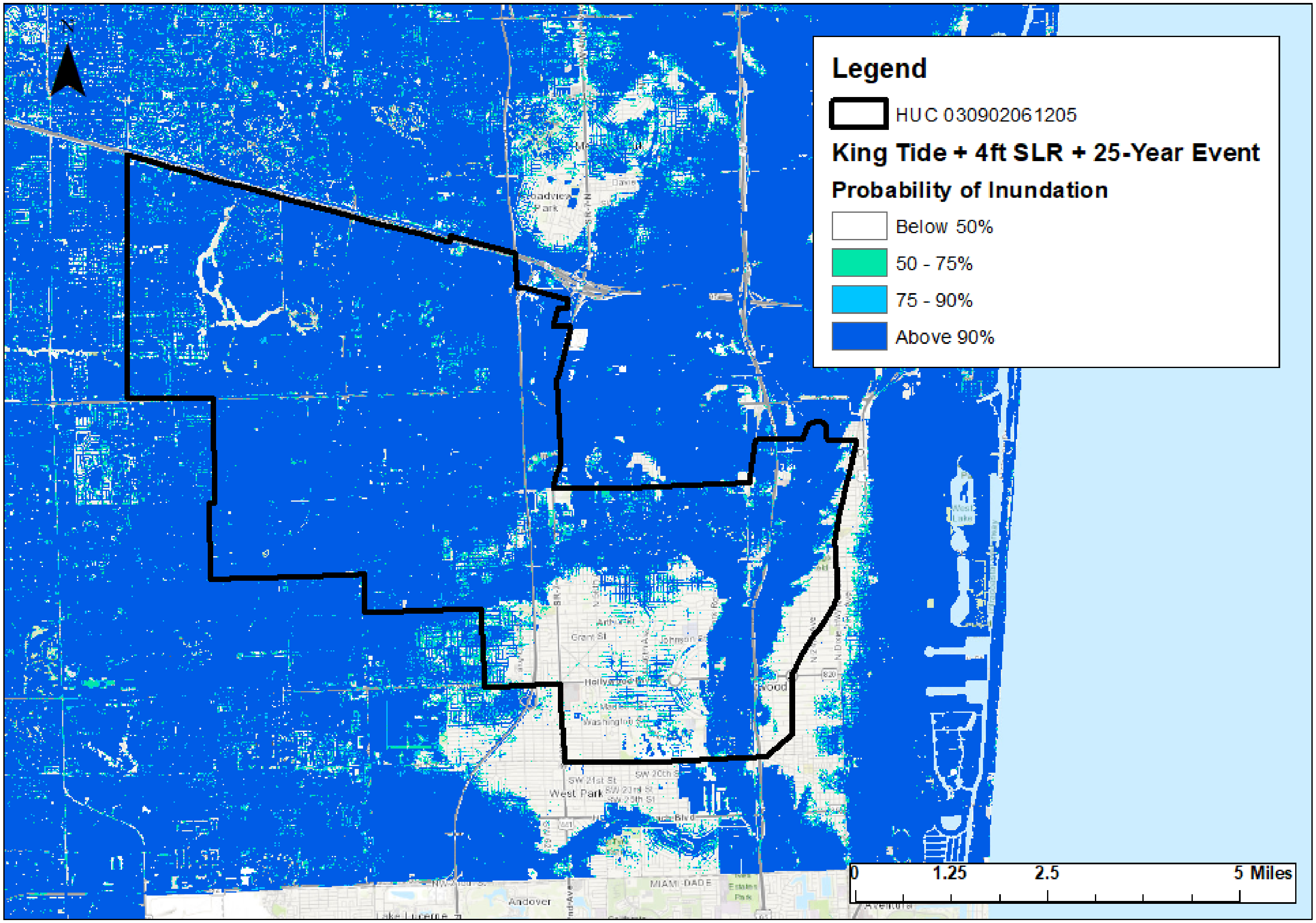

Figure 76. King tide at 2.6 ft + 4 ft sea level rise scenario above GW + 3-day, 25-year storm for the HUC 030902061205 Davie/Dania Beach subwatershed

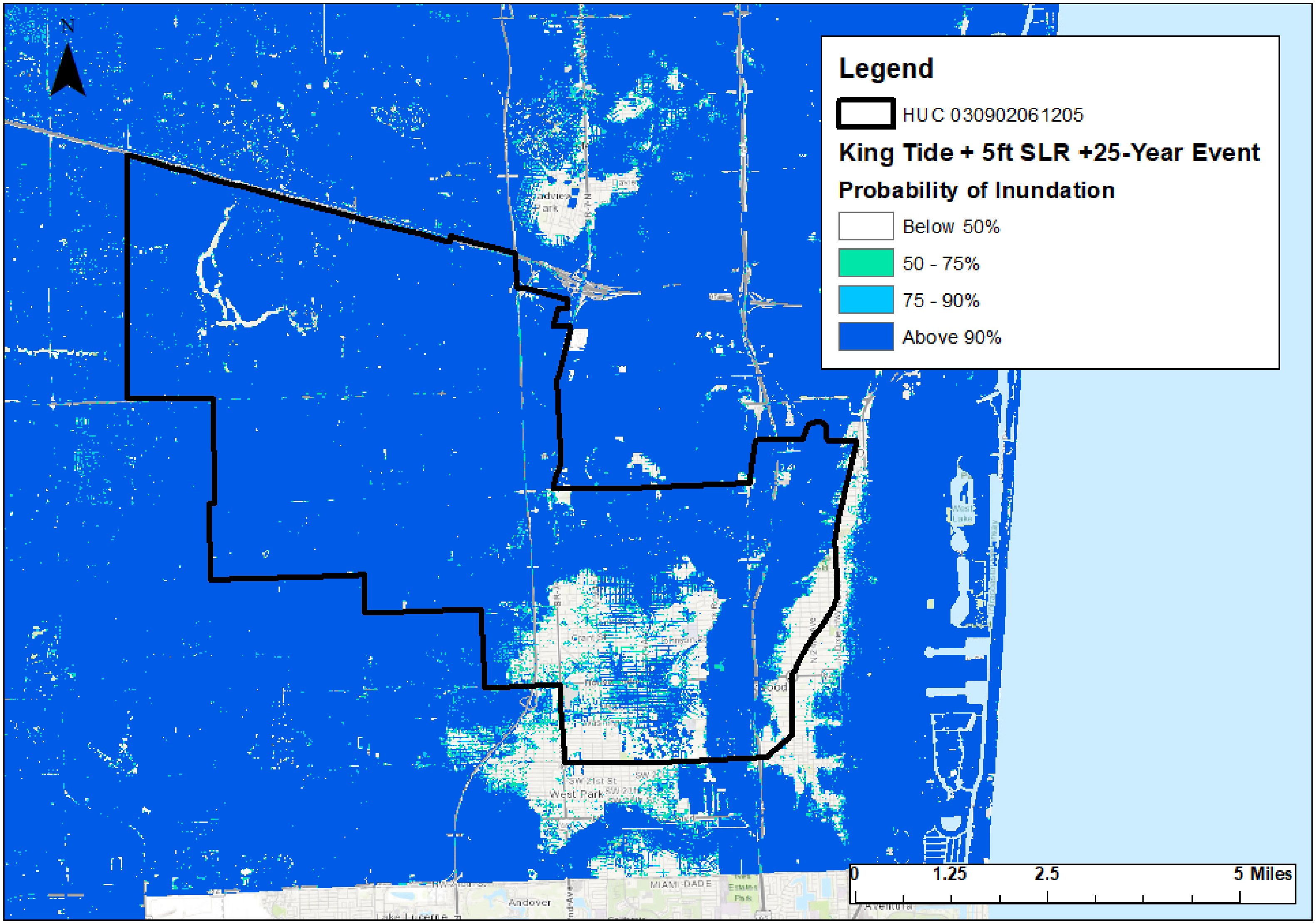

Figure 77. King tide at 2.6 ft + 5 ft sea level rise scenario above GW + 3-day, 25-year storm for the HUC 030902061205 Davie/Dania Beach subwatershed

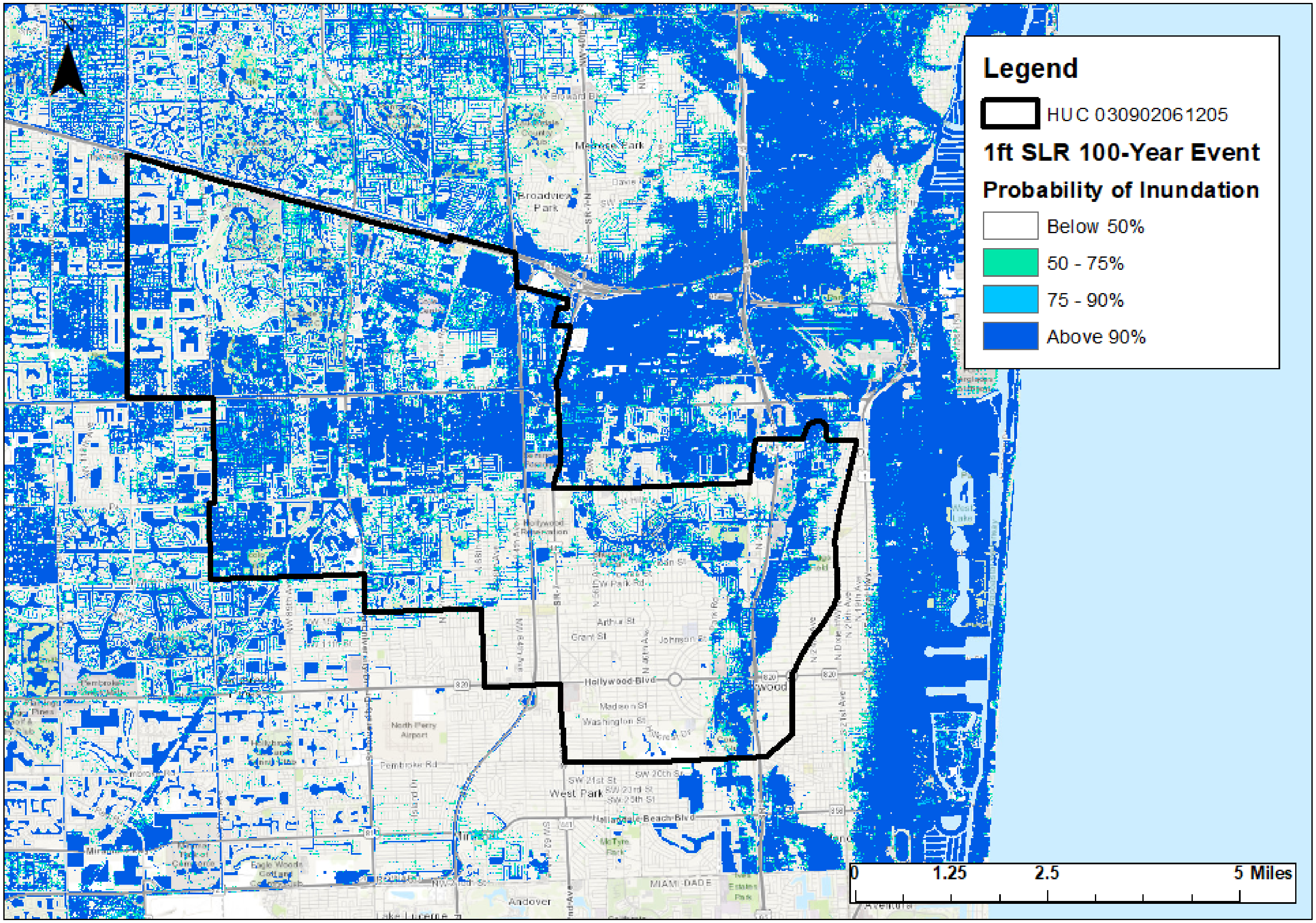

Figure 78. Sea level rise of 1 ft (only coastal area and GW affected – GW layer rises 1 ft) + 1-day, 100-year storm for the HUC 030902061205 Davie/Dania Beach subwatershed

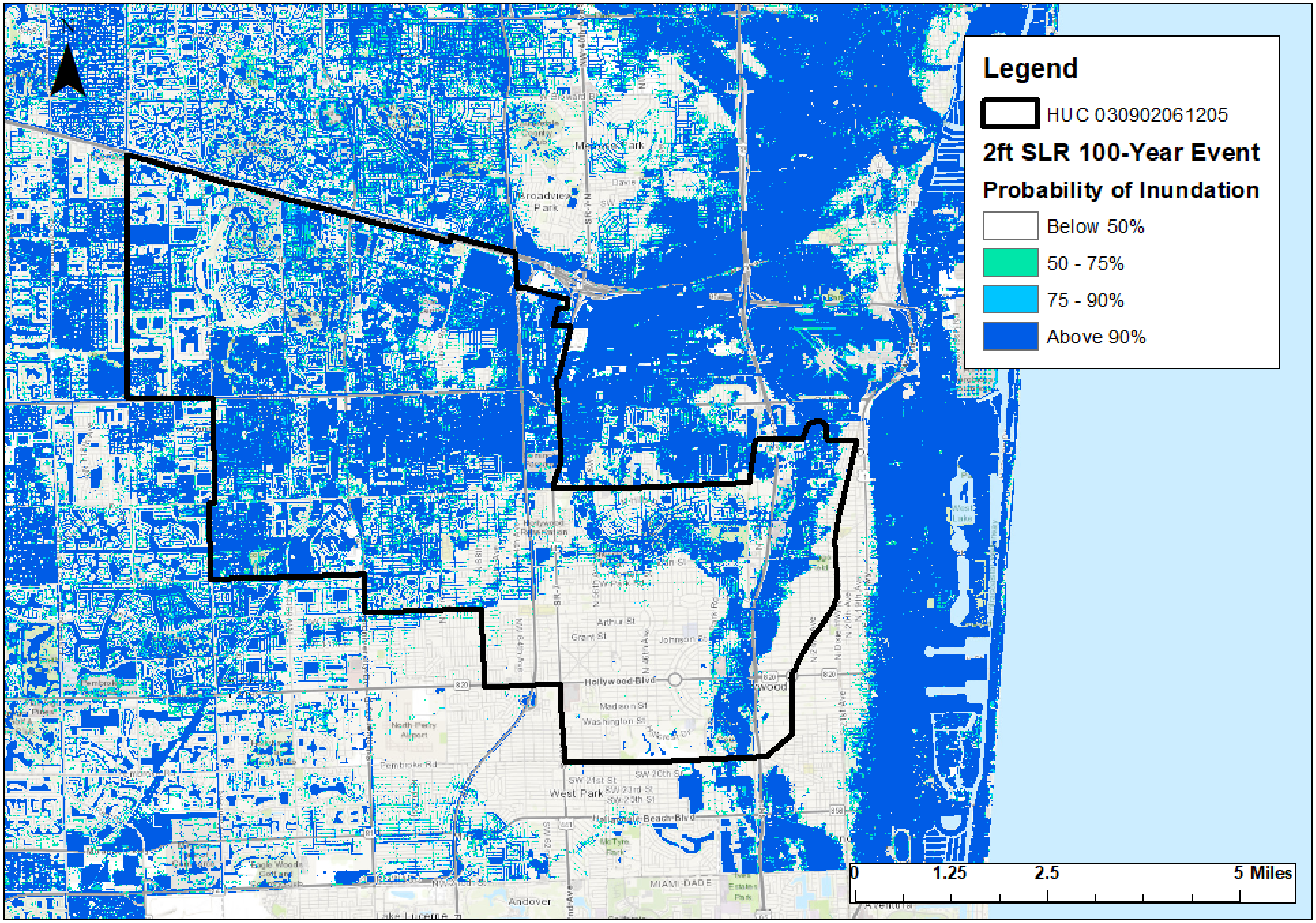

Figure 79. Sea level rise of 2 ft (only coastal area and GW affected – GW layer rises 2 ft) + 1-day, 100-year storm for the HUC 030902061205 Davie/Dania Beach subwatershed

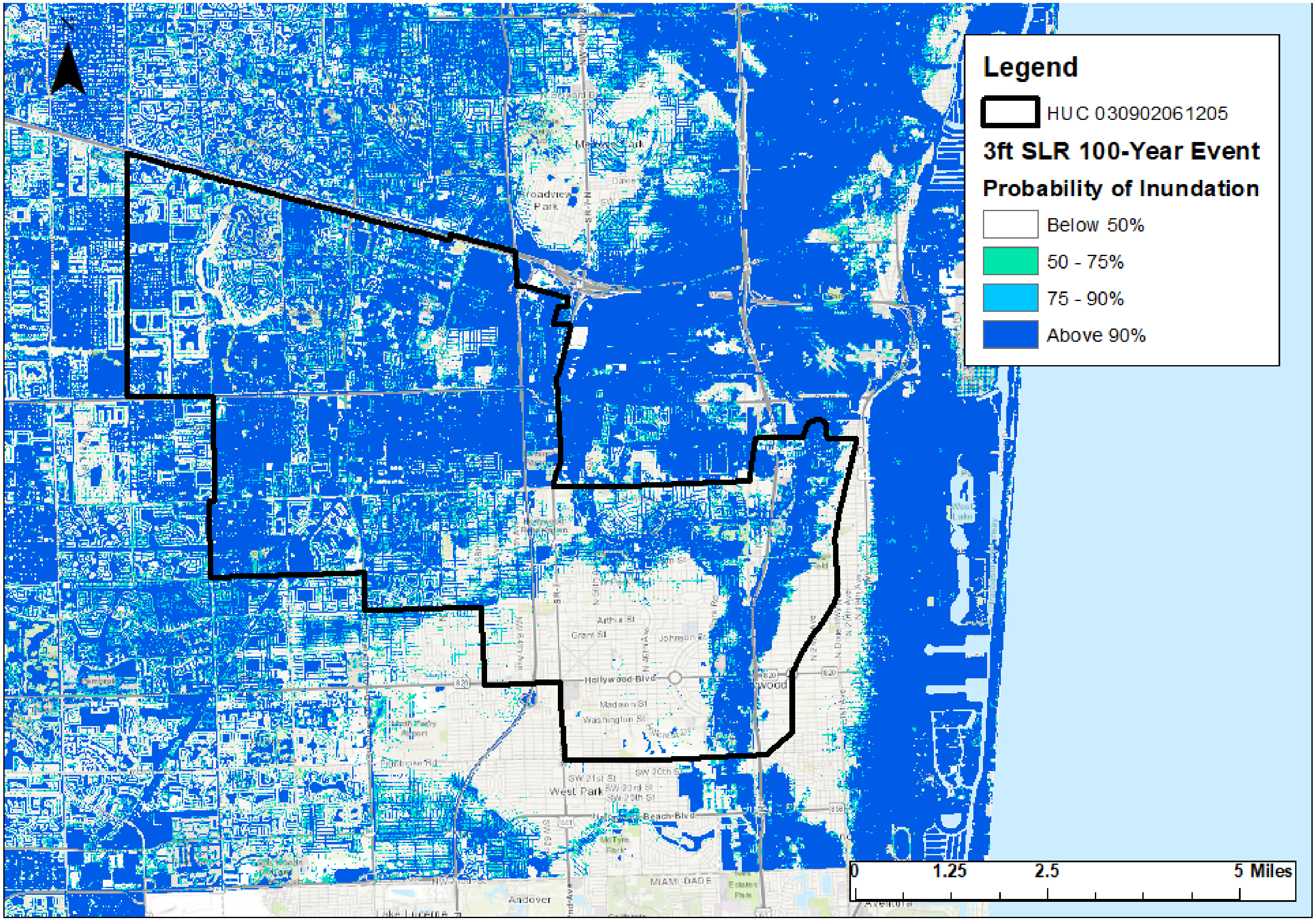

Figure 80. Sea level rise of 3 ft (only coastal area and GW affected – GW layer rises 3 ft) + 1-day, 100-year storm for the HUC 030902061205 Davie/Dania Beach subwatershed

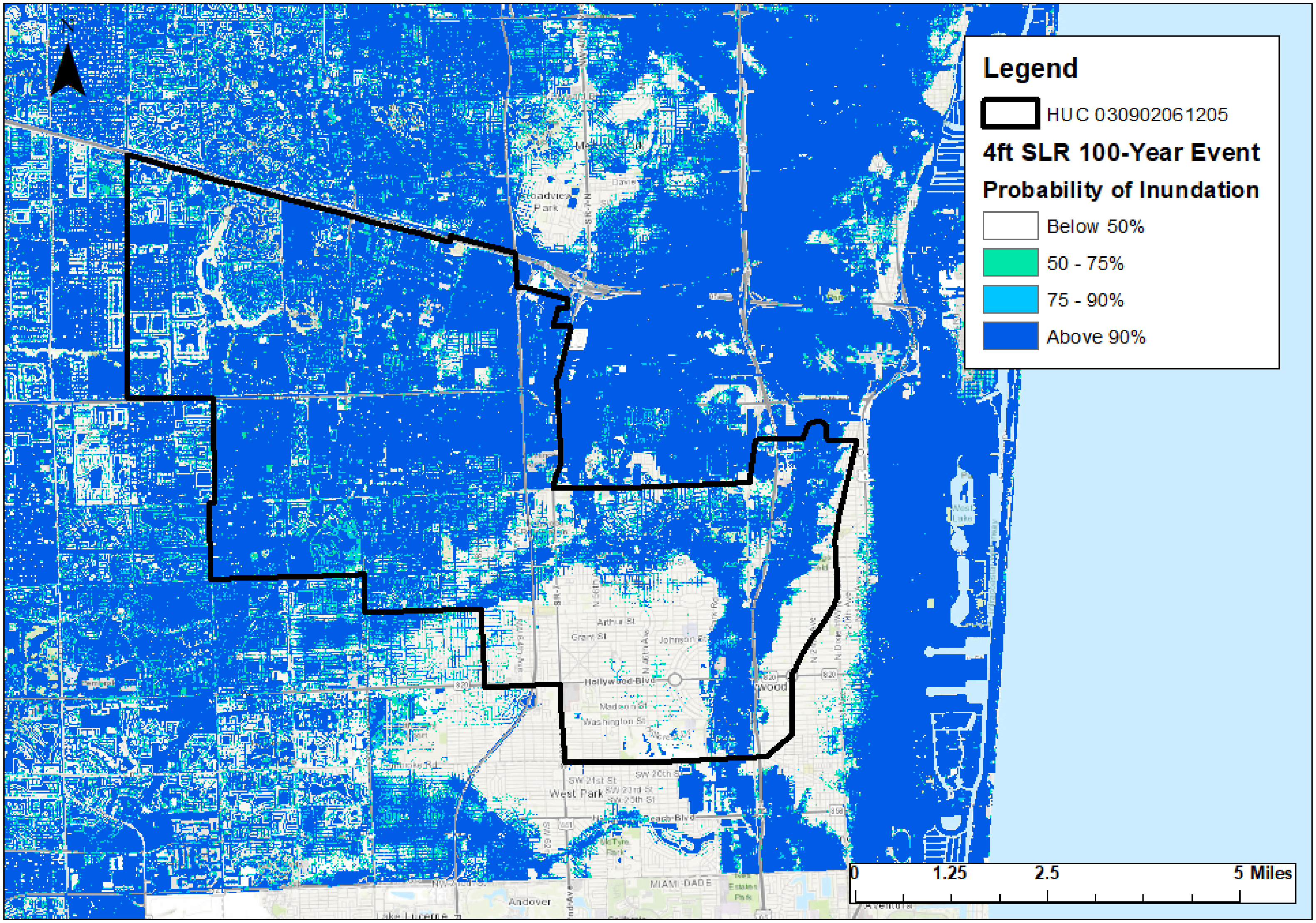

Figure 81. Sea level rise of 4 ft (only coastal area and GW affected – GW layer rises 4 ft) + 1-day, 100-year storm for the HUC 030902061205 Davie/Dania Beach subwatershed

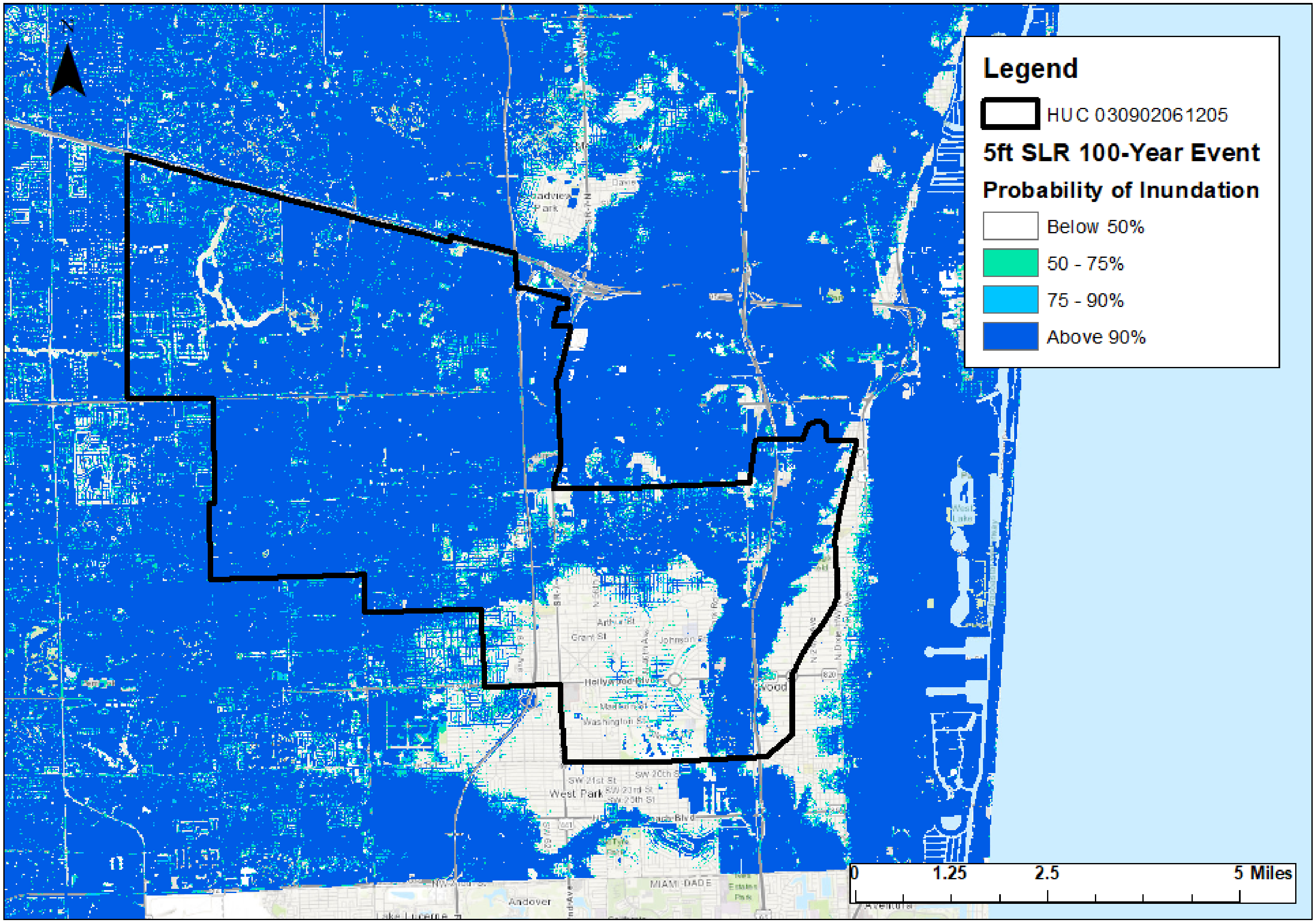

Figure 82. Sea level rise of 5 ft (only coastal area and GW affected – GW layer rises 5 ft) + 1-day, 100-year storm for the HUC 030902061205 Davie/Dania Beach subwatershed

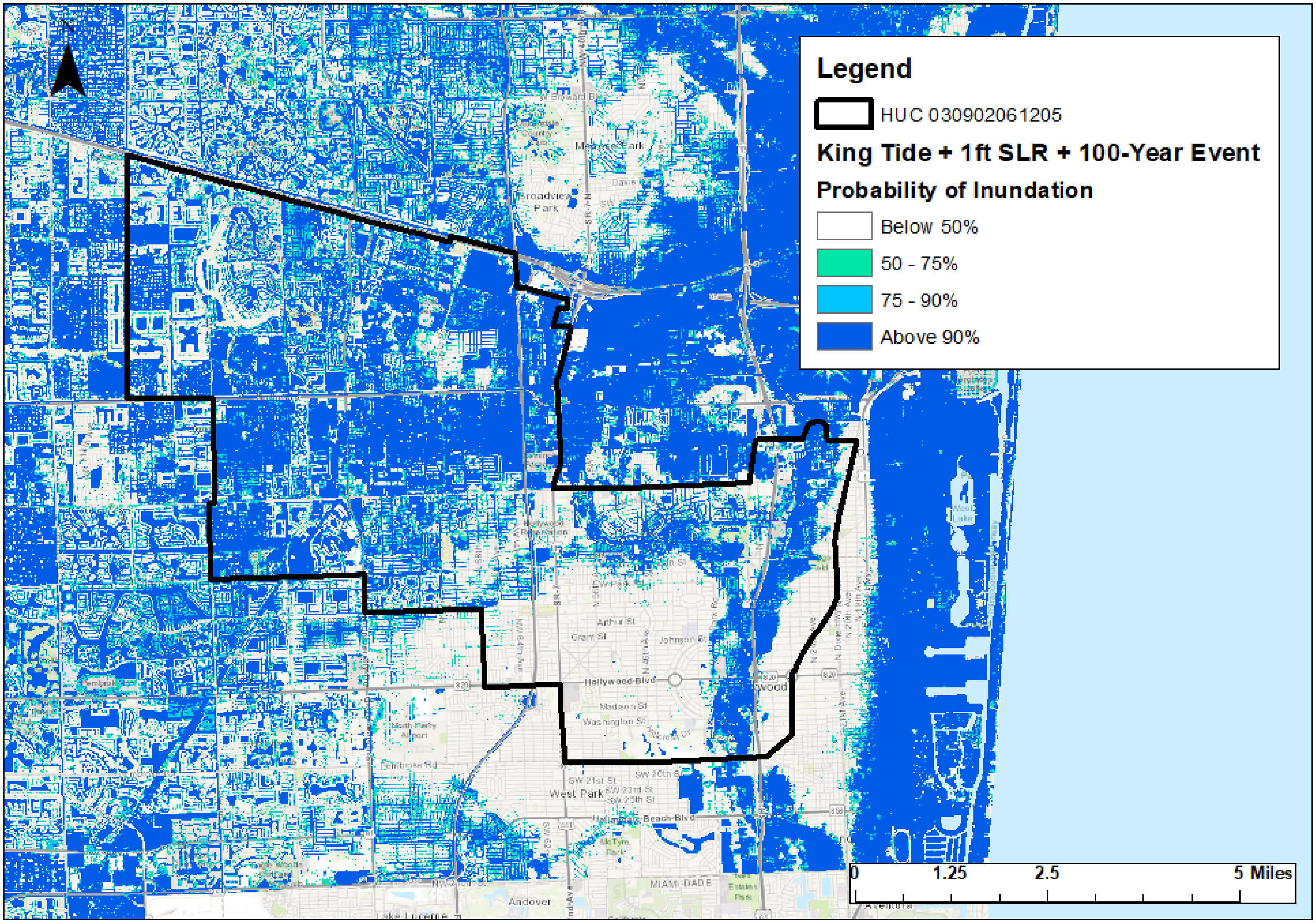

Figure 83. King tide at 2.6 ft + 1 ft sea level rise scenario above GW + 1-day, 100-year storm for the HUC 030902061205 Davie/Dania Beach subwatershed

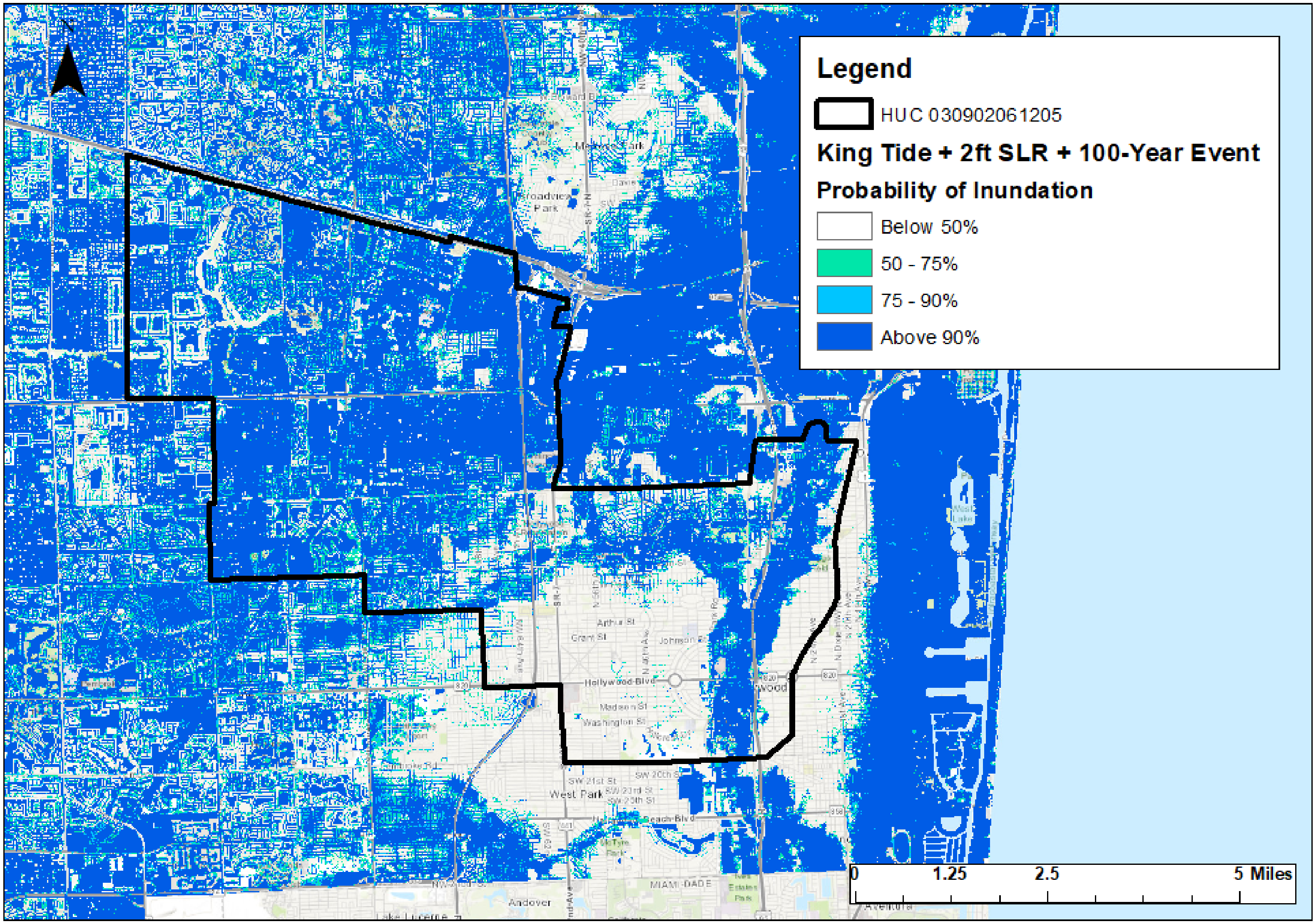

Figure 84. King tide at 2.6 ft + 2 ft sea level rise scenario above GW + 1-day, 100-year storm for the HUC 030902061205 Davie/Dania Beach subwatershed

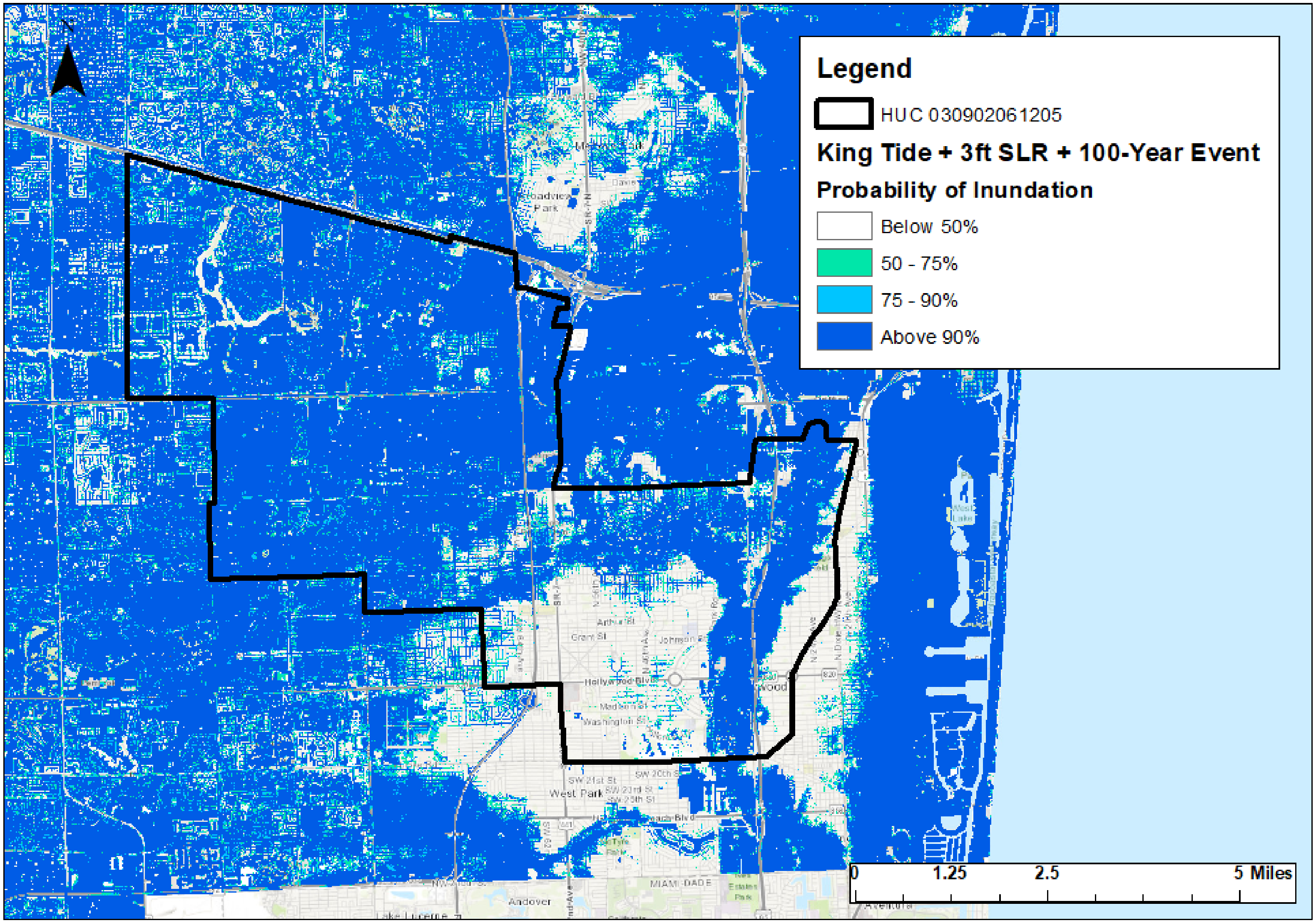

Figure 85. King tide at 2.6 ft + 3 ft sea level rise scenario above GW + 1-day, 100-year storm for the HUC 030902061205 Davie/Dania Beach subwatershed

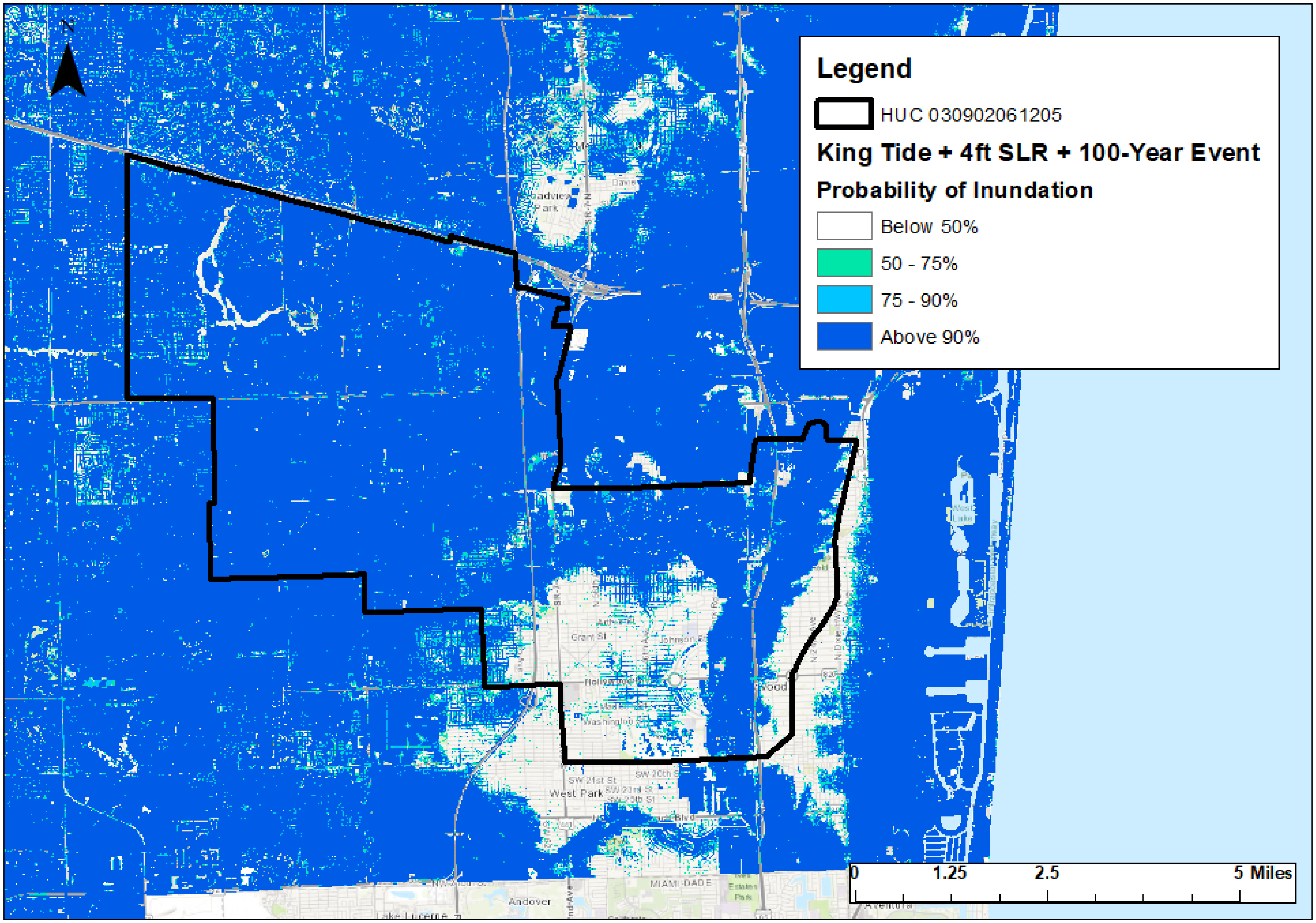

Figure 86. King tide at 2.6 ft + 4 ft sea level rise scenario above GW + 1-day, 100-year storm for the HUC 030902061205 Davie/Dania Beach subwatershed

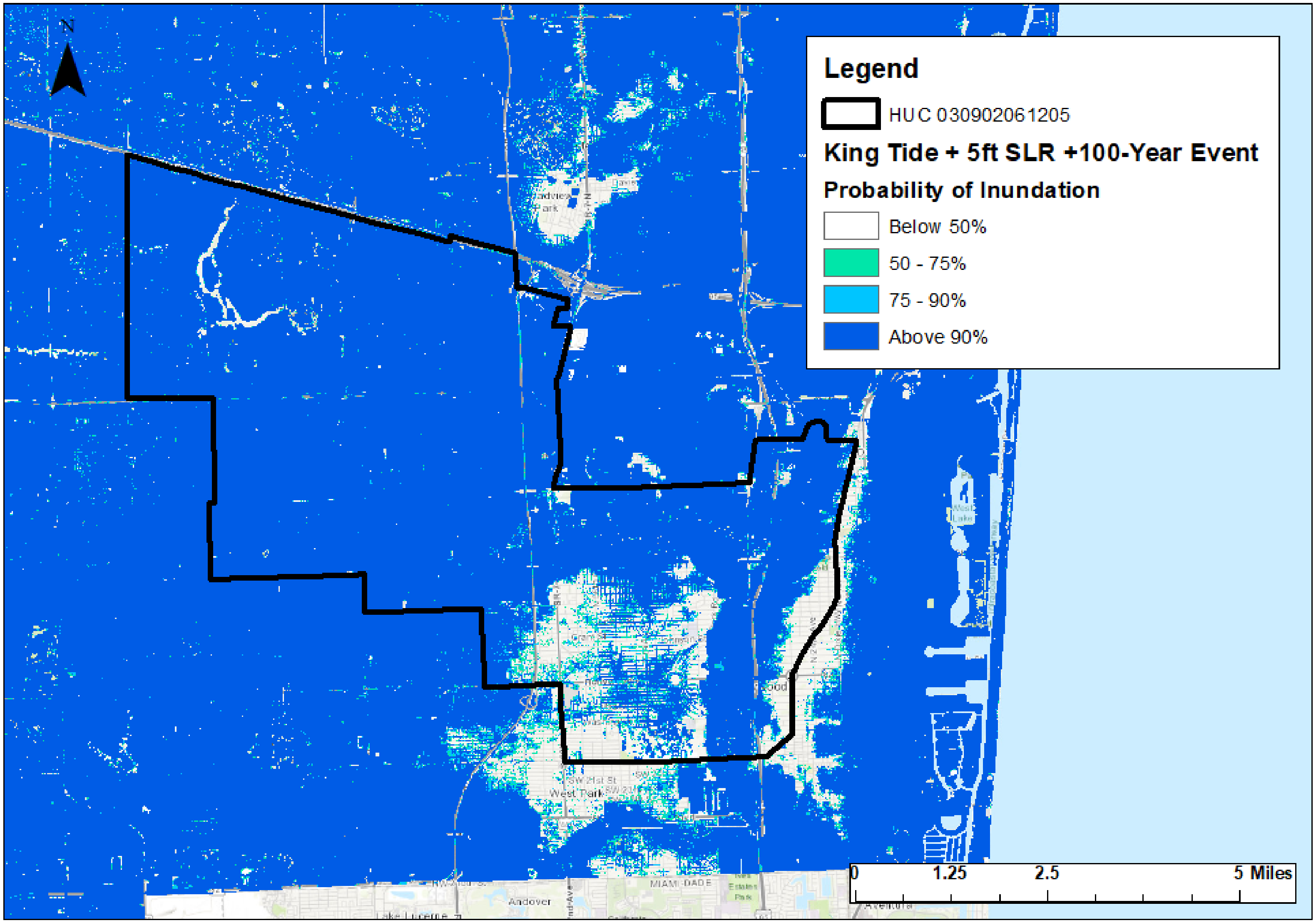

Figure 87. King tide at 2.6 ft + 5 ft sea level rise scenario above GW + 1-day, 100-year storm for the HUC 030902061205 Davie/Dania Beach subwatershed

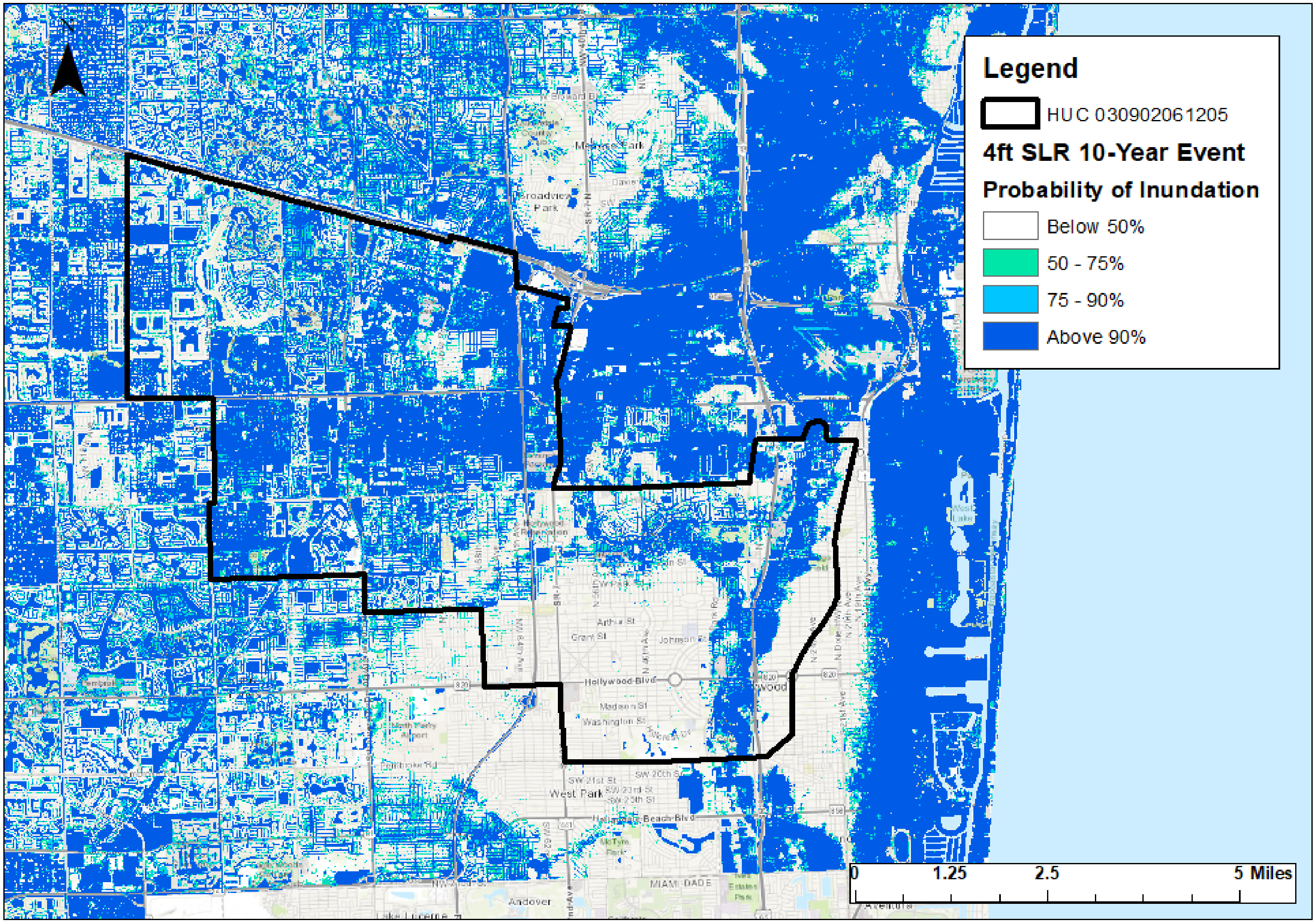

Figure 88. Sea level rise of 4 ft (only coastal area and GW affected – GW layer rises 4 ft) + 1-day, 10-year storm for the HUC 030902061205 Davie/Dania Beach subwatershed

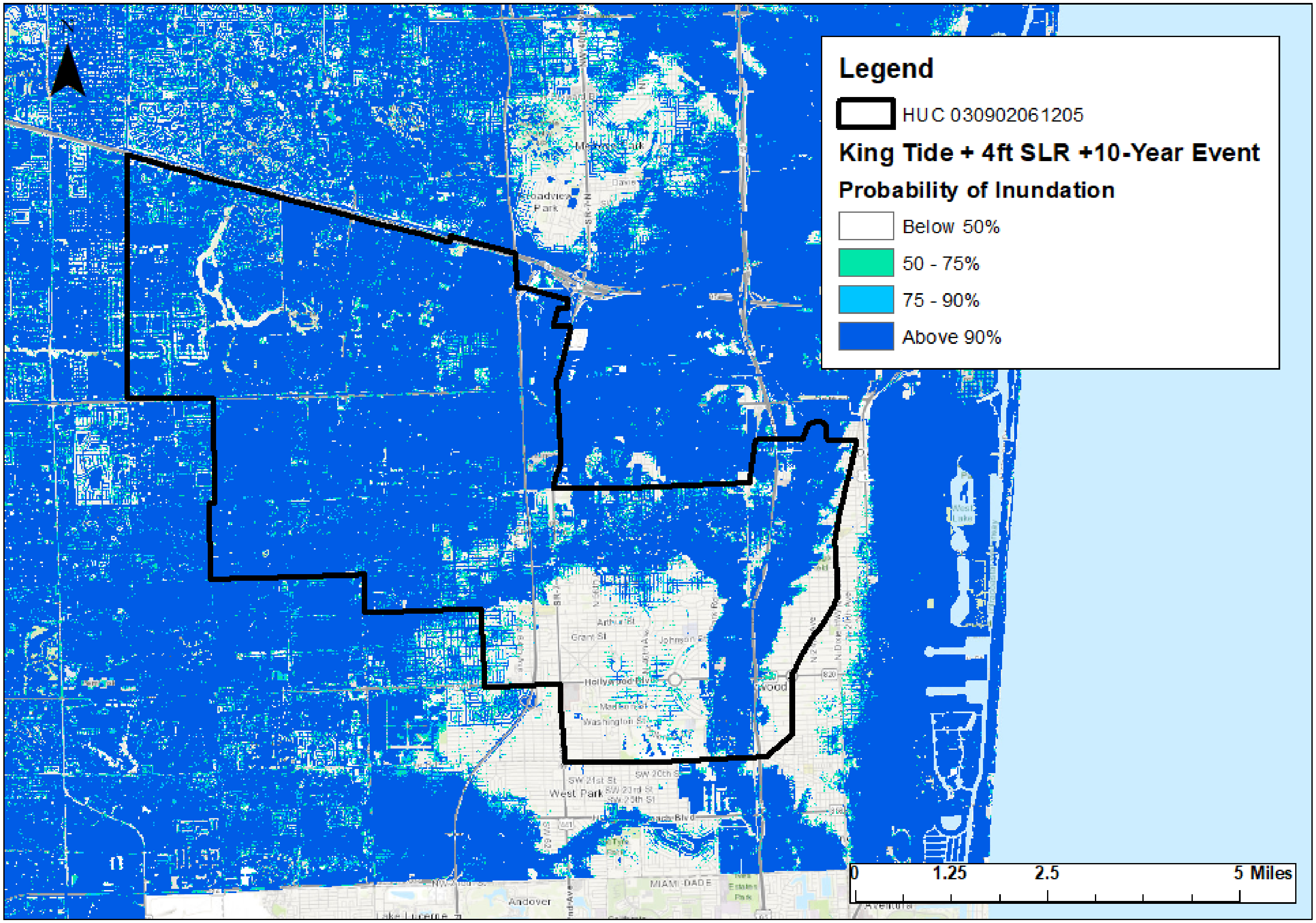

Figure 89. King tide at 2.6 ft + 4 ft sea level rise scenario above GW + 1-day, 10-year storm for the HUC 030902061205 Davie/Dania Beach subwatershed

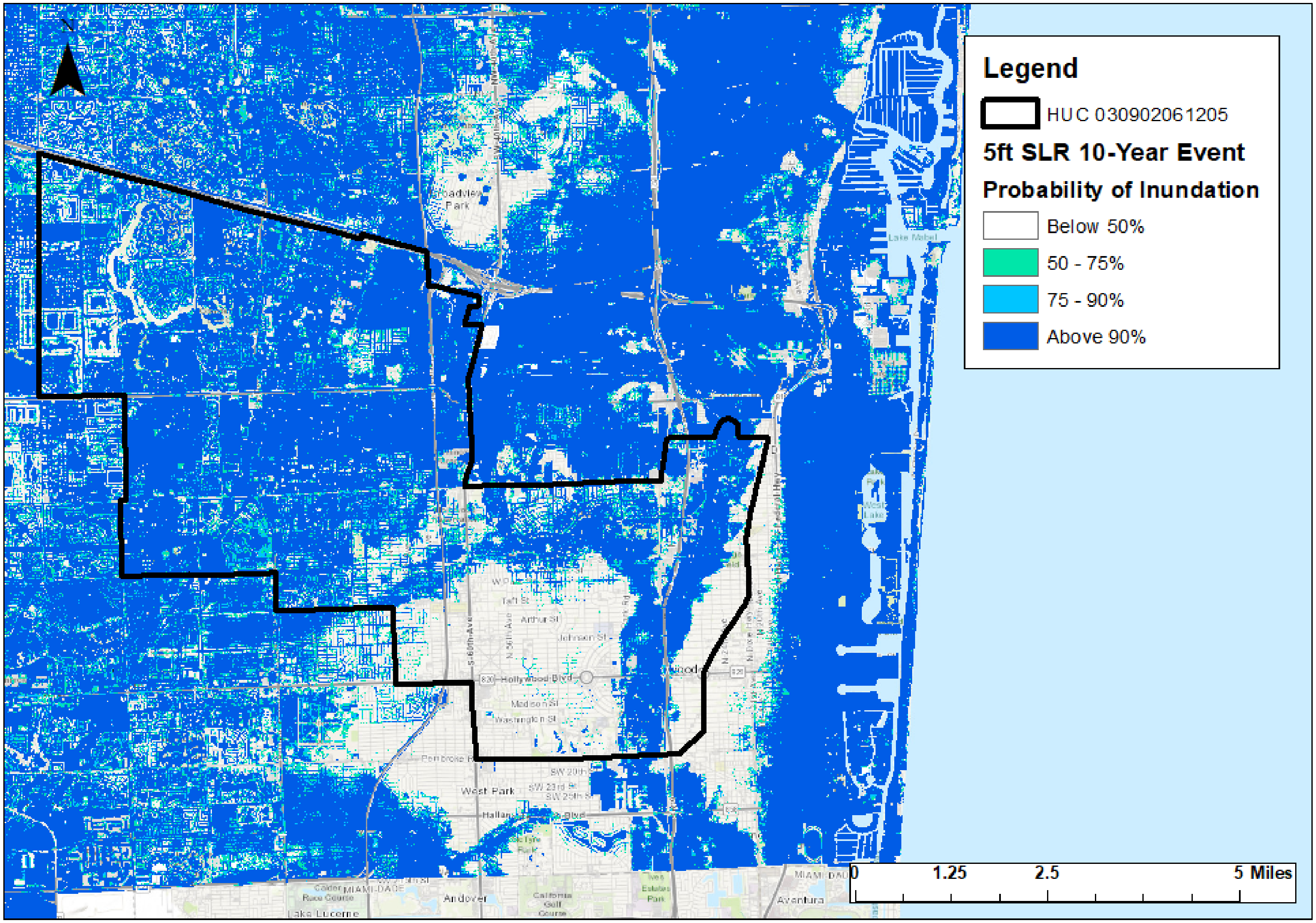

Figure 90. Sea level rise of 5 ft (only coastal area and GW affected – GW layer rises 5 ft) + 1-day, 10-year storm for the HUC 030902061205 Davie/Dania Beach subwatershed

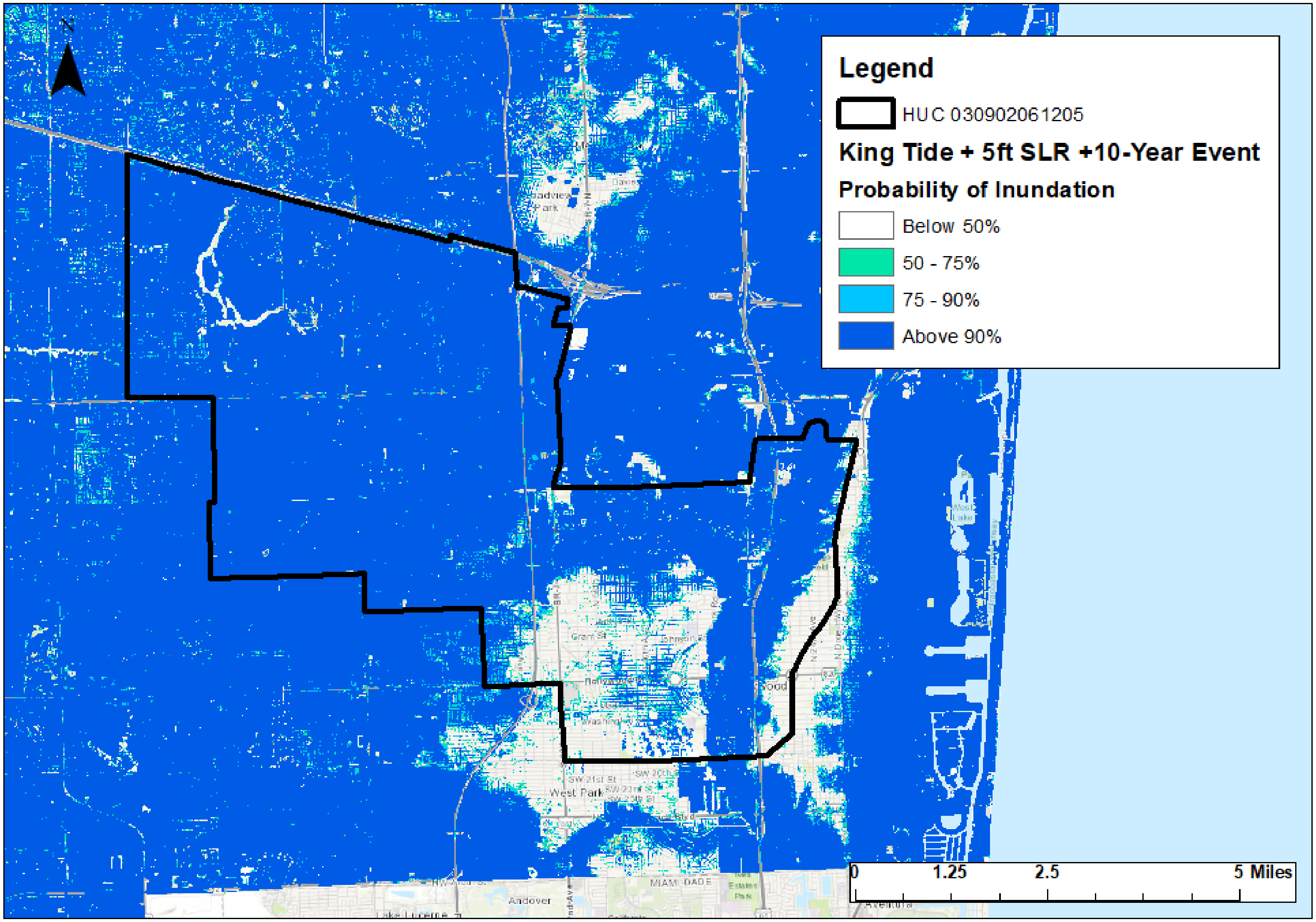

Figure 91. King tide at 2.6 ft + 5 ft sea level rise scenario above GW + 1-day, 10-year storm for the HUC 030902061205 Davie/Dania Beach subwatershed

5.0 INVENTORY OF POTENTIAL SOLUTIONS

Once watershed master planning assessments are prepared and strategies (both adaptive and hardening) are identified and evaluated, decisions must be made to implement the priority projects. At the center of these planning efforts should also exist the provision for an adequate drainage system, designed to accommodate an increased volume of water and/or increased peak flows.

5.1 Toolbox with Design Guidelines

The process of identifying potential mitigation measures to implement begins with narrowing down the feasible engineering alternatives using threshold criteria and quantifiable selection criteria that include measures of effectiveness, cost, and added benefit to the community. The toolbox describes a variety of strategies that could be used to improve potential flood management conditions. They are community-specific and most require significant engineering and planning to determine the most efficient configuration to achieve the community's goals. Hard infrastructure systems are usually the first systems to be impacted because they are built at lower elevations than the finished floor of structures. In addition, many infrastructure systems are located within the roadways (water, sewer, stormwater, power, phone, cable tv, internet, etc.). At present, most roadway base courses are installed above the water table. If the base stays dry, the roadway surface will remain stable. As soon as the base is saturated, the roadway can deteriorate.

Catastrophic flooding should be expected during heavy rain events if there is nowhere for the runoff to go. Considerations for enhancing resiliency include retrofitting, material protective measures, rehabilitation and, in some cases, relocation of facilities to accommodate sea-level rise impacts. As they are related, groundwater is, similarly, expected to have a significant impact on flooding in these low-lying areas because of the loss of soil storage capacity.

For this document, 36 solutions referred to as the "Periodic Table" menu of green and grey infrastructure technologies (Figure 92) are presented. The menu is organized to address various flooding types, from *pluvial* (rainfall and runoff mitigation in upland areas), *fluvial* (runoff, high ground water, and surface water management in low-lying flood prone areas), *tidal* (flooding associated with storm surge, high ground water, and tidally influenced), and *all* (applies across the spectrum). Table 12 outlines each of these options, their benefits, and limitations.

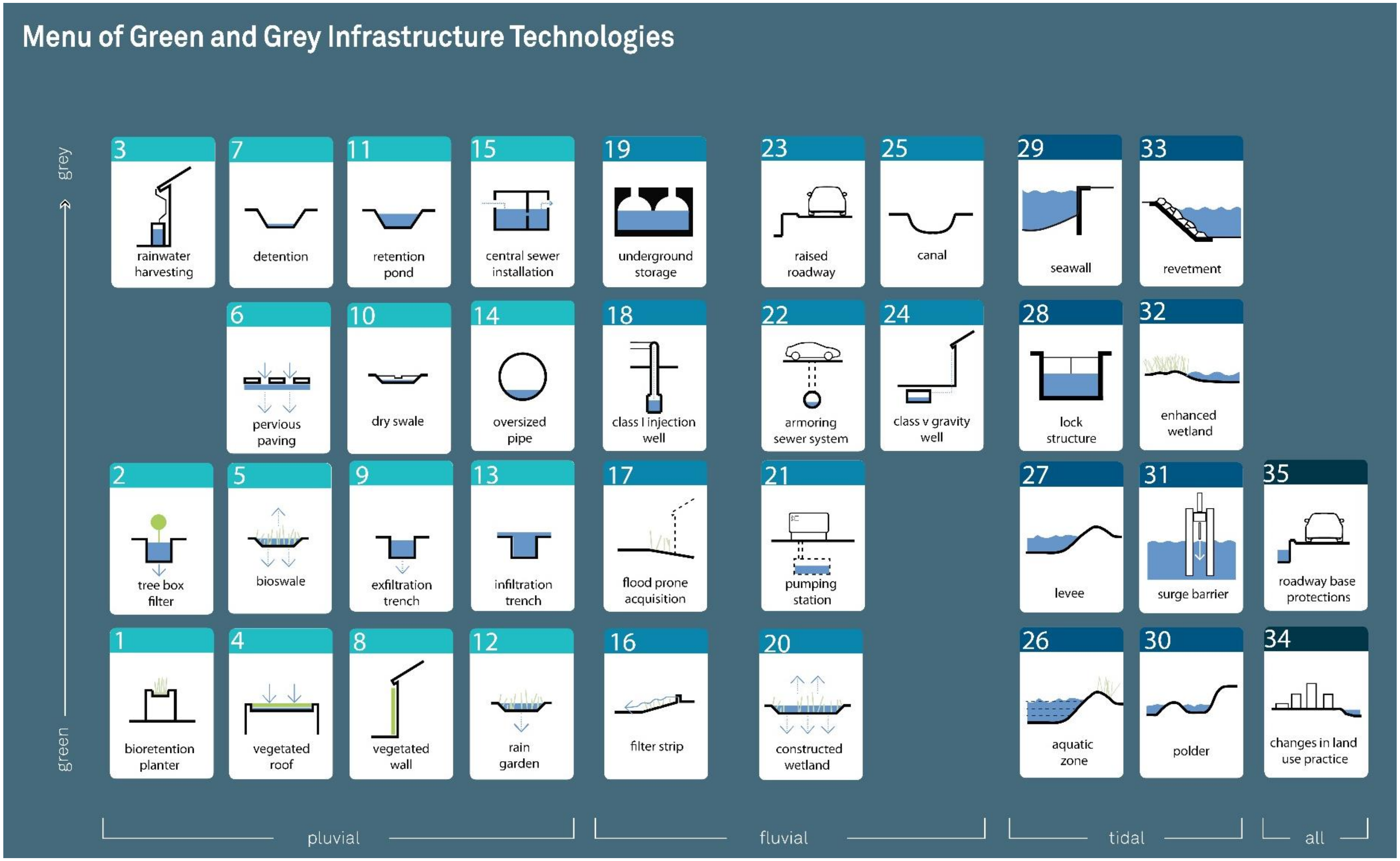

Figure 92. "Periodic table" menu of green and grey infrastructure technology options.

Table 12. Summary of benefits, costs, and barriers for each of the engineering alternatives in the toolbox

Strategy Class	Implementation Strategy	Applications	Benefits	Cost	Barriers to Implementation
Green	Bioretention planter	Local, small scale, easily implemented in developed areas	Protects property, treats runoff	$2500 each	Limited volume disposed of, so many are needed, maintenance
Green	Tree box filter	Local, small scale, easily implemented in developed areas	Protects property, treats runoff	$2500 each	Limited volume disposed of, so many are needed, maintenance
Green	Rainwater harvesting	Local, small scale, easily implemented in developed areas	Protects property, treats runoff	Under $5,000	Limited volume disposed of, so many are needed, maintenance
Green	Vegetated roof	Specific to a building, absorbs water, reduces runoff	Protects property, treats runoff	$100/sf	Requires irrigation if insufficient rainfall occurs Requires runoff control if too much rainfall occurs
Green	Bioswale	Parking lots, runoff from development - primarily treatment for discharge to another system	Protects property, treats runoff	$20K/acre	Maintenance, limited volume disposed of, used mostly for treatment
Gray	Pervious paving	Parking lots, patios, driveways, anything except paved roads due to traffic loading	Reduces roadway and parking lot flooding	$10-20/sf, requires bumpers and sub-base to maintain paver integrity	Must be maintained via vacuuming or the perviousness fades after 2-3 years
Green	Detention	Common for new development, but difficult to retrofit; limited to open areas	Removes water from streets, reduces flooding	$200K/acre	Land availability, maintenance of pond, discharge location Uses up land that could otherwise be developed

Strategy Class	Implementation Strategy	Applications	Benefits	Cost	Barriers to Implementation
Green	Vegetated wall	Used on walls of buildings and retaining walls	Protects property, treats runoff	$30/sf	Requires irrigation if insufficient rainfall occurs Requires runoff control if too much rainfall occurs
Gray	Exfiltration Trench	Any low-lying area where stormwater collects and the water table is more than 3 ft below the surface; densely developed areas where retention is not available, roadways	Excess water drains to aquifer, some treatment provided	$250/ft	Significant damage to roadways for installation, maintenance needed, clogging issues reduce benefits
Green	Dry Swale	Parking lots, runoff from development - primarily treatment for discharge to another system	Protects Property, treats runoff	$200K/mile	Maintenance, limited volume disposed of, mostly for treatment
Green	Retention Ponds	Common for new development, but difficult to retrofit; limited to open areas	Removes water from streets, reduces flooding	$200K/acre	Land availability, maintenance of pond, discharge location Uses up land that could otherwise be developed
Green	Rain Gardens	Local, small scale, easily implemented in developed areas	Protects property, treats runoff	$20K/acre	Limited volume disposed of, so many are needed, maintenance
Gray	Infiltration Trench	Low lying areas that collect stormwater, but the water table is just below the surface meaning that retention and exfiltration trenches will not work properly	Excess water is drained to pump stations, creating soil storage capacity to store runoff, soil treatment	$250/ft plus pump station	Significant damage to roadways for installation, maintenance needed, clogging issues - must discharge somewhere (pump station, detention pond)

Strategy Class	Implementation Strategy	Applications	Benefits	Cost	Barriers to Implementation
Green	Oversized pipes	Local solution - not watershed level, holds water to reduce flooding	Protects property and roadways	$350/ft of more	Sediments, maintenance needs, lack of means to flush, cost
Gray	Central sewer installation	All areas where there are septic tanks. Mostly a water quality issue	Public health benefit of reducing discharges to lawns, canals, and groundwater from septic tanks	$15,000 per household	Cost, assessments against property owners, property rights issues
Green	Filter strips	Localized	Protects property, treats runoff	$50K/mile	Does not address flooding, treatment/water quality measure
Green	Flood prone property acquisition	Regional agency - could be any low-lying areas	Removes flood prone areas from risk	$2K-$100K/acre depending on whether it is already developed	Difficult to implement if occupied, issues with willing sellers, cost, lack of funds for acquisition
Gray	Class I injection wells	Any low-lying area where stormwater collects, and there is sufficient land to permit, install and operate a Class I well - limited	Means to drain neighborhoods - potentially large volumes	$3-6 million depending on size/depth	Needs baffle box, injection zone may not be available, requires a permit, may compete with water users
Green	Underground storage	Common for new developments, but difficult to retrofit	Storage of excess runoff from rainfall, can be used for irrigation, can sit under parking lots, unobtrusive	$2/gallon	If the tank is full, there is no storage

Strategy Class	Implementation Strategy	Applications	Benefits	Cost	Barriers to Implementation
Green	Constructed wetlands	Where there is low lying flood prone land that can be converted into wetlands	Reduces flooding by providing a low-lying area for water to go	$200-$1M/acre	Water quality, permitting, monitoring costs, maintenance
Gray	Pump stations	Any low-lying area where stormwater collects, and there is a place to pump the excess stormwater to such as a canal; common for developed areas	Removes water from streets, reduces flooding	Start at $1.5 to 5 million each, number unclear without more study	NPDES permits, maintenance cost, land acquisition, discharge quality
Gray	Armored sewer systems	Any area where gravity sanitary sewers are installed	Keeps stormwater out of sanitary sewer system and reduces potential for disease spread from sewage overflows	$500/manhole	Limited expense beyond capital cost
Gray	Raised roadways	Limited to areas where redevelopment is occurring areawide due to ancillary impacts on adjacent properties	Keeps traffic above floodwaters, access for emergency vehicles, commerce	$2 - 4 million/lane mile	Runoff, cost, utility relocation
Gray	Class V gravity wells	Any low-lying areas where stormwater collects and is located where saltwater has intruded the surficial aquifer beneath the site	Means to drain neighborhoods, limited volume	$250K each	Needs baffle box, limited flow volume (1 MGD), zone for discharge may not be available, permits, water supply wells
Gray	Canals	Limited	Means to drain neighborhoods, provides treatment of water	$2 million/mile	Land area, flow volume, maintenance, ownership, capacity issues due to sea level rise pressure

Strategy Class	**Implementation Strategy**	**Applications**	**Benefits**	**Cost**	**Barriers to Implementation**
Green	Aquatic zones	Any low-lying or flood-prone area that is undeveloped and can store large volumes of water	Place to store large volumes of water	$200K/acre	Must be maintained, cost, impact on property owners
Gray	Levees	Regional issue - along rivers, lakes, impoundments	Protects widescale property	$ millions	Must be maintained, must be continuous, must be planned for extreme events (i.e. Hurricane Katrina showed that New Orleans planning horizon was not sufficient)
Gray	Lock structures	Regional (WMD) responsibility	Keeps seawater out, reduces saltwater intrusion	Up to $10 million, may require ancillary stormwater pumping stations at $2-5 million each	Permitting, private property rights arguments
Gray	Sea walls	Barrier islands and downtown coastal areas	Protects property	$1200/ft	Private property rights, neighbors
Green	Polders	Barrier islands and downtown coastal areas	Provides storage for coastal waters	$200K/acre	Permitting, land acquisition
Gray	Surge barriers	Coastal communities – large footprint	Protects property	>$1B	Cost, open ocean access challenges, property rights
Green	Enhanced wetlands	Where there is an existing wetlands area that can be augmented	Reduces flooding by providing a low-lying place for water to go	$200-$1M/acre	Water quality, permitting, monitoring costs, maintenance, ecosystem impacts

Strategy Class	Implementation Strategy	Applications	Benefits	Cost	Barriers to Implementation
Green	Revetments	Retention, helps maintain the storage volume, in conjunction with other measures	Improves walls of retainage	Varies based on material, depth, wall height	Land area, maintenance
Policy	Changes in land use	Applicable universally	Achieves flood risk mitigation by adjusting permitted land use	Low but may incur private property rights conflicts and litigation	Private property rights conflicts and litigation
Gray	Roadway base protection	Low-lying areas, coastal communities	Protects roads and access routes	$1 million per lane mile	Cost, adjacent properties become uninsurable
Policy	Enhanced elevation of buildings	Developers would implement this for new construction	Reduced flood risk	Varies	Potential issues with building structure or latticework, and existing homes that are not elevated
Policy	Abandon Land for development	Land that cannot be protected would be taken out of circulation	Reduced flood risk	Potentially huge, and loss of tax revenue for local governments	Potential issues with private property rights, potential major reduction in the value of neighboring properties

5.2 Risk and Vulnerability

The screening tool modeling exercise from Section 4.2.2 identified areas within the communities that are vulnerable to flooding. Higher priority concerns should be those properties or assets that are considered essential and need to be kept in service during a flooding event. The major regional issues in the greater watershed are the C-43 reservoir and capital projects associated with the SFWMD plans for controlling discharges that impact the ecosystem in the west end of the watershed. Hence regional water management districts and USACE projects have higher priority due the larger area served. All other improvements are distinctly local. To help with prioritization, the following is suggested:

- Tier 1 - Critical facility protection (water/sewer utilities, public safety, hospitals, schools, power).
- Tier 2 - Essential facilities (groceries, pharmacies, roadways)
- Tier 3 - Economic centers (protecting jobs)
- Tier 4 - At risk communities
- Tier 5 - Other urban/suburban property
- Tier 6 - Agriculture/public property/vacant/undeveloped

Table 13 outlines the US Department of Revenue (DOR) codes from the property appraiser's office and assigns an associated priority level to each parcel. Note that for residential property, identifying at-risk communities (income, age, disability, health) requires a further drilldown to the neighborhood level (i.e. wealthy neighborhoods with few older, poor health individuals would have a lower priority than at risk communities, which generally have lower value housing and denser development). In the latter case, more people are impacted, and those people have less ability to mitigate risk. Based on these priorities, the relative risk priority DOR land use codes were evaluated based on a scale of 1 to 6, where 6 is least vulnerable and 1 is the most vulnerable.

Table 13. Department of Revenue (DOR) land use codes

DOR (use code)	Description	Priority	Delineator
000	Vacant Residential	6	
001	Single Family Residential	Depends	Value, Age, Income
002	Mobile Homes	4	
003	Multi-Family >9 units	4	
004	Residential Condo	Depends	Value, Age, Income
007	Misc. Residential	5	

DOR (use code)	Description	Priority	Delineator
008	Multi-Family <10	4	
009	Residential Common Area	6	
010	Vacant Commercial	6	
011	One-Story Stores	3	
012	Mixed Use Store	4	
013	Department Store	3	
014	Supermarket	2	
015	Regional Shopping Center	3	
016	Community Shopping Center	3	
017	Office Non Professional	3	
018	Service Multi-Story	3	
019	Professional Services Building	3	
020	Terminals	3	
021	Restaurant	3	
022	Drive-in	5	
023	Financial	2	
026	Laundry	3	
027	Service Station	3	
028	Mobile Home Sales, Parking Lot, Mobile Home Parks	5	
031	Drive-in Theater	5	
032	Auditoriums/Indoor Theaters	5	
033	Bar	5	
034	Skating Rinks, Poolhalls, Bowling Alleys	5	
035	Tourist Attractions	5	
038	Golf Course	6	
039	Hotel	3	
040	Vacant Industrial	6	
041	Light Manufacturing	4	
048	Warehouse Distribution	5	
049	Open Storage	6	
052	Cropland	6	
063	Grazing Land	6	
066	Orchard	6	
067	Poultry	6	
069	Ornamentals	6	
070	Vacant without Features	6	
071	Church	5	
072	Private School	3	

DOR (use code)	Description	Priority	Delineator
073	Private Hospital	2	
074	Home for the Aged	4	
075	Orphanage	4	
076	Cemetery	6	
077	Club, Hall	5	
078	Convalescent Homes	4	
080	Vacant Government	6	
082	Military, Forest, Parks	6	
083	Public School	2	
084	Public College	2	
086	County	Depends	Utilities, Arterial =1
087	State	Depends	Arterial = 1
088	Federal	6	
089	Municipal	1	
091	Utility	Depends	Water/Wastewater Treatment Plants, Public Safety = 1
094	Right of Way	Depends	Florida Department of Transportation (FDOT), Arterial = 1
095	Submerged, lakes	6	
096	Sewage Disposal	1	
099	Other Non-Agricultural Acreage	6	

Having identified the vulnerable properties in Section 4.2.2, by determining the risk priority from 1 to 6 in the DOR codes and the percentage of the parcel that floods during the applicable design storm, properties that are more critical to the function of the community can be identified. The methodology is to first convert the DOR code priority tier to its inverse scale by the following equation to define a consequence of risk factor:

Consequence of risk factor = 7 – DOR Code Priority Tier

The flood risk factor from the screening tool is interpreted based on flooding probability. We take all parcels in tiers #1-4 that have greater than 50% chance of flooding during a particular design storm and calculate the percent of the parcel that would flood during that event. The percentage is converted to a 6-point scale termed as the Flood Risk Factor, as shown in Table 14.

Table 14. Flood risk factor scale based on percent of parcel flooded

Percent of Parcel Flooded	**Flood Risk Factor**
90-100%	6
80-89%	5
70-79%	4
60-69%	3
50-59%	2
<50%	1

If 75% of the importance is assigned to the consequence of flooding and 25% importance to flood risk, or three times the importance to the consequence of flooding to come up with a composite score as follows:

$$\text{Flood Risk Factor} \times 25\% + \text{Consequence of Risk Factor} \times 75\% = \text{Composite Score}$$

Example:

$$1 \times 25\% + 6 \times 75\% = 4.75$$

Those higher priority properties that received the higher composite score are where the mitigation strategies and financial resources should focus first. Figure 93, and Table 15 shows the application of this methodology to the study area.

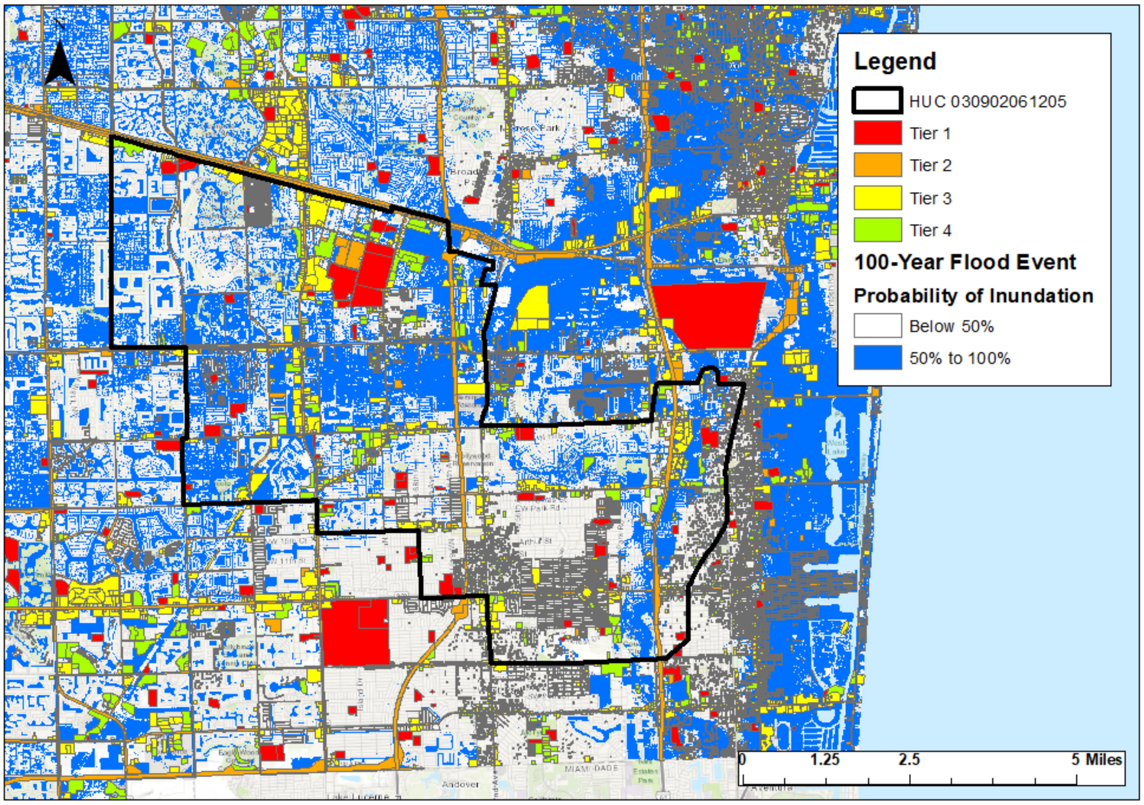

Figure 93. HUC 030902061205 Davie/Dania Beach subwatershed flood risk and critical infrastructure map

Table 15. High-risk critical facilities that are in DOR code priority tiers #1-4 and experience 10-percent or more flooded area during a 1-day, 100-year storm event for the HUC 030902061205 Davie/Dania Beach subwatershed

Folio Number	**Facility**	**Legal Description**	**Priority Tier**	**DOR (code)**	**DOR Use Code Description**	**Total Area (acres)**	**Percent-Flooded (1d 100y)**	**Flood prob factor = 25%**	**Consequence of Risk Factor = 75%**	**Factor**
514104010012	ROW	EVERGLADES SUGAR & LAND CO SUB 2-75 D 4-51-41 E 150 OF TRACTS 1 THRU 4,29 & 30 K/A:RESERVATION	1	91	Utility, gas & electricity, telephone & telegraph, locally assessed railroads, water & sewer service, pipelines, canals, radio/television communication	6.811	70.00%	4	6	5.5
504137011443	private WWTP	NEWMANS SURVEY SUB NO 1 & 2 2-26 D 23-50-41 TRACT 5 E 122.50 OF S 182.50 OF N 497.50 OF W 245 TIER 21	1	91	Utility, gas & electricity, telephone & telegraph, locally assessed railroads, water & sewer service, pipelines, canals, radio/television communication	0.513	76.00%	4	6	5.5
504137011442	private WWTP	NEWMANS SURVEY SUB NO 1 & 2 2-26 D 23-50-41 TRACT 5 W 122.50 OF S 182.50 OF N 497.50 OF W 245 TIER 21	1	91	Utility, gas & electricity, telephone & telegraph, locally assessed railroads, water & sewer service, pipelines, canals, radio/television communication	0.513	62.60%	3	6	5.25
514110010091	Mem West Hospital	A J BENDLE SUB 1-27 D 10-51-41 TR 22 BEG NE COR,WLY 918.42, S 330.65,E 137.30,S 330.52, E 254,N 330.52,E 527.14,N 330.47 TO POB	1	73	Privately owned hospitals	8.7	62.70%	3	6	5.25

Folio Number	Facility	Legal Description	Priority Tier	DOR (code)	DOR Use Code Description	Total Area (acres)	Percent-Flooded (1d 100y)	Flood prob factor = 25%	Consequence of Risk Factor = 75%	Factor
504132010022	Pioneer MS	NEWMANS SURVEY 2-26 D 32-50-41 TR 9 NLY 745 OF WLY 710 TOGETHER WITH NLY 748.38 OF PT OF TR 10 LYING ELY OF C/L OF SW 90 AVE TOG WITH THAT PT OF TR 10 DESC, COMM AT NE COR OF TR 10,W 477.03 S 748.37 TO POB,CON S 420.13 TO N/L OF 80 FT CANAL,E 477.44,N 420.13,W 477.29 TO POB AKA:PIONEER MIDDLE	1	83	Public county schools – includes all property of board of public instruction	24.959	63.60%	3	6	5.25
504137011441	private WWTP	NEWMANS SURVEY SUB NO 1 & 2 2-26 D 23-50-41 TR 5 N 315 OF W 245 TIER 21	1	91	Utility, gas & electricity, telephone & telegraph, locally assessed railroads, water & sewer service, pipelines, canals, radio/television communication	1.772	69.60%	3	6	5.25
504125010410	ROW	NEWMANS SURVEY 2-26 D 25-50-41 BEG SW COR SEC 25,N 1033.92, E 57.72, S 1036.15, W 69.86 TO POB LESS POR TO FSTA OR 511/319	2	94	Right-of-way, streets, roads, irrigation channel, ditch, etc.	0.524	90.70%	6	5	5.25
514109010030	ROW	EVERGLADES SUGAR & LAND CO 2-75 D 9-51-41 BEG AT A PT 360 W & 53 S OF NE COR OF SAID SEC,SLY 110, WLY 305,NLY 110,ELY 305 & N 53 OF SAID SEC LESS E 210 OF N 53 OF TR 1 LESS PT DESC IN OR 14037/685	2	94	Right-of-way, streets, roads, irrigation channel, ditch, etc.	4.315	91.00%	6	5	5.25
504127011020	ROW	WIMBERLY ADD TO DAVIE 14-18 B STREET IS DEDICATED TO THE PERPETUAL USE OF THE PUBLIC PER SAID PLAT	2	94	Right-of-way, streets, roads, irrigation channel, ditch, etc.	0.758	91.50%	6	5	5.25
504135270010	ALF	YADEL HOLDING COMPANY 175-62 B PARCEL A	2	73	Privately owned hospitals	9.595	92.20%	6	5	5.25
504135020390	Medical (Davie Rd)	EVERGLADE LAND SALES CO RESUB 2-34 D 35-50-41 TR 58 W1/2 LESS E 400	2	73	Privately owned hospitals	1.588	94.30%	6	5	5.25
504132024460	ROW	COOPER COLONY ESTATES 49-17 B STREETS,AVENUES,TERRACES,WAY, PLACES AND COURTS DEDICATED TO PUBLIC PER PLAT	2	94	Right-of-way, streets, roads, irrigation channel, ditch, etc.	35.531	95.70%	6	5	5.25
504233380020	DCOTA School	DESIGN CENTER OF THE AMERICAS 119-32 B PARCEL ""A"" LESS NLY 626	2	29	Wholesale outlets, produce houses, manufacturing outlets	1.212	97.90%	6	5	5.25

Folio Number	Facility	Legal Description	Priority Tier	DOR (code)	DOR Use Code Description	Total Area (acres)	Percent-Flooded (1d 100y)	Flood prob factor = 25%	Consequence of Risk Factor = 75%	Factor
514204000081	ROW	4-51-42 W1/2 OF NW1/4 OF NE1/4 OF NE1/4 PT TO C & SFFCD & LESS RD	2	94	Right-of-way, streets, roads, irrigation channel, ditch, etc.	2.566	82.70%	5	5	5
504132032570	ROW	COOPER COLONY ESTATES SEC 2 49-34 B STREETS,AVENUES,ROADS,TERRACES, WAYS,PLACES AND COURTS DEDICATED TO PUBLIC PER PLAT,LESS POR VACATED IN COOPER COLONY ESTATES SEC 2-C 69-5 B	2	94	Right-of-way, streets, roads, irrigation channel, ditch, etc.	18.848	83.00%	5	5	5
504128010500	ROW	NEWMAN'S SURVEY 2-26 D 28-50-41 W 50 OF E 350 OF TRACT 31	2	94	Right-of-way, streets, roads, irrigation channel, ditch, etc.	1.115	83.60%	5	5	5
514111310010	W Taft Shopping center	HOLLYWOOD FESTIVAL OUTPARCELS 178-44 B PARCEL 1	2	23	Financial institutions (banks, savings & loan companies, mortgage companies, credit services)	0.879	87.30%	5	5	5
504137011870	FAU Davie	NEWMANS SURVEY SUB 1 & 2 2-26 D 22-50-41 COMM SW COR TR 9 TIER 45,NW 15, NE 1245.66 TO POB,NE 1441.66,SE 990,NE 660,SE 1409.76,SW 2101.66 NW 2399.76 TO POB,LESS 46991/265 LESS OR 4478/543,LESS BEG SE COR OF PAR IN 4478/543,SW 76.57,NW 193.20,SW 16.94,NE 82.91,SE 208.82 TO POB: TOG WITH BEG NE COR OF PAR IN 4478/543,NW 208.64 SW 76.90,SE 208.71,NE 76.81 TO POB	2	84	Colleges	28.151	89.00%	5	5	5
504123010023	School bus depot	WESTPORT BUSINESS PARK PARCELS A & B 143-5 B BEG NW COR PAR B,NE 347.91,SE 207.52,SW 5.03,SW 5,SELY 62.85, SLY 569.53,NW 37.66,NW 31.14,NW 28.60,NW 32.92,SW 20.78,SW 63.77 NE 298.84 TO POB,& COMM NW COR PAR B,NE 347.94 TO POB,NE 207,NE 221.75,SW 202.22,SW 10.89,NW 207.52 TO POB & TOGETHER WITH POR DESC IN OR 20843/616 AKA:WEST CENTRAL BUS PARKING	1	83	Public county schools – includes all property of board of public instruction	23.902	13.10%	1	6	4.75
504129060010	Sliver Ridge Elem	SCHOOL SITE 3080 142-28 B PARCEL ""A""	1	83	Public county schools – includes all property of board of public instruction	12.55	14.10%	1	6	4.75

Folio Number	Facility	Legal Description	Priority Tier	DOR (code)	DOR Use Code Description	Total Area (acres)	Percent-Flooded (1d 100y)	Flood prob factor = 25%	Consequence of Risk Factor = 75%	Factor
504127060010	School bus depot	DAVIE SECOND ADD 10-63 B BLK 1-6 7-8 LESS S 50 & OR 23766/903 & 32236/1284,TOGET WITH PT VAC R/W ADJ & BUTTING SAID LOST & DAVIE THIRD ADD 14-26B BLK 1 & 2 AS DESC IN OR 2467/304 & HOLLYWOOD VILLAS 12-10 B BLKS 3-6 DESC IN OR 2467/307,LESS OR 3091/55,& NEWMAN SURVEY SUB 1&2 2-26 D 22- 50-41& 23-50-41 TR 9 TIER 33,TR9 TIER 35,TR 9 TIER 37 LESS PT OR 4068/941,2467/304,45544/437 FOR RD & EVERGLADS LAND SALES CO SUB 2-34 D SEE MEMO FOR ADD LEGAL	1	83	Public county schools – includes all property of board of public instruction	81.327	14.30%	1	6	4.75
504127230010	Davie Pub works	DAVIE COMMUNITY FACILITIES II 123-48 B TRACT A	1	89	Municipal other than parks, recreational areas, colleges, hospitals	9.39	22.90%	1	6	4.75
504132010143	Cooper City High	NEWMANS SURVEY 2-26D 32-50-41 W 1347.80 OF:COMM SE COR TR 15,W 478 TO POB,N 1010.82,W 2162.06,S 1023.40,E 2161.50 TO POB LESS RD AS IN OR 18314/735 & 19751/261 & PT TR 15 DESC AS:COMM SE COR SEC 32,W 459.22,W 1944.09,N 55 TO POB,W 158.56,N 912.16,E 153,S 728.99,E 5,S 182.17 TO POB & N 50 OF:COMM SE COR TR 15,W 478 TO POB,N 1010.82,W 2162.06,S 1023.4 E 2161.50 TO POB,LESS E 50 & W 1397.80 TOG WITH POR DESC IN OR 45647/318 AKD:COOPER CITY HIGH	1	83	Public county schools – includes all property of board of public instruction	29.908	23.80%	1	6	4.75
504117200010	Fox Trail Elem	CALUSA RIDGE 147-47 B TRACT A LESS POR DESC:BEG MOST NLY NW COR TR A,SE 812.94,SW 67.37,SW 343.97,SW 467.48,W97.15 N 105.80,W 12,N 10.91,NE 200.72, N 300,NE 56.30 TO POB & POR TR B DESC:COMM NW COR SEC 17,S 853.28 E 67 TO POB,E 417,SE 33,SW420.32 W 36.32,N 35 TO POB&COMM NW COR SEC 17,S 853.28,E 100,E 1331.29 TO POB,N 180,E 150,SW 234.31 TO POB;LESS POR K/A PARCEL 130 PER OR 47717/1428	1	83	Public county schools – includes all property of board of public instruction	25.641	28.40%	1	6	4.75

Folio Number	Facility	Legal Description	Priority Tier	DOR (code)	DOR Use Code Description	Total Area (acres)	Percent-Flooded (1d 100y)	Flood prob factor = 25%	Consequence of Risk Factor = 75%	Factor
514209260010	Oakridge Elem	OAKRIDGE ELEMENTARY SCHOOL PLAT 179-10 B TRACT A	1	83	Public county schools – includes all property of board of public instruction	6.96	28.70%	1	6	4.75
504132020040	Cooper City Elem	COOPER COLONY ESTATES SEC 1 49-17 B TRACT D	1	83	Public county schools – includes all property of board of public instruction	8.663	29.80%	1	6	4.75
504116000021	field	16-50-41 E 200 OF W 275 OF N 610 OF S 1790 OF SEC 16-SAME AS OR 1383 PG 61	1	91	Utility, gas & electricity, telephone & telegraph, locally assessed railroads, water & sewer service, pipelines, canals, radio/television communication	2.801	29.80%	1	6	4.75
504123010025	SFWMD	WESTPORT BUSINESS PARK PARCELS A & B 143-5 B PT OF PARCELS A1 & B DESC'D AS, BEG SE COR PAR A1,WLY 28.97,NLY 26.08,N 19.20,NE 16.51,N 24.61, NW 33.97,NW 5.14,W 37.38,W 177.5 W 35.07,SW 33.46,SW 32.43,W 24.6 SW 30.31,SW 31.45,SW 26.52,SWLY 25.34,SW 22.73,SW 20.64,SW 22.17 SW 28.55,SW 10.52,SW 37.78,SWLY 38.5,SW 17.79,NW 47.25,WLY 35.47 WLY 70.68,W 42.77,NW 25.93,ELY 571.62,SE 38.47,ELY880.14,E81.81 W 18.27,SW 375.5 TO POB (SFWMD)	1	86	Counties (other than public schools, colleges, hospitals) including non-municipal	9.544	33.40%	1	6	4.75
504127010250	Nova Communtiy School	EVERGLADE LAND SALES CO SUB 2-34 D 27-50-41 TRACT 21 LESS RD DESC IN OR 2467/304 & THAT PART OF TRACT 22 DESC IN OR 2467/307 LESS RD R/W DESC IN OR 3661/32 & LESS POR DESC IN OR 47865/1925	1	83	Public county schools – includes all property of board of public instruction	12.106	35.30%	1	6	4.75
504122070010	McFatter	MC FATTER VOCATIONAL SITE 163-17 B PARCEL A	1	83	Public county schools – includes all property of board of public instruction	39.469	35.70%	1	6	4.75

Folio Number	Facility	Legal Description	Priority Tier	DOR (code)	DOR Use Code Description	Total Area (acres)	Percent-Flooded (1d 100y)	Flood prob factor = 25%	Consequence of Risk Factor = 75%	Factor
514105280010	Red Apple Charter	CHARTER SCHOOL-COOPER CITY 180-24 B PAR A LESS POR DESC AS: COMM AT MOST WLY SW COR OF TR A OF SOUTH BROWARD SPORTS CENTER"" 116-20 B,E 600.83,S 202.55 TO POB, CONT S 86.30,W 75,N 86.30, E75 TO POB	1	72	Private schools and colleges	5.816	39.50%	1	6	4.75
514204150010	Attuck MS Dania	SCHOOL SITE 0340 154-17 B PARCEL 'A'	1	83	Public county schools – includes all property of board of public instruction	39.201	39.90%	1	6	4.75
504122060010	Nova SE Univ	NOVA UNIVERSITY NO.1 146-49 B PARCEL A & POR VAC'D R/W LESS POR DESC:BEG NW COR PAR A,NE 110.63,NE 271.10,SE 704.08,SE 220.46,SW 697.90, NW 61.43,SW 112.19,NW 483.49,NE 112.74,NW 535.65,N 620 TO POB & LESS PT DESC IN OR 46669/1609 & LESS EX C IN OR 47436/1920 & LESS PT PAR A INC IN INST# 114910442 & LESS PAR DESC AS:COM SE COR PLAT,NE 70.98,NW 75.51 TO POB,NW 234.57, NE 383.58,SE 234.57,SW 383.58 TO POB, LESS INSTR #115538303	1	72	Private schools and colleges	111.609	43.10%	1	6	4.75
504127110011	Davie Hist. Museum	EVERGLADES LAND SALES CO SUB OF N1/2 TR 52 27-50-41 3-80 D POR LOTS A & B DESC AS:COMM NE COR TR,S 197,W 102 TO POB;W 110 S 58,E 35,S 42,E 75,N 100 TO POB	1	83	Public county schools – includes all property of board of public instruction	0.219	46.20%	1	6	4.75
504137011622	Borward Co	NEWMANS SURVEY SUB NO 1 & 2 2-26 D 22 & 23-50-41 THAT PT OF TRS 6 TO 9,TIER 31, TRS 6 TO 9 TIER 33,TRS 6 TO 9 TIER 35 & TRS 6 TO 9 TIER 37 & RD INC IN DESC,BEG 203.6 E OF SW COR SEC 23,NE 2526.66, NW 2334.33,SW ALG/L 35 E OF W/L TIER 37 FOR 2782.68,SE 2334.33, N 256.55 TO POB,LESS PT SHOWN IN MISC PLAT BOOK 6 PG 23 B FOR RD & LESS PT DESC'D IN OR 24250 PGS 743-746 FOR ADD'L R/W	1	83	Public county schools – includes all property of board of public instruction	145.052	46.50%	1	6	4.75
514102300020	Driftwood Elem	SCHOOL SITE 0720 & 0860 157-41 B TRACT B AKA:DRIFTWOOD MIDDLE	1	83	Public county schools – includes all property of board of public instruction	12.799	47.30%	1	6	4.75

Folio Number	Facility	Legal Description	Priority Tier	DOR (code)	DOR Use Code Description	Total Area (acres)	Percent-Flooded (1d 100y)	Flood prob factor = 25%	Consequence of Risk Factor = 75%	Factor
514209000250	Driftwood Elem	9-51-42 PORTION OF SHERIDAN STREET (ST RD 822) RIGHT OF WAY AS PER R/W MAP 5-27, LYING BOTH E OF I-95 AND LYING WITHIN SEC 9	2	94	Right-of-way, streets, roads, irrigation channel, ditch, etc.	3.826	71.30%	4	5	4.75
504125010660	ROW	NEWMANS SURVEY 2-26 D 25-50-41 PART TRACT 25 DESC AS:BEG AT PT 20 FT E OF AND 43 FT N OF SW COR SEC 25-50-41, N 990.92,NE 337.75 S 998.44, W 349.40 TO POB LESS R/W FOR GRIFFIN RD	2	94	Right-of-way, streets, roads, irrigation channel, ditch, etc.	0.992	72.70%	4	5	4.75
504133010440	field	EVERGLADES SUGAR & LAND CO SUB 3-67 D 33-50-41 TRACT 34	2	86	Counties (other than public schools, colleges, hospitals) including non-municipal	10.01	72.90%	4	5	4.75
514208170010	Apts, At Risk	FEDERATION MANOR 127-34 B PORTION OF PARCEL A DESC AS: BEG NW COR PAR A,E 257.14, S 68.86, E 12.35, S 99.35, W 5.50, S 54.25, W 40.68, S 18, SW 34.79, SE 46.52, S 75.29, SE 71.85, S 54.03, W 246.12, SW 40 TO W/L PAR A, N 490 TO POB	2	73	Privately owned hospitals	2.79	73.30%	4	5	4.75
504123010034	Bank	WESTPORT BUSINESS PARK PARCELS A & B 143-5 B POR OF PAR B DESC AS COMM AT SE COR SAID PAR B,NW 81.02,NW 100.72,NW 70.45 TO POB,CONT NW 139.71,NE 20.09,NW 23.86,NE 55.03,NE 101.20,SE 184.55,SW 174.13 TO POB AKA:WESTPORT PUBLIX OUT PARCEL	2	23	Financial institutions (banks, savings & loan companies, mortgage companies, credit services)	0.667	73.70%	4	5	4.75
504125010670	ROW	NEWMANS SURVEY 2-26 D 25-50-41 PT TRACTS 25 & 26 DESC AS:BEG AT PT ON N/L TR 25 1033.92 N AND 357.75 E OF SW COR SEC 25-50-41, E 151.63,SELY 477.59,SE 297.14, SELY 271.51,SE 245.79,S 29.63,NW 572.84,NW 297.14,NWLY 517.51, N 54.03 TO POB TOG WITH BEG AT PT ON N/L R/W GRIFFIN RD 43' N OF & 1180.31 E OF SW COR,NW 165.11, NWLY 189.34,SE 383.24,W 38.34 TO POB	2	94	Right-of-way, streets, roads, irrigation channel, ditch, etc.	2.346	74.70%	4	5	4.75
504127140230	ROW	GRIFFIN PARK ESTATES 78-45 B THE TERRACE IS DEDICATED TO THE PERPETUAL USE OF THE PUBLIC PER SAID PLAT	2	94	Right-of-way, streets, roads, irrigation channel, ditch, etc.	1.463	77.80%	4	5	4.75

Folio Number	Facility	Legal Description	Priority Tier	DOR (code)	DOR Use Code Description	Total Area (acres)	Percent-Flooded (1d 100y)	Flood prob factor = 25%	Consequence of Risk Factor = 75%	Factor
514105230013	Bank	COOPER CITY COMMONS 170-119 B PORTION OF PARCEL A DESC'D AS: COMM AT SE COR OUTPARCEL 2,ELY 40 ALG S/L PAR A TO P/C,ELY ARC DIST 159.27 TO POB,NLY 233.20, ELY 62.42 TO P/C,ELY ARC DIST OF 91.87,SE 89.52,SLY 169.35 TO P/A WLY ARC DIST 195.29 TO POB AKA: OUTPARCEL 3	2	23	Financial institutions (banks, savings & loan companies, mortgage companies, credit services)	1.017	79.50%	4	5	4.75

After this analysis, if the conclusion of the stakeholder group is that none of the identified vulnerable areas meet the minimum threshold score, then none of the parcels will be added to the prioritized project list. If, however, some of them do meet the requirements established by the stakeholder group, then each parcel that does will qualify to be placed on the prioritized project list for capital improvement (see Section 6.4.3). The exact decision of the various implementation projects will vary from watershed to watershed, but this process should identify those projects that should be prioritized. However, it is ultimately up to the stakeholder group to assign the weights of the flood probability factor and the consequence of risk factor as well as the tie breaker procedure and regional priorities, so that the process best meets the needs of the community. Using a matrix table and including costs, allows for rapid prioritization to assign the proper resources that will make the most impact with limited funds (see Table 16 in Section 6.4).

5.3 Mitigation Strategies

Infrastructure improvements are necessary to harden properties and lessen flood risks. These improvements may come as hard improvements like pump stations, dikes and piping (termed gray infrastructure), retention areas, swales and the like (termed green infrastructure), policy improvements (paper infrastructure), and concepts that revise how development occurs modeled to a future time (changes in flood elevations for buildings, etc.). To optimize watershed protection goals, disparate goals of potential water supplies, agricultural use, development pressure, property rights, flood control and ecosystem protection must be considered. These are not always compatible goals. For example, additional water will be needed in the dry season to retard saltwater migration in coastal areas, but those areas are likely to flood from storms – these are not compatible goals. As a result, a more managed system is likely to be needed to meet multiple or competing objectives. Long-term plans would need to focus on the following issues:

- Providing additional onsite storage for stormwater
- Changes in building elevation and height restrictions
- Movement (i.e. Relocation? Transfer of development rights?) of development away from flood prone areas
- Increasing pumping to reduce groundwater levels to maintain soil capacity in low lying areas.
- Onsite infiltration and use of stormwater for potable water supplies
- Flood control structures may need to be added, or existing ones modified as to operating stage
- Dry or wet floodproofing with water and flood damage resistant materials
- Ecosystem sustainability need to be undertaken by federal, state, and regional governments to determine the available tools to maintain as much diversity as possible, realizing ecosystem protection may have significant economic benefits

6.0 ACTION PLAN

The key components of the implementation phase are: 1) the implementation team, 2) information/education, 3) capital improvement projects, 4) maintenance, 5) monitoring, and 6) evaluation and adjustments. A watershed implementation team made up of key stakeholder partners from the planning team, particularly those whose responsibilities include making sure tasks are being implemented, reviewing monitoring data, ensuring technical assistance in the design and installation of management measures, finding new funding sources, and communicating results to the public.

6.1 Information/Education Plan

Every WMP should include an outreach component that involves the community. Because individual actions and voluntary practices are involved in the solutions outlined in the plan, effective public involvement and participation will promote adoption of management practices, ensure sustainability, and encourage changes in behavior that will help to successfully achieve the goals and objectives. This comprehensive guide has six critical steps of outreach:

1. Defining goals and objectives
2. Identifying target audiences
3. Developing appropriate messaging
4. Selecting materials and activities
5. Distributing the messages
6. Conducting evaluation and continuous improvement

Although awareness of the issues is a good first start, the public should be educated on the challenges facing the watershed and become invested in the solution by knowing what specific actions they can take to participate in successful implementation.

6.2 Maintenance Plan

The goal of managing stormwater is to protect public health, welfare, and safety by reducing flood impacts on a community, the potential for waterborne disease from flooding, and to lessen the potential for property damage if flooding occurs. Public and private property may include homes, businesses, roadways, railroads, bridges, utilities, etc., so the first objective is to remove excess water in a timely manner, to a place where it will not adversely impact the public and the economy. To prevent flooding and the potential for health risks associated with stagnant water, stormwater runoff must be managed in an organized and systematic manner if property owners are to enjoy the full use of their property and roadways are to be clear. As a result, stormwater facilities must be constructed and maintained to reduce the negative impacts of runoff.

The burden of managing this stormwater typically falls to a local community stormwater organization – typically a special district, stormwater utility or a division of a local government. For this study area, these entities are:

- Broward County
- City of Dania Beach
- City of Cooper City
- City of Hollywood
- Town of Davie
- South Florida Water Management District
- USACE

Federal programs created under the Clean Water Act specify that those communities with local stormwater infrastructure – pipes, pumps, catch basins, exfiltration trenches, retention basins, etc. – are required to fund and perform the following:

- Annual Maintenance
    - Disk dry retention area bottoms
    - Disk swale bottoms
    - Correct stormwater wet retention area

- Semi-Annual Maintenance
    - Correct areas of erosion, undercutting or dead grass in wet and dry retention areas and swales
    - Take appropriate action on petroleum or other pollution spills noted
    - Swale cleaning
    - Remove invasive plants
    - Remove sediment from exfiltration trenches
    - Clean exfiltration trench

- As Needed Maintenance
    - Mow wet and dry retention areas and swales
    - Stabilize banks of wet and dry retention areas
    - Rehabilitate exfiltration trenches every 10 years
    - Correct wet and dry retention area equipment
    - Correct dry retention area bottoms
    - Nutrient/pesticide management
    - Clean bottom debris

- Re-sod banks of wet and dry retention areas as needed
- Inspect all retention ponds

Such maintenance activities also require good record-keeping to develop and maintain accurate mapping of the drainage system and track improvements in areas with ongoing stormwater issues.

6.3 Monitoring and Compliance Requirements

Because stormwater protection is often more regional than local in many cases, most communities participate in programs under permits secured by a regional agency (county level is common) to address the interconnectedness of waterbodies through neighboring jurisdictions. Monitoring programs are primarily an administrative feature of watershed management. A good environmental monitoring program (EMP) will assess the effectiveness of the overall practices and provide necessary information to prevent failures or property damage, or at least reduce the risk. The following are typical monitoring program elements:

Inspections:

- Annual
  - Wet retention area
  - Swale bottoms
  - Disk bottom
- Semi-Annual
  - Dry Retention areas
  - Exfiltration trenches
  - Swales
  - Sediment in wet retention, dry retention and swale areas
- Quarterly
  - Catch basins

Stormwater Management Program:

- Submit annual inspection and maintenance report
- Conduct required inspections and maintenance
- Develop and maintain record-keeping system

New Development:

- Implement state, local and regional policies with regard to stormwater and drainage management controls
- Review Land Development Regulations to determine where changes must be made, especially to swales, low impact development, stormwater reuse and landscaping

Roads:

- Litter control

- Implement Best Management Practices (“BMPs”), also called Best Stormwater Practices
- Perform maintenance of catch basins, grates, storm drains, structures, swales gutters and other features

Flood Control:

- Ensure new development flood control meets performance standards in 62-40 F.A.C.
- Strengthen local comprehensive plans and submit them to the County
- Maintain a GIS layer with water quality information
- Ensure flood control meets with water management district rules

Pesticides and Herbicides:

- Provide certification and licensing of applicators to the County

Illicit Discharges:

- Conduct assessment of non-storm discharges
- Provide copies of newly adopted ordinances prohibiting illicit discharges and dumping
- Continue random inspection program
- Define allotment of state and resource to stormwater program
- Report and prosecute all violators
- Conduct periodic training to staff on identification and reporting of illicit discharges
- Terminate illicit discharges and document same.
- Develop municipal procedures for handling and disposing of chemicals and spills, including training of staff on emergency response
- Distribute brochure to public on appropriate disposal of hazardous materials
- Develop public outreach effort for oil, toxic and hazardous waste for public
- Promote Amnesty Day for hazardous materials
- Develop voluntary storm drain marking program
- Continue infiltration and inflow program on sanitary sewer system
- Investigate septic tank discharges to stormwater system

Industrial Runoff:

- Maintain inventory of high risk discharges, including outfall and surface waters where discharge occurs.
- Provide ongoing inspections of high risk facilities
- Provide annual report to appropriate agency for enforcement
- Monitor high risk facility discharge water quality

Construction Sites:

- Ensure stormwater system meets treatment performance standards in 62-40 FAC
- Continue construction site inspection program to ensure reduction of off-site pollutants
- Implement standard, formalized checklist of stormwater management and water quality inspection items
- Maintain log of stormwater management activities at construction sites

- Provide detailed description of inspection program and forms
- Provide summary of activities
- Continue inspection certification program to stormwater management, erosion and sediment control for operators, developers and engineers
- Develop outreach program for local professional organizations

Monitoring programs should verify ongoing demonstration of maintenance through the use of logs, work orders, photographic documentation, and geographic information systems (GIS) support to insure all of these facilities not only operate properly, but also reduce pollutants. These requirements mean that the community needs funds to ensure proper execution of the program for compliance. Significant effort is required to maintain functioning of stormwater systems, many of which have been neglected with time. Extra effort may be recommended prior to rainy seasons to limit flooding potential from unmaintained facilities.

6.4 Capital Plan

Once the vulnerability assessment and mitigation measures have been determined, the next step is to implement the plan to address these issues—in other words, it is often possible to add mitigation measures to existing capital improvement programs. Every infrastructure agency will spend money to operate and maintain the system. Agencies involved in flood protection are no different, they all spend money on operations, debt, and capital. These factors are brought together in annual budget documents. Budgets are a necessary part of operations and are statutorily required for most jurisdictions. In most cases, all infrastructure agencies should be set up as an enterprise fund to allow the organization to pay its own way, which will also make it easier to evaluate the operational aspects of an infrastructure system.

Coordination between the financial, budget, and operating policies of a utility system allows managers to properly allocate costs to those benefiting from the service, develop pricing strategies that can be clearly explained to the public and prevent challenges to allocation methodologies. Operations, capital programs, and long-term variability of the utility system operation require financial and facility planning. Multi-year economic forecasts and financial plans are standard tools in business and are worthy of consideration by flood protection agencies and elected officials.

An example process that USEPA (2013) suggests for capital plans is as follows:

1. “Inventory existing management efforts in the watershed, considering local priorities and institutional drivers
2. Quantify the effectiveness of current management measures
3. Identify new management opportunities

4. Identify critical areas in the watershed where additional management efforts are needed
5. Identify possible management practices
6. Identify relative pollutant reduction efficiencies
7. Develop screening criteria to identify opportunities and constraints
8. Rank alternatives and develop candidate management opportunities"

6.4.1 SFWMD/USACE Regional Capital Improvement Projects

CERP is a hydrologic restoration project for the water resources of central and south Florida that was authorized by Congress in 2000. Through June 2018, the State of Florida and SFWMD have invested more than $2.3 billion in CERP-related project design, engineering, construction, and land acquisition. Florida has now designated consistent funding for restoration through the Legacy Florida Act (Laws of Florida, Chapter 2016-201) and the Water Resources Law of 2017 (Laws of Florida, Chapter 2017-10, Senate Bill 10) and through advancement of other projects. Of note, CERP was envisioned as a partnership between USACE and the State of Florida, with SFWMD acting as the local sponsor on behalf of the state. While Florida's funding commitment has outpaced the federal government's in the 18 years since the plan was approved, cost sharing on the larger components is lacking. As a result, none of the major project components described in CERP has been completed.

SFWMD and USACE are spearheading CERP, which is being coordinated with the Lake Okeechobee Watershed Construction Project Phase II Technical Plan. This plan will address pollutant load reductions based on adopted TMDLs. It will also include a goal for salinity levels and freshwater inflow targets.

Components of the multi-phase plan include the following:

- Policy
  - Implementing agricultural best management practices on more than 1.7 million acres of farmland
  - Adopting new regulations that will reduce the impacts of development on water quality and flow
  - Using green infrastructure nutrient control technologies to reduce phosphorus loads from the watershed
- Infrastructure
  - Building treatment wetlands to pretreat water flowing into Lake Okeechobee

- Creating between 0.9 – 1.3 million acre-feet of water storage north of Lake Okeechobee through a combination of above-ground reservoirs, underground storage, and alternative water storage projects on public and private lands

The Lake Okeechobee Watershed Construction Project (LOWCP) was undertaken to identify issues that are affecting water quality and/or quantity in each of the subwatersheds and basins within the Lake Okeechobee Watershed (and downstream), and then, determine if projects, also known as management measures, are adequately addressing those issues. The water quality issues in Lake Okeechobee are critical to the HUC 030902061205 Davie/Dania Beach subwatershed because the lake is drained in part through the canals the flow into southeast Florida. Nutrient-laden water from Lake Okeechobee creates significant downstream water quality impacts.

6.4.2 County-Wide Capital Improvement Projects

Broward County has funding for transportation improvements for roads and transit, but little of this is stormwater-related beyond replacing existing culverts. The County has proposed providing matching funds to the local communities for “complete streets” improvements, but this is not currently defined.

6.4.3 Local Capital Improvement Projects

Programs for monitoring operations and ensuring that ongoing inspections take place are needed once the WMP is adopted. FDEP can coordinate the regulatory compliance aspects of Clean Water Act requirements. In addition, upon completion of the regional reservoir projects, re-modeling of the watershed should be conducted incorporating these features. That will permit a change to the impact maps, allowing for some potential reductions to impacted areas. The impact of sea level rise must also be considered in future decision-making as it may mean effort in the east to reduce flooding from Lake Okeechobee discharges are replaced by prioritizing flood reduction from sea level rise in the west.

Large flood protection/storage projects are designed to reduce risk and are likely to score high on a priority scale. Localized infrastructure will tend to score lower due to the scale. In this study area, there were no high-impact projects identified in the capital plans for any agency. However, SFWMD has several projects that provide substantial benefit, so these are deemed to have important consequences.

6.4.4 Study Area Level Capital Improvement Projects

Table 16 outlines the projects in the 5-year capital plans for the communities located in the study area, noting where the projects are or are not within the subwatershed (refer to individual plans in Section 3.5.5 for details), opinions of probable cost, benefitting jurisdiction, and the funding source. Note planning activities may be partially within the subwatershed but are not capital projects and the extent of study is unknown. As a result, to prioritize projects in the study area, all projects that are outside the subwatershed boundary, or are labeled as “partial” were removed. Table 17 shows the priority of the remaining projects based on the protocol outlined herein that relies on an assessment of the risk and vulnerability to create a composite score for prioritization.

Table 16. Capital plan and prioritization estimate

Location in Subwatershed?	Name of Project	Project Location	Responsible Agency	Benefiting Jurisdiction	Fund Source	Opinion of Cost (000s)	Type of Construction (New, Deferred, Completed)	Timeframe for Completion
No	Complete Streets	Broward	Local	Dania Beach	Transportation surtax	20000	New	10 years
Partial	General Maintenance Annual	Cooper City	Cooper City	Cooper City	SW Utility	50/yr	New	ongoing
Yes	Cooper City School/City Hall	Cooper City	Cooper City	Cooper City	SW Utility	2500	New	2030
No	SE Drainage Project	Dania Beach	Dania Beach	Dania Beach	SRF	13500	New	2023
No	SW 43rd Terr	Dania Beach	Dania Beach	Dania Beach	SW Utility	2200	New	2024
Partial	Stormwater Master Plans	Dania Beach	Dania Beach	Dania Beach	SW Utility	200	New	2022
No	SW 26th St	Dania Beach	Dania Beach	Dania Beach	SW Utility	2000	New	2025
No	Dania Cove	Dania Beach	Dania Beach	Dania Beach	SW Utility	200	New	2021
No	NW Master Plan	Dania Beach	Dania Beach	Dania Beach	SW Utility	200	New	2022
No	North Beach	Dania Beach	Dania Beach	Dania Beach	SW Utility	200	New	2023
No	DCOTA- NW Dania	Dania Beach	Dania Beach	Dania Beach	SW Utility	2500	New	2025
No	Dania Beach Risk Assessment Stormwater	Dania Beach	Dania Beach	Dania Beach	Legislature	795	New	2022
Yes	Davie - College Area	Davie	Davie	Davie	General Fund	5000	New	2025
Yes	Davie Fox Trail	Davie	Davie	Davie	General Fund	2500	New	2025
No	Stormwater Master Plans	Davie	Davie	Davie	General Fund	80	Completed	2018
Partial	Flood Mitigation Program ($3M/yr)	Davie	Davie	Davie	TBD	3000/yr	New	ongoing
Partial	General Maintenance Annual	Davie	Davie	Davie	General Fund	480/yr	New	ongoing
Partial	Citywide Misc Stormwater	Hollywood	Hollywood	Hollywood	SW Utility	5240	New	2021-25
Partial	Flood Mapping	Hollywood	Hollywood	Hollywood	SW Utility	383	New	2021
No	Small Drainage	Hollywood	Hollywood	Hollywood	SW Utility	1354	New	2021-25
No	SW Infrastructure Program	Hollywood	Hollywood	Hollywood	SW Utility	5673	New	2021-25
No	Stormwater Master Plan	Hollywood	Hollywood	Hollywood	SW Utility	2000	New	2022
No	SW NDPES Program	Hollywood	Hollywood	Hollywood	SW Utility	202	New	2021-25
Yes	W Hollywood/Driftwood	Hollywood	Hollywood	Hollywood	SW Utility	1500	New	2026
Yes	W Hollywood Taft	Hollywood	Hollywood	Hollywood	SW Utility	2500	New	2028
Yes	Hollywood/Attucks	Hollywood	Hollywood	Hollywood	SW Utility	2500	New	2029
Partial	Hollywood Risk Assessment Stormwater	Hollywood	Hollywood	Hollywood	Legislature	400	New	2022

Table 17. Suggested prioritization of flood mitigation projects, organized by community, based on the methodology of this work

Name of Project	**Project Location**	**Responsible Agency**	**Benefiting Jurisdiction**	**Priority Score**	**Fund Source**	**Opinion of Cost (000s)**	**Type of Construction (New, Deferred, Completed)**	**Timeframe for Completion**
Cooper City School/City Hall	Cooper City	Cooper City	Cooper City	4.75	SW Utility	2500	New	2030
Davie - College Area	Davie	Davie	Davie	5.00	General Fund	5000	New	2025
Davie Fox Trail	Davie	Davie	Davie	4.75	General Fund	2500	New	2025
W Hollywood Taft	Hollywood	Hollywood	Hollywood	5.00	SW Utility	2500	New	2028
W Hollywood/Driftwood	Hollywood	Hollywood	Hollywood	4.75	SW Utility	1500	New	2026
Hollywood/Attucks	Hollywood	Hollywood	Hollywood	4.75	SW Utility	2500	New	2029

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