Digital Flood Vulnerability Assessment

Resilient Cedar Key: Digital Flood Vulnerability Assessment **is an initiative to digitally document the core of historic Cedar Key and its waterfront area to prepare 3D visualizations of sea level rise projections and identify and map historic buildings that are vulnerable.**

The initiative is a partnership between the City of Cedar Key and the University of Florida's Historic Preservation Program and Urban Regional Planning Department with financial support from the Florida Division of Historical Resources.

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RESILIENT CEDAR KEY

EXECUTIVE SUMMARY

Cedar Key, Levy County, is a small historic community among many islands along the Gulf Coast of Florida. It sits 50 miles southwest of Gainesville, Florida (where the University of Florida is located). Highway 24 connects the inland to Cedar Key, three miles out into the Gulf of Mexico. About 800 full-time residents live in the City of Cedar Key.[1] Annual visitation is approximately 300,000, estimate based on the Department of Transportation sensors used for the annual Cedar Key Seafood and Arts Festivals; Visitors to the Cedar Key Welcome Center operated by the Chamber of Commerce; and the Marina. This island provides visitors with a variety of natural attractions, and the roads are shared with bicycles and golf carts. The historic core of Cedar Key incorporates around 100 structures ranging from the late nineteenth to early twentieth century in the downtown and residential area, and this study adds some 30 properties from the recent past (built before 1975) that can potentially contribute to the historic district. Visitors come to experience the island's historical places and natural environment. These irreplaceable resources are increasingly threatened by short-term flood events and longer-term sea level rise.

Resilient Cedar Key: Digital Flood Vulnerability Assessment is an initiative to digitally document the core of historic Cedar Key and its waterfront area to prepare 3D visualizations of sea level rise projections and identify and map historic buildings that are vulnerable. The digital data and other products generated by this initiative are being used in a variety of ways:

§ Highly precise elevation and building data to inform adaptation strategies as they are developed and implemented;

§ Vulnerability assessment of 135 individual properties—some of which have a group of buildings within the same parcel; 165 structures in total—that make up the Cedar Key study area;

§ Informed by case studies of programs and projects in other historic coastal communities, considerations for integrating resiliency and adaptation measures into historic preservation guidelines;

§ 3D visualizations and other materials that help communicate sea level rise projections and impacts and raise awareness of resiliency among residents and stakeholders;

§ The analyzed data and digital vulnerability assessment are being exhibited at the City of Cedar Key Welcome Center operated by the Chamber of Commerce and presented at meetings and workshops for local government officials, residents, and other key stakeholders to review vulnerable areas and resources and to develop an approach for adaptation strategies;

§ Engagement with the public around topics of historic preservation, natural hazards, projected sea level changes, and adaptation strategies for building and community resilience; and

§ *Resilient Cedar Key: Digital Flood Vulnerability Assessment* is intended to serve as a model for other historic coastal communities in Florida and across the country that are working to enhance resiliency while maintaining historical and architectural character and sense of place.

[1] Cedar Key Chamber of Commerce. Accessed July 11, 2019. http://cedarkey.org

PROJECT BACKGROUND

In 1843, when the Second Seminole Indian War ended, Augustus Steele, a New Englander, turned the island into a port for transporting cotton, sugar, tobacco, and lumber from surrounding keys and inland plantations along the coast.[1] David Levy Yulee, one of Florida's first U.S. Senators and Steele's friend, built the first railroad crossing Florida from Fernandina to Cedar Key and developed the town grid. After the Civil War, the town became the main port at the southwest coast of Florida due to the railroad terminus. The City of Cedar Key was incorporated in 1869 and experienced an urban development boom including the construction of residences, stores, hotels, warehouses, infrastructure, and sawmills like the Eagle Pencil Company Mill at Third and G Streets (the present site of Faraway Inn). Sawmills, seafood facilities, and several other industries employed several thousand people in and around Cedar Key. However, in the late 1880s, the industries started declining as the land and sea resources were depleted. An 1896 hurricane caused drastic storm surge and fire that destroyed many industrial facilities that ceased operations. The railroad was abandoned in 1932. Although some manufacturing factories continued service in the early twentieth century, Cedar Key gradually became a small fishing village and has retained the cultural landscape of a historic coastal community until today.

Natural conservation efforts and regulations have provided habitats of wildlife and places for researchers and artists. The Cedar Keys Historic and Archeological District (National Register of Historic Places reference number: 88001449; listed on October 3, 1989) comprises the core downtown and west residential area where some of the late nineteenth century structures that are associated with the City's development history have remained. The only individual National Register property in Cedar Key is the 1861 Island Hotel (reference number: 84000252; listed on November 23, 1984). The City of Cedar Key has a local historic preservation ordinance. The Historic Board regulates the local historic district and the individual properties that make it up.

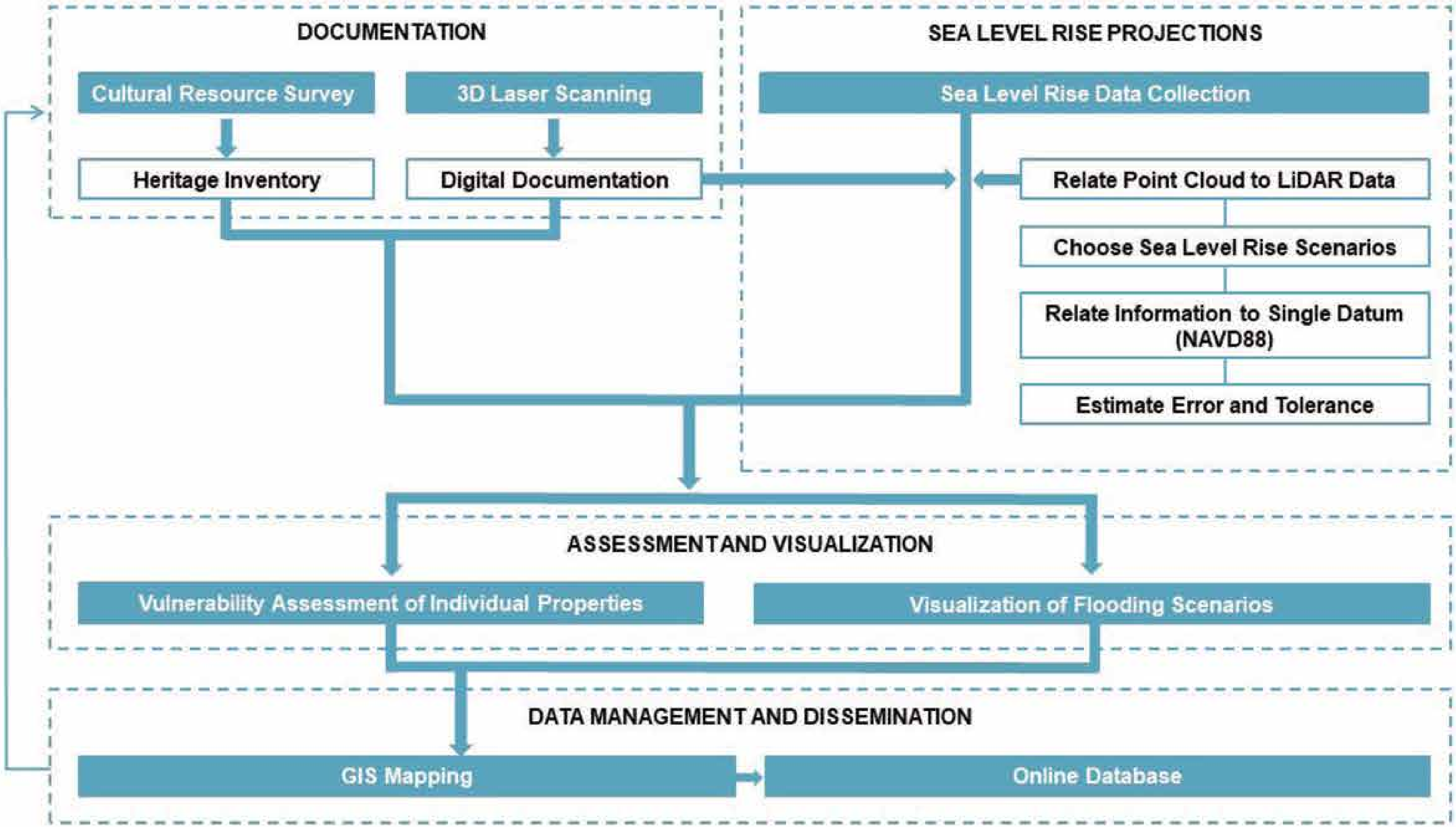
A primary goal of the *Resilient Cedar Key: Digital Flood Vulnerability Assessment* is to raise awareness of the City's historical, cultural, and archaeological resources and the impact of sea level rise. The project is intended to continue and enhance the public dialog on short and long-term flooding due to sea level rise and to help develop strategies for adaptation. The project will also help ensure the long-term preservation of Cedar Key's historic buildings and sense of place vital to the City's tourist-based economy.

[1] The Cedar Key Historic Society. *Historic Old Cedar Key: a walking tour*. 1987 (Revised 1997).

The *Resilient Cedar Key* study area focuses on the core of the City of Cedar Key and its waterfront. The study area encompasses a range of historical, cultural, and architectural resource types. Prominent buildings include the Island Hotel (left), W. R. Hodges House (right), and Cedar Key Public Library / Schlemmer Rooming House (center).

PROJECT METHODOLOGY

FLOW CHART



PROJECT METHODOLOGY

OVERVIEW

DOCUMENTATION

Cultural Resource Survey

- Background research, field survey, data organization, and inventory development
- Photographs, structural information, conditions, and archival data

3D Laser Scanning

3D point clouds by terrestrial laser scanning provide:

- Accurate building measurements for architectural heritage documentation
- 3D imagery and information for flood visualization and vulnerability assessment

SEA LEVEL RISE PROJECTION

Step 1: Relating Point Cloud to LiDAR Data

Ground elevations from airborne LiDAR data from the Florida GIS archive

Step 2: Choosing Sea Level Rise Scenarios

NOAA Intermediate-High scenarios for the years of 2040, 2060, 2080, and 2100

Step 3: Relating Information to a Single Datum (NAVD88)

Datum chart of NAVD88 and tidal elevations for the community

Step 4: Estimating Error and Tolerance

Benchmark setup considering different accuracy of airborne LiDAR and terrestrial laser scanning

Step 5: Identifying Vulnerable Heritage

Cultural and geospatial understanding through field observation and digital analysis

Step 6: Flooding Scenarios Visualization

Bathtub approach where a digital water level is raised and rendered with the point cloud to represent the selected scenarios in vulnerable locations in Cedar Key

FLOOD VULNERABILITY ASSESSMENT AND GIS MAPPING

Step 1: Measuring First Floor Elevations

Levels of living space measured to door threshold of the main entrances of each building

Step 2: Generating GIS Attribute Table and Study Area Map

Historical and architectural information as well as measured floor levels and other factors

Step 3: Identifying Filtering Factors and Creating Analytical Layers

Mapping of historic spaces inundated under NOAA Intermediate-High scenarios

Step 4: Populating Detailed Survey Dataset

Historic resource survey as well as measured documentation for individual properties

Step 5: Disseminating and Managing GIS Maps and Information

Data shared with the public and continuously updated with refined research and assessment

PROJECT METHODOLOGY

3D LASER SCANNING

STEP 1: DATA CAPTURE

The *Resilient Cedar Key: Digital Flood Vulnerability Assessment* project methodology relies on terrestrial laser scanning. Laser scanning is defined as the "act of using a laser device that collects 3D coordinates of a given region of a surface automatically and in a systematic pattern at a high rate [as much as a million points per second] achieving the results in (near) real time."[1] Terrestrial laser scanners are "contact-free measuring devices that can collect dense point-clouds of objects [including the built and natural environments]."[2] Each point that makes up the point cloud is assigned XYZ coordinates and color value.

Among other reasons, the project team employs terrestrial laser scanning for the accuracy in recording historic building measurements, features, and condition. While the *Resilient Cedar Key* project utilizes information and 3D imagery of terrestrial laser scanning for flood visualization and vulnerability assessment, the researchers are also using the data for architectural heritage documentation as part of current and future efforts to adapt the historic environment to be more resilient.

A FARO Focus3D X 130 terrestrial laser scanner is used to document the historic urban context, waterfront, and buildings. The FARO Focus3D X 130 is a phase-shift laser scanner that can provide accuracy up to 2-4 mm, and the working range can reach 130 meters. On average, the laser scan setting for the data capture was:

- Resolution 10240x4267 (1/4)
- Quality 4x (laser is emitted four times to average for noise reduction)
- Time Approximately 11:28 minutes
- MPts 43.7 million points (maximum number of points)
- Point Distance 6.136 (mm/10m)

Initial deliverables are raw scan datasets incorporating metric points (XYZ coordinates) and digital photographs (RGB color information).

The features and character of the built environment inform approaches to data capture. For example, more dense urban areas where buildings are positioned close together (like Second Street downtown) can require fewer scans to get a complete point cloud by overlapping 3D data fractions. However, additional scans are typically undertaken to capture a higher level of building detail. Less dense areas where buildings are located further apart and set back from the street (like First Street waterfront), can require more scan positions. In addition to the urban fabric, typical challenges to outdoor scanning include, among others, weather conditions, moving cars and pedestrians (which result in "noise" or stray points in the point cloud), and vegetation and other environmental factors that obscure building information.

[1] David M. Jones, ed., 3D Laser Scanning for Heritage: Advice and Guidance to Users on Laser Scanning in Archaeology and Architecture, 2nd ed. (Swindon: English Heritage, 2001).
[2] https://www.gim-international.com/content/article/terrestrial-laser-scanning-2

PROJECT METHODOLOGY

3D LASER SCANNING

STEP 2: DATA PROCESSING AND POST-PROCESSING

The raw scan data is processed and registered using Autodesk ReCap Pro 2019 software to produce a complete point cloud (.rcp, .rcs, and other metadata files). Noise points from vehicles, pedestrians, and other moving objects and interferences are removed. The table below indicates the types of elements and noise that need to be addressed during the post-processing. The removal of these elements and noise varies from task to task. This table is only a reference, and researchers may need to adapt their approaches to the physical conditions and project goals.


Point Cloud Data with Noise Points


Point Cloud Data without Noise Points

Types of Elements and Noise	Vulnerability Assessment	Visualization	Building Documentation (orthographic representation)
Pedestrians and moving vehicles	Unnecessary	Necessary	Necessary
Parked cars	Unnecessary	Unnecessary	Recommended
Glass and metal reflection	Unnecessary	Necessary	Recommended
Water	Unnecessary	Unnecessary	Recommended
Interior	Unnecessary	Recommended	Necessary
Vegetation	Unnecessary	Unnecessary	Dependent on location
Power lines	Unnecessary	Unnecessary	Dependent on location
Color issue (e.g., over-exposure and moving objects on building)	Unnecessary	Recommended	Recommended

Table 1. Recommendations for Level of Point Cloud Clean Up during Post-Processing

PROJECT
METHODOLOGY

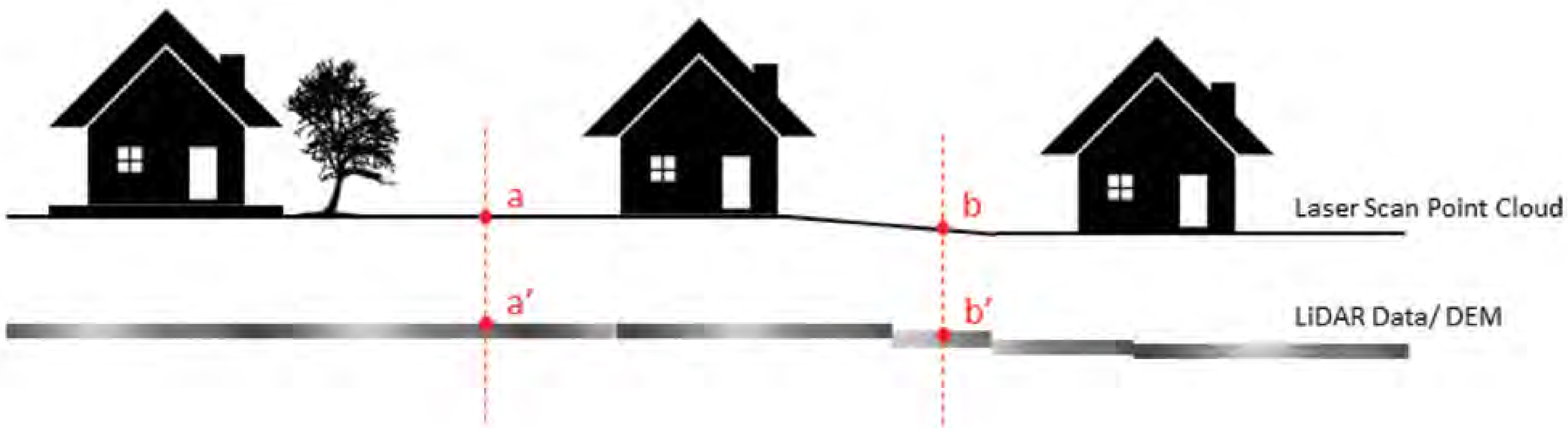
SEA LEVEL RISE PROJECTION

STEP 1: RELATING POINT CLOUD TO LIDAR DATA

Once the point cloud(s) are processed and post-processed, they need to be related to known elevation reference points. These elevation reference points can be features such as water covers, storm drains, crosswalks, or other ground level elements that have been previously surveyed by a Total Station or other GPS survey method or mapped using airborne LiDAR (light detection and ranging)[1], which is distinguished from terrestrial laser scanning regarding accuracy, survey scale, and operating positions, among other differences. LiDAR data is often available at a state GIS repository as a 2D rasterized DEM (digital elevation model) and provides elevation information on the overlay of satellite imagery or maps.

For the Cedar Key and other Florida projects, LiDAR data is available through the University of Florida GeoPlan Center's *Sea Level Scenario Sketch Planning Tool*: https://sls.geoplan.ufl.edu/

[1] As defined by Dictionary.com, LiDAR is a process similar to radar in principle and operation but using infrared laser light instead of radio waves and capable of detecting particles, distant objects, and varying physical conditions in the atmosphere. Retrieved June 25, 2019 from https://www.dictionary.com/browse/lidar.



PROJECT

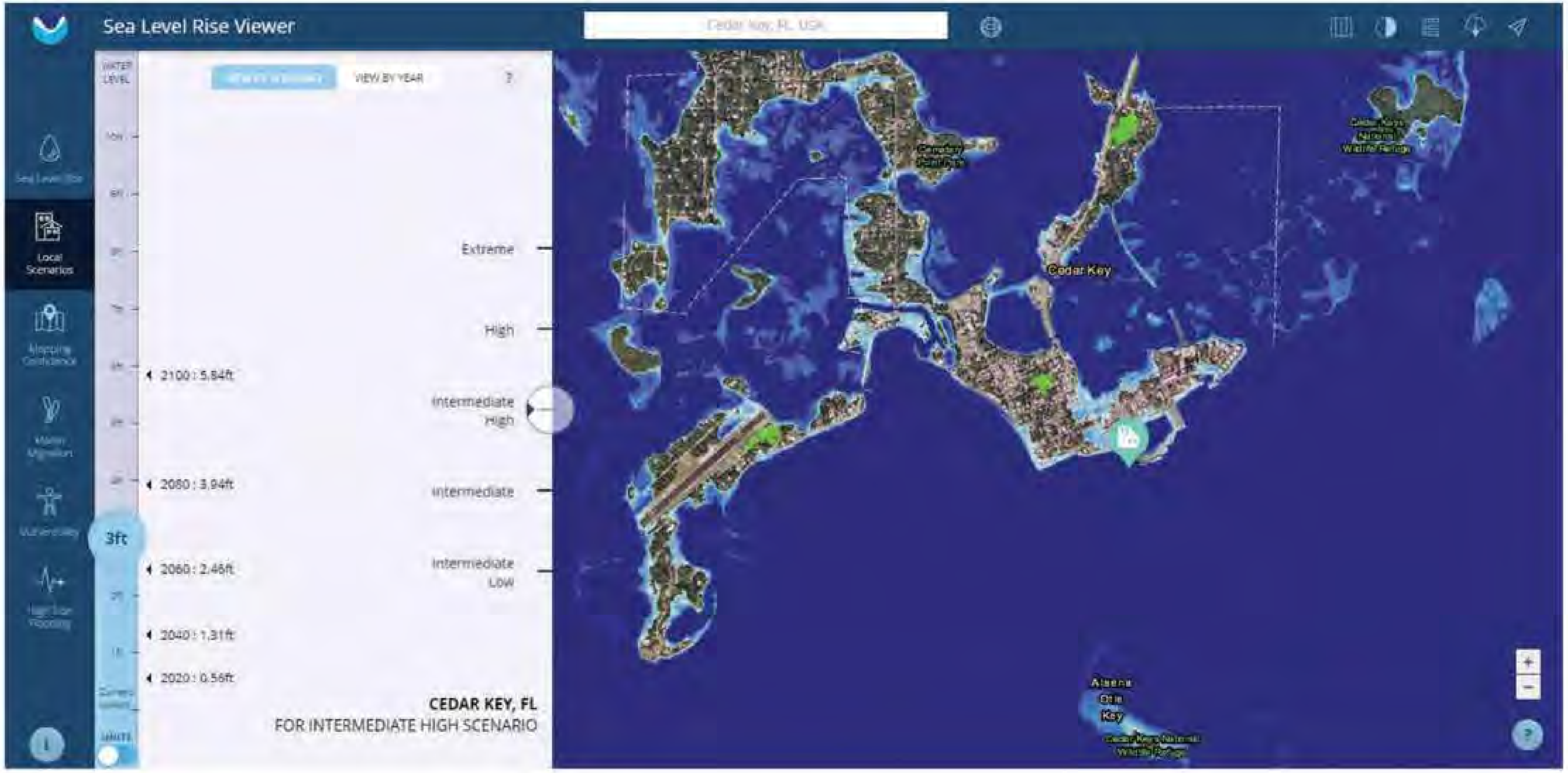
METHODOLOGY

SEA LEVEL RISE PROJECTION

STEP 2: CHOOSING SEA LEVEL RISE SCENARIOS

National Oceanic and Atmospheric Administration (NOAA) provides each community with different sea level rise scenarios by intensity level, such as the low, intermediate, high, and extreme, as well as by year. The *Cedar Key Digital Flood Vulnerability Assessment* uses a medium level of projection, like the intermediate-high, to avoid underestimating or exaggerating future water elevations. Depending on topographical characteristics of the study area, researchers can select multiple years under the chosen intensity of scenario so that the 3D simulations represent the gradual rise of sea level, which can help prioritize pre-disaster mitigation and sea level rise adaption efforts.

NOAA Sea Level Rise Viewer: https://coast.noaa.gov/slr/



PROJECT
METHODOLOGY

SEA LEVEL RISE PROJECTION

STEP 3: RELATING INFORMATION TO A SINGLE DATUM (NAVD88)

Sea level rise scenarios, tidal records, and LiDAR data can have different reference points. For instance, NOAA sea level rise projections are related to MHHW (Mean Higher High Water) whereas LiDAR (light detection and ranging) data is often related to NAVD88 (the North American Vertical Datum of 1988). For consistency, it is necessary to relate all the collected data to the same reference, like NAVD88. NOAA provides a datum chart for showing the relationship of NAVD88 and tidal elevations of each tidal station and community.

The datum chart for Cedar Key (station number: 8727520) is available at: https://tidesandcurrents.noaa.gov/datums.html?id=8727520

	Relative to MLLW	Relative to NAVD88
MHHW	3.8 (feet)	1.54
NAVD88	2.26	0
MSL	2.04	-0.22
MLLW	0	-0.26

Table 2. Tidal Elevation Datum for Cedar Key, Florida

2100 Projections	Relative to MHHW	Relative to NAVD88
Extreme	10.17 (feet)	11.71
High	8.20	9.74
Intermediate High	5.84	7.38
Intermediate	3.61	5.15
Intermediate Low	1.61	3.15

I-H by year	Relative to MHHW	Relative to NAVD88
2100	5.84 (feet)	7.38
2080	3.94	5.48
2060	2.46	4.00
2040	1.31	2.85

Table 3. NOAA Sea Level Rise Scenarios for Cedar Key, Florida

Hurricane Hermine (September 2, 2016, morning) flood reached 7.5 feet above NAVD88, which is close to the 2100 Intermediate High projection.

Photo: Bonish, Pat. "Hurricane Hermine Hits Cedar Key." Every Miles a Memory. September 3, 2016. http://everymilesamemory.com/hurricane-hermine-hits-cedar-key/

PROJECT METHODOLOGY

SEA LEVEL RISE PROJECTION

STEP 4: ESTIMATING ERROR AND TOLERANCE

Although recent airborne LiDAR provides reliable elevation information, its accuracy is different from (often lower than) terrestrial laser scanning because the aim is a different scale of survey. While airborne LiDAR records a large geographical area, terrestrial laser scanning helps capture structures (exterior and interior), sites, and streetscapes in millimeter accuracy. For consistency, a researcher can set up a benchmark in the 3D laser-scan point cloud by using the elevation of the spot from LiDAR. A benchmark can be selected for an area consisting of some urban blocks. For a large survey, multiple benchmarks can be utilized when dividing the laser scan data by area to help manage file sizes and decrease the margin of errors. Projected sea levels and grade and building elevations are then measured from the benchmarks.

STEP 5: IDENTIFYING VULNERABLE HERITAGE

Informed by the cultural resource survey (i.e., Florida Master Site Files), researchers can identify highly recognizable historic landmarks, streetscapes, vistas, and public gathering places that are vulnerable to flooding and rising sea level to visualize the areas for public education and communication. This step requires the understanding of both the geospatial characteristics and urban and cultural landscape of the places through field observation and GIS digital analysis.

STEP 6: FLOODING SCENARIOS VISUALIZATION

Autodesk 3ds Max 2017 is used to render a point cloud with realistic texture, like water. However, as computer software is subject to frequent updating and retiring, a range of software options should be researched and considered.

Based on the expected water levels under the chosen scenarios, a water plane can be moved up and down in the 3D virtual environment (point cloud). The water in the visualizations is left somewhat transparent to better relay what components of the urban environment will be inundated. Vehicles parked on the streets are often left in the images to provide a sense of scale.

The flood visualizations should be the results directly generated from 3D rendering without much image editing or enhancement (i.e., Photoshop work) to avoid the arbitrary creation of flooding images. The researcher, however, can apply minimum image editing if it can improve the readability of the visualizations. For instance, if flood water should not appear where laser scan data is missing, another image without the digital water can be overlaid and fill in the gap. However, misleading information should be avoided.

Task (Function of Software)	Identifying areas to render	Optimizing the size of point cloud	Placing water, setting camera, and rendering	Making minor edits on images
Software Example (used in this study)	Autodesk ReCap Pro	Autudesk ReCap Bentley Pointools	Autodesk 3Ds Max	Adobe Photoshop
Point Cloud Formats	.RCS	.E57 and .PTS	.RCS	.TIF or .JPG

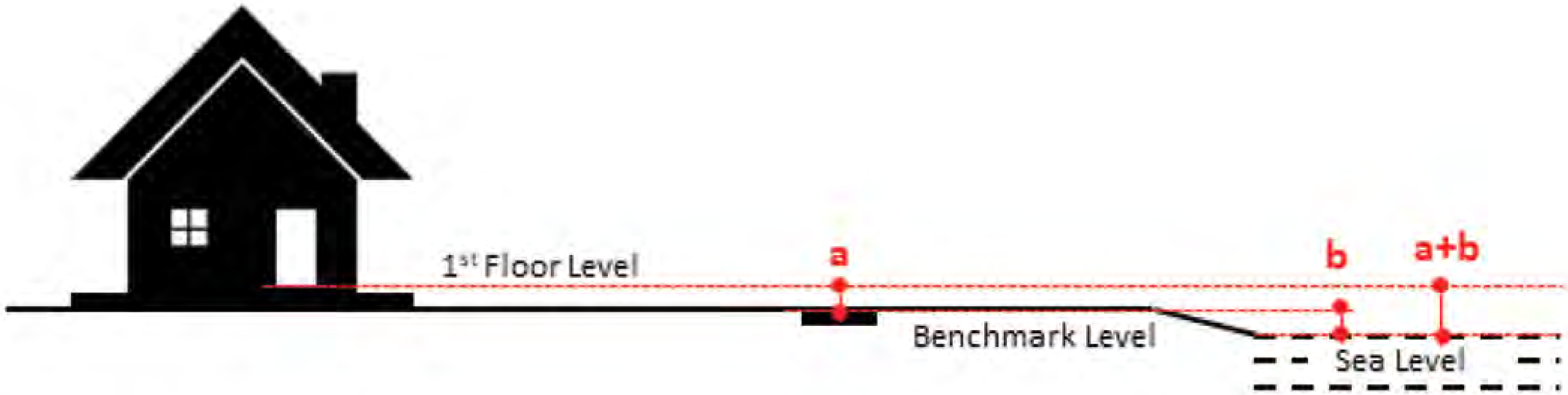
PROJECT METHODOLOGY

FLOOD VULNERABILITY ASSESSMENT & GIS MAPPING

STEP 1: MEASURING FIRST FLOOR ELEVATIONS

The first-floor elevations of the buildings in the study area are measured from the benchmarks, related to NAVD88. The project team defines a first floor as the lowest level of primary living space that excludes a basement, storage, and garage. The researchers measure first-floor heights both from the NAVD88 sea level and the street where the building is located. The data acquisition by terrestrial laser scanning is limited to the exteriors and streetscapes. The researchers, however, are able to collect the first-floor levels by measuring to door thresholds of the main entrances of each building.

It is critical that the laser-scan data includes building entrances when possible. When the field conditions do not allow the surveyors to capture doors due to obstacles, such as vegetation, the researchers can measure other features, such as porch edges, and get approximate building floor levels by using the average slopes and threshold heights from other historic buildings from a similar period.



PROJECT
METHODOLOGY

FLOOD VULNERABILITY ASSESSMENT & GIS MAPPING

STEP 2: GENERATING GIS ATTRIBUTE TABLE AND STUDY AREA MAP

To develop the study area map for the vulnerability assessment for historic buildings, the project team updates the GIS (geographic information system) attributes of individual properties (building footprint polygon shapefiles) with historical and architectural information (e.g., construction years and structural types). The attribute table also incorporates the measured floor level as well as other factors such as the proximity to water, surrounding buffers, and other factors that can inform flood vulnerability assessment. The project team uses the software Esri ArcGIS Desktop and Online for this task.

As an example, the *Resilient Cedar Key* project includes attributes critical for vulnerability assessment such as:

Attribute	Purpose
Street address in US standard format	Geocode (position) individual properties
Construction year (45 year)	Identify historic buildings (including potentially eligible ones)
Structural types and elements	Inform potential adaptation and feasibility
First-floor levels	Identify living spaces vulnerable under chosen SLR scenarios
Proximity to water	Assess vulnerability to storm surge
Buffer	Assess vulnerability to storm surge
Other variables	Depend on project goals and local conditions
URL of documentation set	Link historical/ architectural documents for individual properties

Table 4. GIS Attributes for Flood Vulnerability Assessment of Historic Structures

PROJECT METHODOLOGY

FLOOD VULNERABILITY ASSESSMENT & GIS MAPPING

STEP 3: IDENTIFYING FILTERING FACTORS AND CREATING ANALYTICAL LAYERS

Once the attribute table of the study area map is ready, the researchers utilize the Esri ArcGIS Desktop to generate map layers for assessing vulnerability to rising sea levels. A primary research question is which historic properties will have first- or ground-floor habitable spaces inundated under a specific scenario (NOAA Intermediate-High projection) by such years as 2040, 2060, 2080, and 2100.

The GIS analysis focuses on buildings with the first floor below the projected water levels in the chosen year. Based on a 45-year framework for the eligibility for existing and potential landmark listing, historic buildings built before 1975 are identified among the impacted properties. The impacted historic buildings are then divided by structural types such as wood frame and masonry to inform the feasibility of potential adaption such as raising and relocating structures.

Task (Function of Software)	Identifying areas to render	Optimizing the size of point cloud	Placing water, setting camera, and rendering	Making minor edits on images
Software Example (used in this study)	Autodesk ReCap Pro	Autudesk ReCap Bentley Pointools	Autodesk 3Ds Max	Adobe Photoshop
Point Cloud Formats	.RCS	.E57 and .PTS	.RCS	.TIF or .JPG

PROJECT METHODOLOGY

FLOOD VULNERABILITY ASSESSMENT & GIS MAPPING

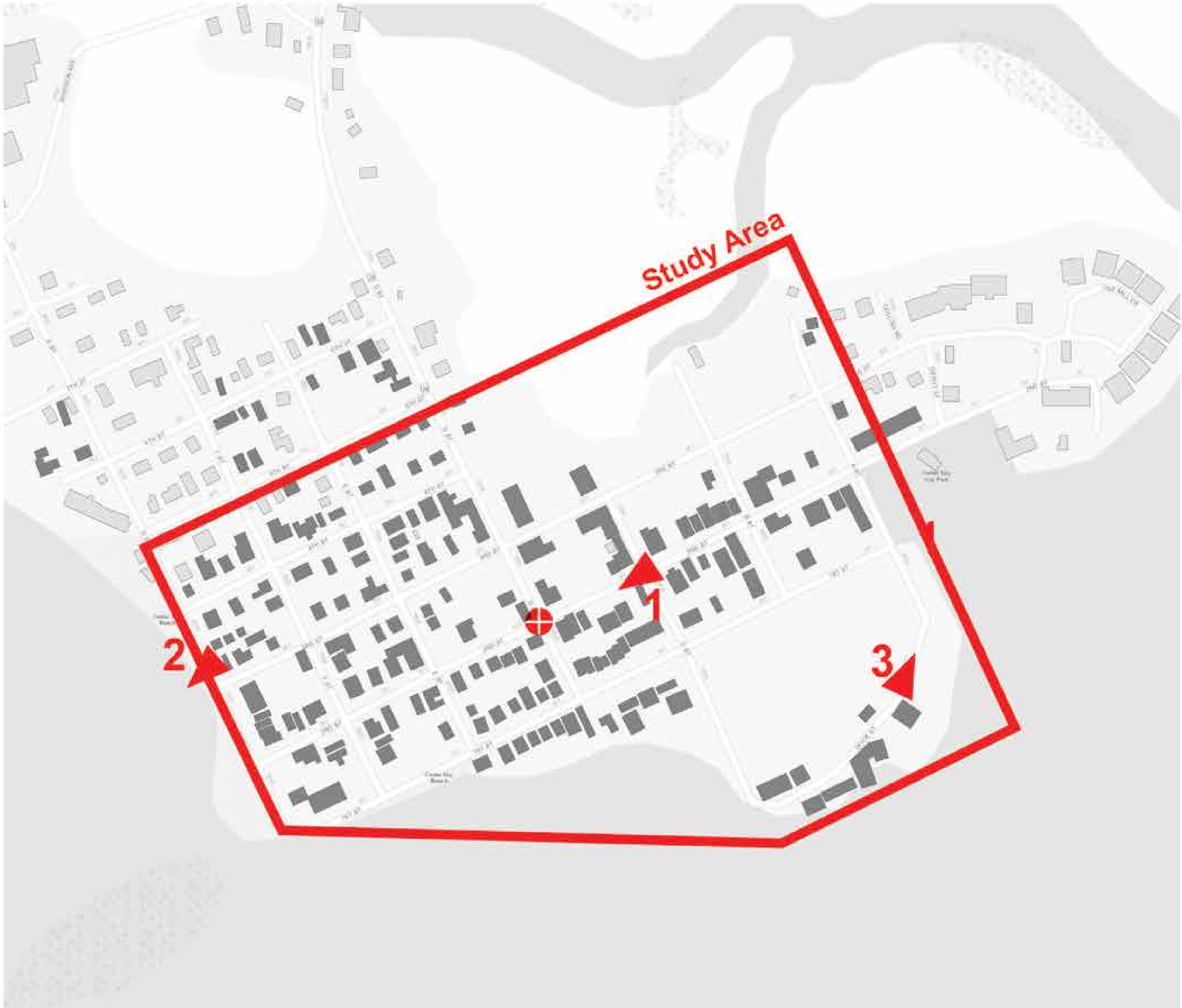
STEP 4: POPULATING DETAILED SURVEY DATASET

To inform preservation planning and research, the researchers update the GIS map with historic resource survey data as well as measured documentation. An individual property's dataset includes, but is not limited to, survey forms, photographic records (both present and historical), historical documents (e.g., National Register records, Historic American Building Survey drawings, and other archival materials), and digital architectural documentation (e.g., scalable orthographic images from laser scan data). The documents are made into PDF files and linked to each property through the Esri ArcGIS Online.

STEP 5: DISSEMINATING AND MANAGING GIS MAPS AND INFORMATION

The GIS maps are made available to the public and continuously updated with refined historical research and vulnerability assessment through the Esri Web Map and ArcGIS Online. The research team hopes that disseminating the information can help with pre-disaster mitigation and adaptation planning as well as historic preservation efforts for Cedar Key. The GIS maps will assist the UF researchers and local preservation groups with prioritizing documentation and adaptation primary areas.

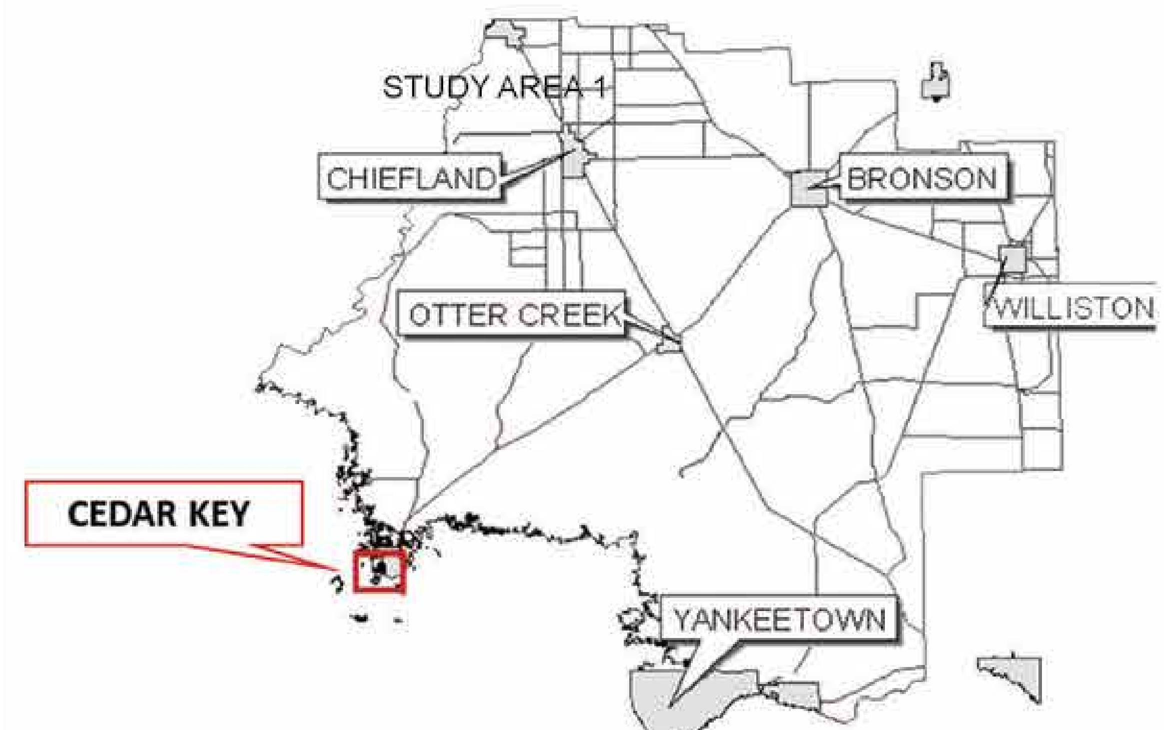
SEA LEVEL RISE VISUALIZATION LOCATOR MAP



Visulaization Locations

1. Second and C Streets
2. Faraway Inn at G Street
3. Dock Street

Benchmark Elevations Relative to NAVD88 5.00ft



SECOND & C STREETS

NOAA Intermediate - High Sea Level Rise Projection
2019 Water Level = 1.54 feet (MHHW above NAVD88)

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SECOND & C STREETS

NOAA Intermediate - High Sea Level Rise Projection
2080 Water Level = 5.48 feet (MHHW above NAVD88)

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SECOND & C STREETS

NOAA Intermediate - High Sea Level Rise Projection
2100 Water Level = 7.38 feet (MHHW above NAVD88)

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RESILIENT CEDAR KEY

FARAWAY INN at G STREET

NOAA Intermediate - High Sea Level Rise Projection
2019 Water Level = 1.54 feet (MHHW above NAVD88)

FARAWAY INN at G STREET

NOAA Intermediate - High Sea Level Rise Projection
2040 Water Level = 2.85 feet (MHHW above NAVD88)

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RESILIENT CEDAR KEY

FARAWAY INN at G STREET

NOAA Intermediate - High Sea Level Rise Projection
2060 Water Level = 4.00 feet (MHHW above NAVD88)

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RESILIENT CEDAR KEY

FARAWAY INN at G STREET

NOAA Intermediate - High Sea Level Rise Projection
2080 Water Level = 5.48 feet (MHHW above NAVD88)

FARAWAY INN at G STREET

NOAA Intermediate - High Sea Level Rise Projection
2100 Water Level = 7.38 feet (MHHW above NAVD88)

DOCK STREET

NOAA Intermediate - High Sea Level Rise Projection
2019 Water Level = 1.54 feet (MHHW above NAVD88)

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RESILIENT CEDAR KEY

DOCK STREET

NOAA Intermediate - High Sea Level Rise Projection
2040 Water Level = 2.85 feet (MHHW above NAVD88)

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RESILIENT CEDAR KEY

DOCK STREET

NOAA Intermediate - High Sea Level Rise Projection
2060 Water Level = 4.00 feet (MHHW above NAVD88)

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RESILIENT CEDAR KEY

DOCK STREET

NOAA Intermediate - High Sea Level Rise Projection
2080 Water Level = 5.48 feet (MHHW above NAVD88)

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RESILIENT
CEDAR KEY

DOCK STREET

NOAA Intermediate - High Sea Level Rise Projection
2100 Water Level = 7.38 feet (MHHW above NAVD88)

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RESILIENT
CEDAR KEY

FLOOD VULNERABILITY ASSESSMENT FOR THE CITY OF CEDAR KEY

OVERVIEW

The UF research team utilized terrestrial laser scanning to record and analyze 135 individual sites (comprising 165 structures in total due to some of those properties have multiple buildings). 106 sites (122 structures), which account for 78.5% of the laser-scanned, were built before 1975 (based on a 45-year framework) and are considered historic properties that currently and potentially contribute to the significance of the Cedar Key historic district. The laser-scan data and vulnerability assessment also include 29 sites (43 structures) that were built recently (in and after 1975). Approximately 62 % of the laser-scanned area (84 sites; 105 structures) are residences, including single-family houses, condominiums, and rental housing, and 38% (51 sites; 60 structures) are for commercial (including mixed-use), lodging, public, religious, or other non-profit use.

The researchers also verified the existing Florida Master Site File surveys of about 20 individual properties (including demolished and moved ones) outside the 3D digital documentation area but did not include them in the vulnerability assessment. In addition, during the fieldwork of laser scanning in spring 2019, two buildings were under construction. As one of them had its structural frame nearly complete, the researchers included it in the assessment. A former historic property on 481 Second Street, which was included in the Florida Master Site File (LV00163-CK035), was demolished and the street façade remains. It was excluded from the vulnerability assessment.

GIS PRESENTATION

To represent building footprints accurately, individual structures are represented as separate polygons although some of them are merged as a single polygon when the structures are connected or close enough to each other. When a property has a group of buildings, the researchers measured a representative one or main building and applied the information to the rest of the structures on site. An exception is the Beach Front Motel (FMSF #: LV00946) at First and G Streets where the lodging and office buildings, both of which are habitable spaces, have different architectural characteristics and floor elevations. The researchers treated them as separate properties although they share the parcels.

The properties with multiple buildings (see the Study Area Map of Flood Vulnerability Assessment for the City of Cedar Key) include:

1. Faraway Inn on 849 3rd Street – 7 (buildings)
2. Housing on 7061 - 7091 G Streets – 4
3. Hale-Johnson House on 781 4th Street – 2
4. Gore House on 774 2nd Street – 2
5. Housing 634 5th Street – 6
6. Cedar Key Historical Society Museum on 609 2nd Street – 2
7. Seashells Cottage Condo on 549 - 597 1st Streets – 6
8. UF Nature Coast Biological Station on 552 1st Street – 2
9. Island Place Condo on 550 1st Street – 5
10. Former L&M Bar on 433 2nd Street – 2
11. Houses on 6031 A street – 2

FLOOD VULNERABILITY ASSESSMENT FOR CITY OF CEDAR KEY
Study Area

FLOOD VULNERABILITY ASSESSMENT FOR CITY OF CEDAR KEY
Contributing / Non-Contributing Buildings in Laser Scanned Area

FLOOD VULNERABILITY ASSESSMENT FOR CITY OF CEDAR KEY
Residential / Non-Residential Buildings in Laser Scanned Area

FLOOD VULNERABILITY ASSESSMENT FOR THE CITY OF CEDAR KEY

SEA LEVEL RISE IMPACTS BASED ON NOAA INTERMEDIATE-HIGH SCENARIOS WITH 20-YEAR INTERVAL

By 2040, the sea level in Cedar Key, Florida will be at 2.85 ft above NAVD88 (1.31 ft rise from the present MHHW or Mean Higher High Water level). It only impacts the 1950s Faraway Inn (a complex of six lodging and one ancillary buildings, constructed of concrete blocks) at Third and G Streets, which is the site of the former Eagle Pencil Company Mill.

By 2060, the sea level will reach 4.00ft above NAVD88 (2.46ft rise from the present MHHW). Under this scenario, a total of 6 properties (4% of the properties in the study area) are inundated. 5 historic properties (12 structures) are impacted. 3 structures (2 sites) are wood frame, and the rest are masonry structures. 1 recent wood-frame building (1980s) on Dock Street is also impacted.

By 2080, the anticipated sea level is 5.48ft above NAVD88 (3.94ft rise from the present MHHW). 13 properties (10% of the properties in the study area) in total are inundated. 12 sites (19 structures) of them are historic properties, among which 5 sites (6 structures) are constructed of wood frames. 1 recent structure is flooded.

By 2100, the sea level reaches 7.38ft above NAVD88 (5.84ft rise from the present MHHW). It makes impact on a total of 47 properties (35% of the properties in the study area) in Cedar Key. 42 historic sites (50 structures) are inundated. 25 properties (27 structures) are wood frame, and 17 properties (23 structures) are masonry constructions, such as concrete block, poured tabby, and brick. The sea level also inundates 5 non-historic properties.

DISCLAIMER FOR VULNERABILITY ASSESSMENT

The potentially contributing (built before 1975) and non-contributing (built after 1975) structures of the Cedar Key local and National Register Historic Districts are based on the 2019 cultural resource survey. The significance of current non-contributing structures will need to be evaluated as they reach 50 years of age.

FLOOD VULNERABILITY ASSESSMENT FOR CITY OF CEDAR KEY
Impacted Buildings under NOAA Intermediate High Scenario

2040

FLOOD VULNERABILITY ASSESSMENT FOR CITY OF CEDAR KEY
Structural Types of Impacted Historic Buildings

2040

FLOOD VULNERABILITY ASSESSMENT FOR CITY OF CEDAR KEY
Impacted Buildings under NOAA Intermediate High Scenario

2060

FLOOD VULNERABILITY ASSESSMENT FOR CITY OF CEDAR KEY
Structural Types of Impacted Historic Buildings

2060

FLOOD VULNERABILITY ASSESSMENT FOR CITY OF CEDAR KEY
Impacted Buildings under NOAA Intermediate High Scenario

2080

FLOOD VULNERABILITY ASSESSMENT FOR CITY OF CEDAR KEY
Structural Types of Impacted Historic Buildings

2080

FLOOD VULNERABILITY ASSESSMENT FOR CITY OF CEDAR KEY
Impacted Buildings under NOAA Intermediate High Scenario

2100

FLOOD VULNERABILITY ASSESSMENT FOR CITY OF CEDAR KEY
Structural Types of Impacted Historic Buildings

2100

2ND STREET
CEDAR KEY, FL

NOAA INTERMEDIATE HIGH
SEA LEVEL RISE PROJECTION

MHHW RELATIVE TO NAVD88

2040 - 2.85FT

2060 - 4.00FT

2080 - 5.48FT

2100 - 7.38FT

C SREET **B SREET**

Name:	Lutterloh / Schlemmer	CK Arts Center	Zewadski	Bodiford / Woolridge	Bodiford
Built Year:	1875 / 1880	1994	1880	1890 / 1881	1878
FMSF #:	LV00145 / LV 00162	Non-Contributing	LV00164	LV00165 / LV00166	LV00167
Structural Type:	Tabby / Brick	Concrete Block	Concrete	Brick / Tabby	Tabby
1st-Floor Level:	6.4 ft / 5.9 ft	6.1 ft	6.4 ft	8.35 ft / 8.55 ft	8.45 ft

0 20 50 100 150 200ft

1ST STREET
CEDAR KEY, FL

NOAA INTERMEDIATE HIGH
SEA LEVEL RISE PROJECTION

MHHW RELATIVE TO NAVD88

2040 - 2.85FT

2060 - 4.00FT

2080 - 5.48FT

2100 - 7.38FT

Name:	Hodges Rental	Hodges	Hodges	Hodges	Hodges	652 1st St	660 1st St
Built Year:	1925	1925	1925	1925	1925	1922	1997
FMSF #:	LV00732	LV00733	LV00734	LV00735	LV00736	LV00737	Non-Contributing
Structural Type:	Wood Frame	Wood Frame	Wood Frame	Wood Frame	Wood Frame	Wood Frame	Wood Frame
1st-Floor Level:	9.2 ft	9.15 ft	9.6 ft	10.9 ft	10.85 ft	11 ft	16.8 ft

0 20 50 100 150 200ft

2ND STREET
CEDAR KEY, FL

NOAA INTERMEDIATE HIGH
SEA LEVEL RISE PROJECTION

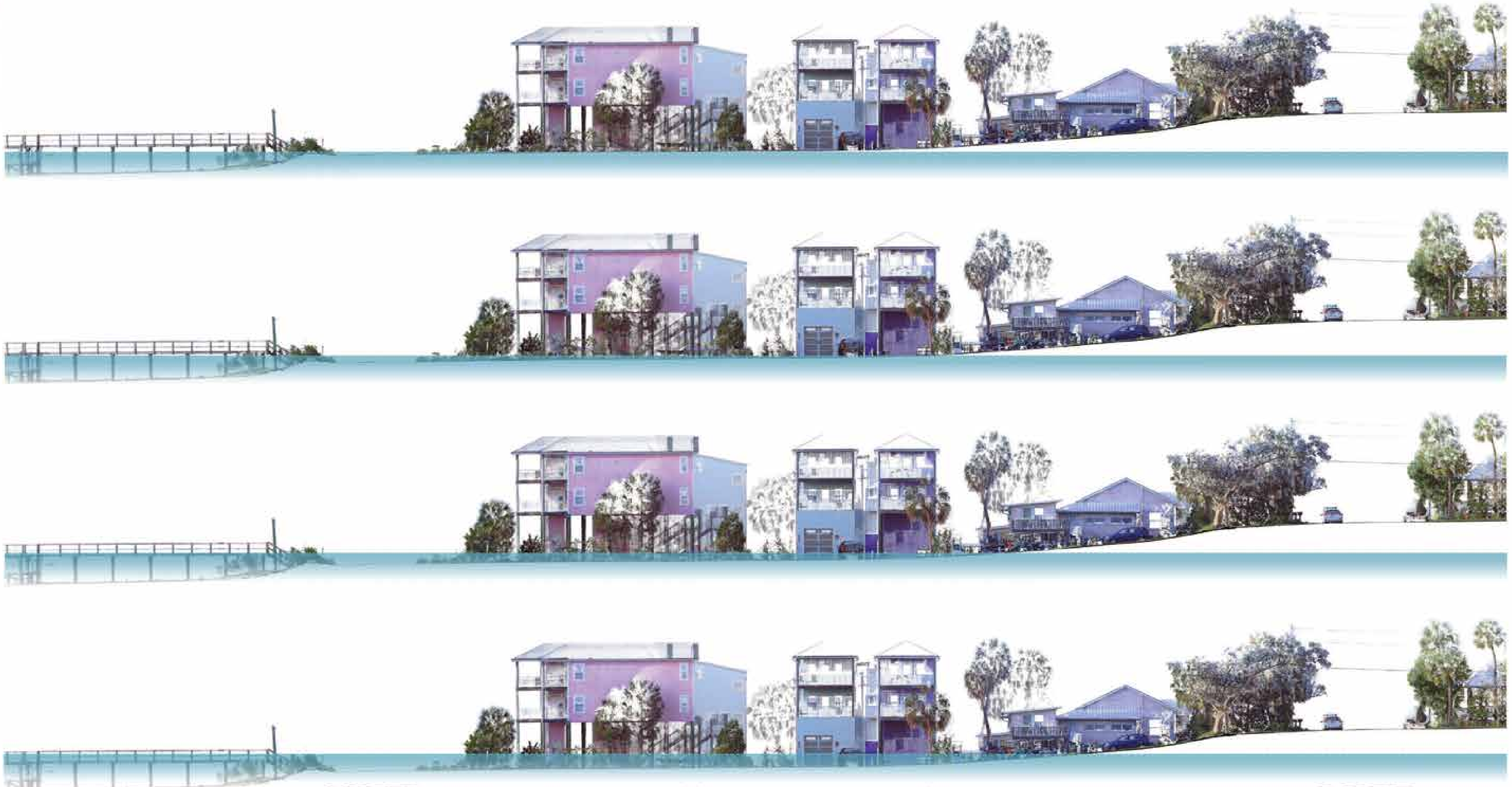
MHHW RELATIVE TO NAVD88

2040 - 2.85FT

2060 - 4.00FT

2080 - 5.48FT

2100 - 7.38FT



G SREET | **F SREET**

Name:	7061-7091 G St.	841 & 849 2nd St.	Hughes House
Built Year:	2009	2009	1919
FMSF #:	Non-Contributing	Non-Contributing	LV00217
Structural Type:	Wood Frame	Wood Frame	Wood Frame
1st-Floor Level:	18.4 ft	19.4 ft	11.3 ft

0 20 50 100 150 200ft